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Safety

Forestry Machine Maintenance Safety

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Forestry Machine Maintenance Safety

GENERAL

Safe Operation is Operator's Responsibility

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

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

- Do not operate machine if you are under the influence of drugs or alcohol. An operator who is taking prescription drugs must get medical advice to determine if he or she can safely operate a machine.
- When working with other personnel on a work site, be sure that all personnel know nature of work and understand all hand signals that are to be used.
- Be sure that all guards and shields are installed in their proper location. Have guards and shields repaired or replaced immediately if damaged.
- Be sure that you understand the use and maintenance of all safety features such as safety lever and seat belt. Use them properly.
- Never remove, modify or disable any safety features. Always keep them in good operating condition.
- Always check for and know the location of underground and overhead utility lines before working.
- Failure to use and maintain safety features according to instructions in this manual, Safety Manual and Shop Manual can result in death or serious injury.

Know Your Machine

Know how to operate your machine. Know the purpose of all controls, gauges, signals, indicators and monitor displays. Know the rated load capacity, speed range, braking and steering characteristics, turning radius and operating clearances. Keep in mind that rain, snow, ice, loose gravel, soft ground, slopes etc., can change operating capabilities of your machine.

Proper Work Tools and Attachments

Only use work tools and attachments that are recommended by HYUNDAI for use on HYUNDAI machines. When installing and using optional attachments, read instruction manual for attachment, and general information related to attachments in this manual. Because HYUNDAI cannot anticipate, identify or test all attachments that owners may want to install on their machines, contact HYUNDAI for written authorization and approval of attachments, and their compatibility with optional kits.

Attachments and attachment control systems that are compatible with the machine are required for safe and reliable machine operation. Do not exceed maximum operating weight (machine weight plus attachment) that is listed on ROPS certification plate.

Make sure that all guards and shields are in place on machine and on work tool. Depending on type or combination of work equipment, there is a potential that work equipment could interfere with the cabin or other parts of machine. Before using unfamiliar work equipment, check if there is any potential of interference, and operate with caution.

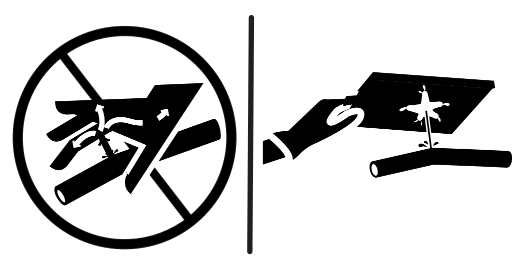
While you are performing any maintenance, testing, or adjustments to attachments, stay clear of the following areas: cutting edges, pinch points, and crushing surfaces.

Never use attachment as a work platform or manlift.

Contact your HYUNDAI distributor about auxiliary hydraulic kits for attachments installation. If you are in doubt about compatibility of a particular attachment with a machine, consult your HYUNDAI distributor.

Pressurized Fluids

Pressurized air or fluids can cause debris and/or fluids to be blown out. This could result in death or serious injury.



FG018457

Figure 1

Immediately after operations are stopped, coolant, engine oil, and hydraulic oil are at their highest temperatures and the radiator and hydraulic tank are still under pressure. Always wait for temperature to cool down. Follow specified procedures when attempting to remove caps, drain oil or coolant, or replacing filters. Always wait for temperature to cool down, and follow specified procedures when performing these operations. Failure to do so can result in death or serious injury.

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

Pressure can be trapped in a hydraulic system and must be relieved before maintenance is started.

Releasing trapped pressure can cause sudden machine movement or attachment movement. Use caution if you disconnect hydraulic lines or fittings.

High-pressure oil that is released can cause a hose to whip or oil to spray. Fluid penetration can result in death or serious injury. If fluid enters skin or eyes, get immediate medical attention from a physician familiar with this injury.

Obey all local laws and regulations for disposal of liquids.

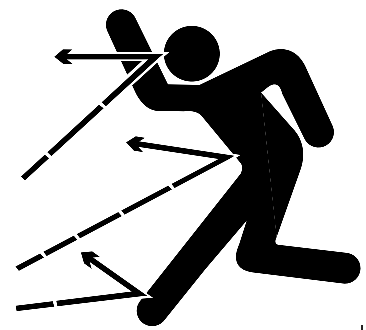
To prevent hot coolant from spraying out, stop engine and wait for coolant to cool. Using gloves, slowly loosen cap to relieve pressure.

Flying or Falling Objects

On work sites where there is a potential hazard that flying or falling objects can hit operator's cabin, select and use a guard to match operating conditions for additional operator protection.

Working in mines, tunnels, deep pits, and loose or wet surfaces, could produce hazard of falling rocks or flying objects. Additional protection for operator's cabin could be required such as an Operator Protection Guard (OPG) or window guards. Contact your HYUNDAI distributor for information on available protective guards.

To prevent personnel from being struck by flying objects, keep personnel out of work area.



HAOA110L

Figure 2

HAOA100L

Figure 3

Personal Protective Equipment (PPE)

Do not wear loose clothing and accessories. Secure long hair. These items can snag on controls or on other parts of equipment.

Do not wear oily clothes. They are highly flammable.

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. Breathing masks and/or ear protection may be required.

Wear a hard hat, safety shoes, safety goggles, mask, leather gloves, earplugs and other protective equipment, as required.

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

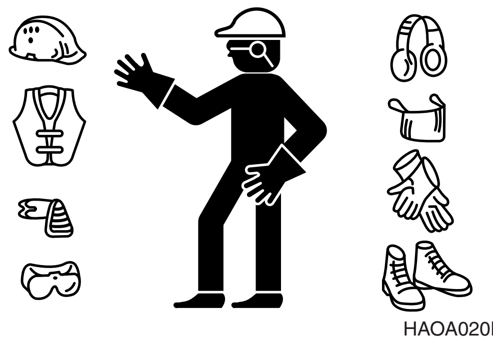


Figure 4

Correction of Machine Problems

If any machine problems are found during operation and maintenance (noise, vibration, smell, incorrect gauges, smoke, oil leakage, etc.), or if any abnormal warning alerts are displayed on display monitor, stop the machine and take the necessary corrective actions. Do not operate machine until problem has been corrected.

Crushing and Cutting

Keep objects away from moving fan blades. Fan blades can throw and cut objects.

Do not use a wire rope that is kinked or frayed, or a wire rope with any loss of diameter. Wear leather gloves when handling a wire rope.

When striking a loose retainer pin, it can fly out and can cause a serious injury. Make sure that area is clear of personnel when striking a retainer pin. To avoid injury to your eyes, wear safety goggles when striking a retainer pin.

Do not put your hand, arm or any other part of your body between movable parts. If going between movable parts is necessary, always position and secure work equipment so it cannot move. Properly support equipment before performing any work or maintenance under raised equipment.

If control levers are operated, clearance between machine and work equipment will change and this may lead to serious damage or can result in death or serious injury. Stay clear of areas that may have a sudden change in clearance with machine movement or equipment movement. Stay clear of all rotating and moving parts. Unless instructed, never attempt adjustments while machine is moving or while engine is running.

Do not depend on hydraulic cylinders to support raised equipment. Equipment can fall if a control is moved, or if a hydraulic line breaks, is loosened or disconnected.

If it is necessary to remove guards to perform maintenance, always install guards after maintenance is completed.

HDO1010L

Figure 5

Hot Coolant and Oils - Burn Prevention

Do not touch any part of an operating engine. Immediately after operations are stopped, coolant, engine oil, and hydraulic oil are at their highest temperatures. The radiator and hydraulic tank are still under pressure. Always wait for temperature to cool down. Attempting to remove caps, drain oil or coolant, or replacing filters may lead to serious burns, if done when hot. Relieve all pressure in air system, hydraulic oil system, lubrication system, fuel system, and cooling system, before any lines, fittings or related items are disconnected.

FG019095

Figure 6

To prevent hot oil or coolant from spraying out, stop engine, wait for oil and coolant to cool. Using gloves, slowly loosen cap to relieve pressure.

FG019096

Figure 7

Fire and Explosion Prevention

All fuels, most lubricants and some coolant mixtures are flammable and can cause a fire resulting in death or serious injury, and property damage. Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause fire.

Inspect for and remove all flammable materials such as spilled fuel and oil, and debris from machine. Do not allow any flammable materials to accumulate on machine.

Always observe the following:


HDO1015I

Figure 8

- Add fuel, oil, antifreeze and hydraulic fluid to machine only in a well ventilated area. Machine must be parked with controls, lights and switches turned "OFF". Engine must be "OFF" and any flames, glowing embers, auxiliary heating units or spark causing equipment must be extinguished, or turned "OFF" and kept well clear of machine.
- Dust that is generated from repairing or grinding nonmetallic hoods or nonmetallic fenders can be toxic, flammable and explosive. Repair these components in a well ventilated area away from flames or sparks and wear dust mask when grinding painted parts.


FG018458

Figure 9

Maintenance

The machine and some attachments have components that are at high temperatures under normal operating conditions. The primary source of high temperatures are the engine and exhaust system. If damaged or incorrectly maintained, the electrical system can be a source of arcs or sparks.

Flammable debris (leaves, straw, etc.) must be removed regularly. If flammable debris is allowed to accumulate, it can cause a fire hazard. Clean machine often to avoid this accumulation. Flammable debris in an engine compartment is a potential fire hazard.

The operator's area, engine compartment and engine cooling system must be inspected every day and cleaned. This is necessary to prevent fire hazards and overheating.

Operation

Do not use machine where exhaust, arcs, sparks or hot components can contact flammable material, explosive dust or gases.

Do not operate machine near any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil spray or fuel spray in case of a break in a line, hose, or seal. Exhaust shields must be correctly installed.

Electrical

Check all electrical wiring and connections for damage daily.

Keep battery terminals clean and tight. Repair or replace any damaged part or wires that are loose or frayed. Clean all electrical connections and tighten all electrical connections.

Never check battery charge by placing a metal object across terminal posts. Use a voltmeter or a hydrometer.

Battery gas can explode and can result in death or serious injury. Follow procedures in this manual for connecting battery and for jump-starting. Do not jump-start or charge a frozen or damaged battery. Keep any flames or sparks away from batteries. Do not smoke in battery charging area.

Improper jumper cable connections can cause an explosion that can result in death or serious injury. Refer to Operation & Maintenance Manual, for proper procedure in this manual.

Do not charge a frozen battery. This can cause an explosion.

After market radios or other electric operated equipment in cabin must have a fuse in the electrical circuit.

Hydraulic System

Check hydraulic tubes, hoses and fittings for damage, wear or for leaks. Hydraulic lines and hoses must be properly routed and have adequate support and secure clamps. Leaks can cause fires. Never use a flame or bare skin to check for leaks.

Tighten or replace any parts that show leakage.

Check that all hose and tube clamps, guards, and cushions are securely attached. If they are loose, they can vibrate during operation and rub against other parts. This can cause damage to hoses and cause high-pressure oil to spray on hot surfaces, causing a fire and death or serious injury.

Always clean fluid spills. Do not use gasoline or diesel fuel for cleaning parts. Use commercial nonflammable solvents.

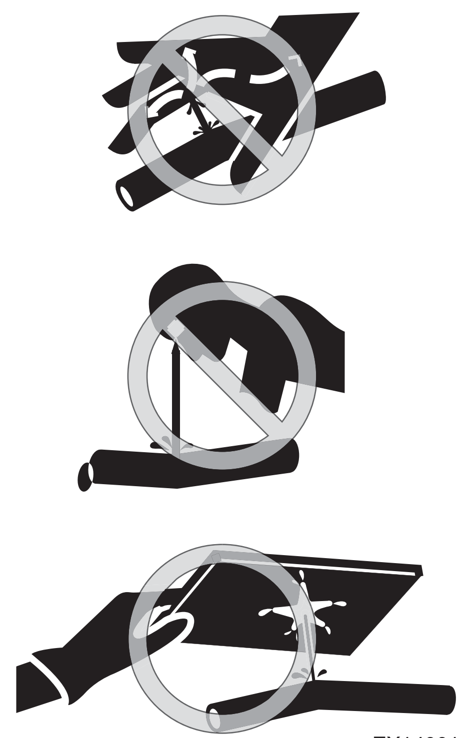

EX1400129

Figure 10

Fueling

Use caution when you are refueling a machine.

Fuel is flammable and can catch fire if it is brought close to a flame.

Stop engine and let it cool before adding fuel. Do not smoke while you are refueling a machine. Do not refuel a machine near flames or sparks. Fill fuel tank outdoors.

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

Store fuels and lubricants in properly marked containers away from unauthorized personnel. Store oily rags and any flammable materials in protective containers.

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

Always place plastic fuel containers on the ground before filling.

EX1400130

Figure 11

Never Use Ether Starting Aids

Do not use ether or starting fluids on any engine that has glow plugs, or an electric grid type manifold heater. These starting aids can cause an explosion and result in death or serious injury.

Use procedures in this manual for connecting battery and for jump-starting.

FG018458

Figure 12

Welding and Grinding

Always clean machine and attachment, set battery disconnect switch to "OFF" position, and disconnect wiring from electronic controllers before welding. Cover rubber hoses, battery and all other flammable parts. Keep a fire extinguisher near machine when welding.

Toxic dust or gas can be produced when grinding or welding painted parts. Grinding or welding painted parts must be done in a well ventilated area. Wear dust mask when grinding painted parts.

Dust generated from repairing nonmetallic parts such as hoods, fenders or covers can be flammable or explosive.

Repair such components in a well ventilated area away from flames or sparks.

Do not weld on lines or on tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent before welding or flame cutting.

If a Fire Occurs

If a fire occurs:

- Do not attempt to move machine or continue operations.
- Turn starter switch to "O" (OFF) position to stop engine.
- Use handrails, guardrails and steps to get off machine.
- Immediately call for help or fire station.
- When using a fire extinguisher, always aim extinguisher at base of fire.
- If an optional fire extinguishing system is in place, be familiar with its operating procedures.

NOTE: *Depending on job conditions, other procedures could be necessary if a fire occurs.*

Figure 13

Fire Extinguisher and First-aid Kit (Emergency Medical Kit)

To be prepared in the event of a fire:

- Be sure that fire extinguishers have been provided and read 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 cabin. Check and service fire extinguisher at regular intervals and make sure that all work site crew members are adequately trained in its use.
- Inspect fire extinguisher and service fire extinguisher regularly.
- Follow instructions on extinguisher instruction plate.
- Keep a first aid kit in cabin and keep another kit at work site. Check kit periodically and keep it properly supplied.
- Keep emergency numbers for doctor, ambulance service, hospital and fire department readily available.

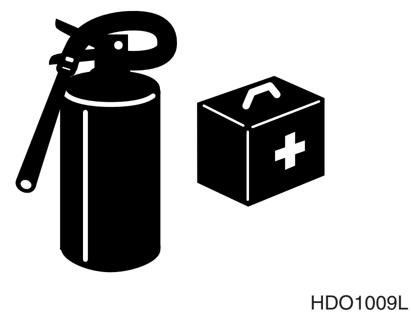


Figure 14

Electrical System and Electrical Shock

Never short across starter terminals or across batteries. Shorting could damage electrical system and engine neutral start system.

When engine is running or immediately after it has stopped, high voltage is generated at injector terminal and inside engine controller, so there is a potential for an electrical shock. Never touch injector terminal or inside of engine controller.

NOTE: *If it is necessary to touch injector terminal or inside engine controller, contact your HYUNDAI distributor.*

Operator Protective Guards and Structures (Optional)

The machine may have different types of guards for operator protection. the type of guards might be vary on the applications and work demands.

Inspect and check the guards daily to ensure no cracks, bent or loose. DO NOT modify the protective structure, guards by welding, grinding, drilling holes or adding attachments. Changes to the cabin can cause loss of operator protection from roll-over and falling objects, and result in death or serious injury.

Always wear your seat belt when operating machine.

Logging operation required the protection from flying debris and / or objects. When use a work tool create flying debris, install a front guard. Close the window and wear safety goggles.

Protecting Cabin from Flying or Falling Objects (Optional)

In a work site where additional operator protection is necessary from falling or flying objects, install adequate protective guards on the cabin.

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

When performing demolition or cutting operation, install a front guard and top guard.

Apply a protective laminated coating sheet to outside of front window. This will prevent glass from being scratched by dust when cleaning it or running wipers.

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 system requires a complete inspection of the structure. Reinstallation, recertification and/or replacement of system may be necessary.

Contact your HYUNDAI distributor for available safety guards and/or recommendations to protect against objects that could strike operator's cabin. Make sure that all other work site crew members are kept away from machine when operating.

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

NOTE: *The preceding instructions assume that conditions are for standard operations, but it may be necessary to add additional guards depending on operating conditions or local rules or regulations for the work site. Always contact your HYUNDAI distributor for advice.*

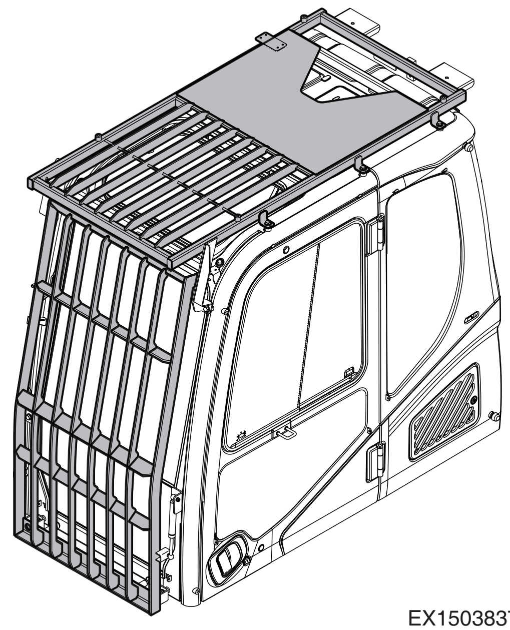


Figure 15

Emergency Exit from Operator's Station

This machine is equipped with a glass breaking tool. It is found on left pillar of cabin. This tool can be used to break the glass to exit from cabin in an emergency. Grip handle firmly and use sharp point to break glass.

- Be careful also not to slip on broken pieces of glass on ground.

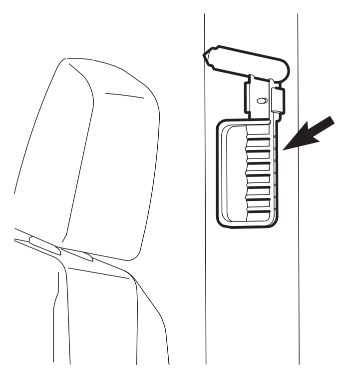


Figure 16

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Protect your eyes when breaking the glass.

TRANSPORTATION

Obey State and Local Over-the-Road Regulations

Check federal, state and local laws and regulations regarding weight, width and length of a load before making preparations for transporting on public roads or highways.

The hauling vehicle, trailer and load must be in compliance with applicable regulations for the shipping route.

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

Refer to Operation & Maintenance Manual, for information on loading, unloading and towing.

The machine can be disassembled into parts for transporting. Contact your HYUNDAI distributor for assistance with disassembly.

Loading and Unloading

To prevent machine tipping or roll-over when loading or unloading machine, always do the following:

- Perform loading and unloading only on firm and level ground. Maintain a safe distance from edge of road or drop-off.
- Never use work equipment to load or unload machine. The machine may fall or tip over.
- Always use loading ramps of adequate strength and capacity. Be sure that ramps are wide, and long enough to provide a safe loading slope. Take steps to prevent ramps from moving out of position or coming off.
- Clean ramp surfaces so they are free of grease, oil, ice and loose materials. Remove dirt from machine tracks and undercarriage. On a rainy day, be careful since ramp surfaces can be slippery.
- Turn auto idle switch "OFF".
- Run engine at low speed and travel slowly.
- When on ramps, do not operate any control lever except for travel lever.
- Never correct your steering on ramps. If necessary, drive off ramps, correct machine direction, then drive back onto ramps.
- When driving up or down ramps, the center of gravity of machine will change suddenly causing the tracks to drop down to the ramps or trailer. This will occur at the joint between the ramps and trailer. Travel slowly over this point.

- For machines equipped with a cabin, always lock door after loading machine to prevent door from suddenly opening during transportation.

Transporting Machine

When transporting machine on a trailer or truck, do the following:

- The weight, transportation height, and overall length of machine may change depending on work equipment attached to it. Always check the machine dimensions and work equipment's dimensions before transporting.
- When passing over bridges or structures on private land, check that structure is strong enough to support weight of machine. Before traveling on public roads, check with appropriate authorities and follow their instructions.

OPERATION

Always make sure that the machine is properly maintained.

Before Engine Starting

Machine Condition

Every day before starting engine for first time, perform the following checks and repair machine before operating, as necessary. If these checks are not properly done death or serious injury could result.

- Check coolant, fuel, and hydraulic tank oil levels, and check for clogged air cleaner and damage to electrical wiring.
- Check operation of gauges, cameras (if equipped) and angle of mirrors, and check that safety lever is in LOCKED position.
- Check that work equipment and travel controls move freely, and work controls return to "NEUTRAL" when released.
- Check that attachment is properly attached and locked.

IMPORTANT

Only use Ultra Low Sulfur Diesel (ULSD) fuel and API CJ-4/ ACEA E9 grade engine oil with this machine.

Make sure that the machine is equipped with a lighting system that is adequate for job conditions and lights are working properly.

Before moving machine, check position of undercarriage. The normal travel position is with idler wheels to front under cabin and drive sprockets to rear. When undercarriage is rotated in reversed position, directional or travel controls must be operated in opposite directions.

Before performing checks, move machine to an area where there are no obstructions, and operate slowly. Do not allow personnel near machine.

Know maximum operating dimensions of your machine.

Work Site

Before starting operations, thoroughly check work area for any hazards, such as underground utility lines, overhead electrical lines, unstable ground, excessive slopes, etc.

Before starting engine and moving machine, make sure that no one is underneath machine, around machine, or on machine.

Know width and length of your machine and work equipment to maintain proper clearance when you operate machine or work equipment near fences or near boundary obstacles.

Know appropriate work site hand signals and personnel that are authorized to give hand signals. Follow hand signals from only one person.

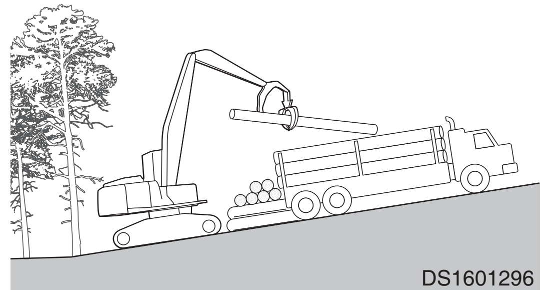


Figure 17

Mounting/Dismounting

Before getting on or off machine, if there is any oil, grease, or mud on handrails, guardrails, 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 machine. In particular, never get on or off a moving machine. These actions can result in death or serious injury.

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

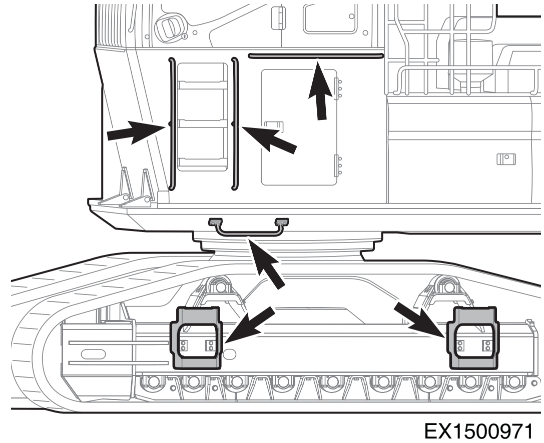


Figure 18

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

Securely latch door. If you grip handrail inside door when moving on top of track shoes, and door latch is not securely engaged, door may move and cause you to fall.

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

Do not carry tools or supplies when you mount or dismount the machine.

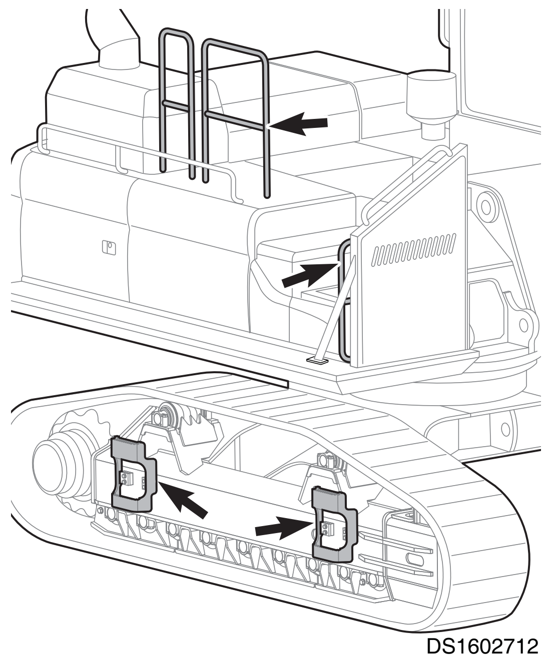


Figure 19

Cleaning

Remove all straw, wood chips, leaves, grass, paper and other flammable debris accumulated in engine compartment, mufflers and around battery. Remove any dirt from window glass, mirrors, handrails, and steps.

Do not leave tools or spare parts in operator's cabin. Vibration of machine during operation can cause tools or spare parts to fall and damage or break control levers or switches. Tools and spare parts can also get caught in spaces between control levers and cause accidental movement of work equipment causing death or serious injury.

When entering operator's cabin, always remove all mud and oil from your shoes. If you operate travel pedal with mud or oil stuck to your shoes, your foot could slip off the control, or dirt and debris may interfere with proper operation of control levers.

After using ashtray, make sure that any matches or cigarettes are properly extinguished, and be sure to close ashtray.

Clean window glass and working lights for good visibility.

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

Never bring flammable or explosive items into operator's cabin. Do not leave cigarette lighters laying around operator's cabin. If temperature inside operator's cabin becomes too high, there is a potential hazard that lighter could explode.

Secure all loose items such as lunch boxes, and other items that are not a part of equipment.

Operator Station

Inspect condition of seat belt and mounting hardware. Replace any parts that are worn or damaged. Do not use a seat belt extension on a retractable seat belt.

Adjust seat so full pedal travel can be achieved with operator's back against back of seat.

Keep all windows and doors closed on machine.

Adjust operator's seat to a position where it is easy to perform operations, and check that there is no damage or excessive wear to seat belt or mounting clamps.

Adjust and clean mirrors so area to rear of machine can be seen clearly from operator's seat.

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

Seat Belt

Check seat belt daily for correct function.

Inspect seat belt system more often if machine is exposed to severe environmental conditions or applications. Conduct the following inspections and replace seat belt system as necessary:

1. Check webbing. If system is equipped with a retractor, pull webbing completely out and inspect full length of webbing. Look for cuts, wear, fraying, dirt and stiffness.
2. Check buckle and latch for correct operation.
3. Make sure latch plate is not excessively worn, deformed or buckle is not damaged or casing is broken.
4. Check retractor web storage device (if equipped) by extending webbing and checking that it spools out and retracts correctly.
5. Check webbing in areas exposed to ultraviolet (UV) rays from sun or extreme dust or dirt. If original color of webbing in these areas is extremely faded and/or webbing is packed with dirt, webbing strength may be reduced.

   NOTE: *Contact your HYUNDAI distributor for seat belt system replacement parts.*

WARNING

AVOID DEATH OR SERIOUS INJURY

Failure to properly inspect and maintain seat belt and seat belt system can cause lack of operator restraint and can result in death or serious injury.

Before fastening seat belt, check that there is no problem in belt mounting bracket. If it is worn or damaged, replace seat belt. Fasten seat belt so it is not twisted.

Always wear seat belt when operating machine.

Visibility Information

A rear/side view cameras (if equipped) and mirrors provide the operator with additional means to see the work area.

NOTE: *These devices may vary from one region to another, depending upon local and regional regulations. If a machine is moved or sold into another region or marketplace, it is the owner's responsibility to make sure it complies with all applicable regulations.*

WARNING

AVOID DEATH OR SERIOUS INJURY

Failure to check for and clear people from the surrounding area of a machine can result in death or serious injury. The operator should make sure that visual aids (mirrors and camera(s)) are in proper working condition.

Your machine may be equipped with visual aids such as mirrors or a rear view camera. Even with these aids, there still may be areas around the machine which cannot be seen from the operator's seat. Always keep personnel and bystanders out of the work area. Be careful when operating and always look in direction of travel.

Adjust visual aids for best visibility around machine.

When swinging work equipment or backing up, press camera button (if equipped) to change display mode on display monitor so you can check rear and side of machine.

Before moving machine, look around work site and use mirrors and display monitor to confirm that no one is in the work area.

While operating or traveling in places with poor visibility it may be impossible to confirm condition of work site. Inspect and remove any obstacles around the machine that could be damaged and keep other personnel out of the work area.

Inspect equipment and repair immediately if there are problems with visual aids. If machine cannot be fixed immediately, DO NOT use the machine. Contact your HYUNDAI distributor and arrange for repairs.

Work Site Rules

- If visibility cannot be sufficiently assured, use a flagman. The operator should pay careful attention to signals and follow instructions from flagman.
- Signals should only be given by one flagman.
- When working in dark places, turn "ON" work lights and front lights on the machine. Set up additional lighting in area.
- Stop operations if there is poor visibility, such as fog, snow, rain, or sandstorms.
- Check mirrors and rear/side view cameras (if equipped) on machine before starting operations. Clean off any dirt and adjust view for good visibility.

When operating or traveling during poor visibility conditions, follow the preceding work site rules.

It may not be possible to adjust all visual aids to see all the way around the machine. Therefore, additional precautions such as flagman, barricades, etc., must be taken to keep other personnel out of the work area.

Boost Starting or Charging Engine Batteries

Follow these instructions to prevent an explosion or fire when connecting booster cables to batteries:

- Turn "OFF" all electric equipment before connecting leads to battery. This includes electric switches on battery charger or battery booster equipment.
- When boost starting from another machine or vehicle do not allow two machines to touch. Wear safety goggles and gloves while battery connections are made.
- 24 volt battery units consisting of two series connected 12 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 metal frame of the machine being boosted or charged. The final booster cable connection, at metal frame of the machine being charged or boost started, must be as far away from the batteries as possible. Refer to Operation & Maintenance Manual.
- Connect positive (+) cable first when installing cables and disconnect negative (-) cable first when removing them.

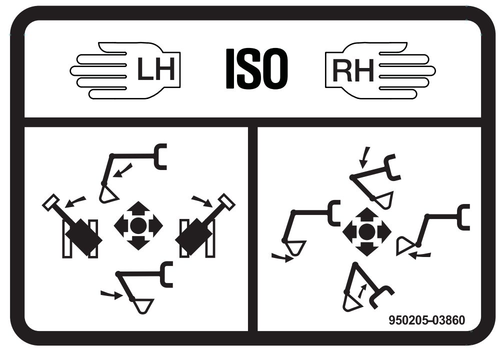
Starting Engine

Only operate the machine from the operator's seat with your seat belt fastened.

Only operate controls while engine is running.

Check for proper operation of all controls and all protective devices while you operate the machine slowly in an open area.

- Read and understand control pattern before operating. Check that movement of the machine matches display on control pattern label. If it does not match, replace it immediately with correct control pattern label.
- Check operation of work equipment, travel system and swing system.
- Check for any problem with machine. Check for unusual sounds, vibration, heat, odor, or improper readings from gauges. Check for any oil or fuel leaks.
- If any problem is found, stop operation and perform repairs immediately.



EX1301191

Figure 20

Do not use cellular telephones inside operator's cabin when driving or operating the machine.

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

The boom and arm linkage can allow work tool or attachment to contact undercarriage or cabin. Be aware of position of work tool.

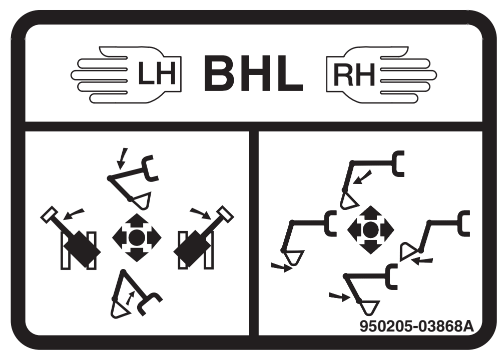
- Do not attempt to start engine by short-circuiting engine starting circuit. This can result in death or serious injury, or fire.
- When starting engine, sound horn as a warning to alert personnel in the work area.

If there is a warning tag or "DO NOT OPERATE" tag hanging from work levers (joysticks) or travel control levers, do not start engine or move levers.

- Prevent personnel from walking or standing under raised boom, unless it is properly supported.

NOTE: *When starting engine in cold temperatures, "white engine exhaust smoke" from the tail pipe can occur until engine reaches normal operating temperatures.*

Also, a white residue, because of water vapor inside engine, can form at the engine oil fill location. These conditions will not affect engine performance or damage the engine or other exhaust system components.



EX1503819

Figure 21

Swinging or Traveling

As a machine operator, you should know and follow local, state and federal laws and regulations when operating on public roads or highways.

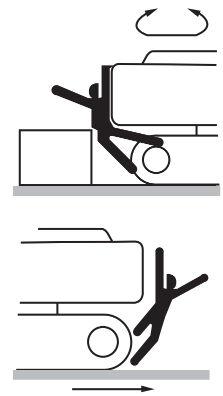
It is important to keep in mind that the machine, in comparison with the rest of traffic, is a slow moving and wide vehicle which can cause traffic delays. Pay attention to traffic behind you and allow traffic to pass you.

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

- When changing travel direction from forward to reverse or from reverse to forward, reduce speed and stop machine before changing travel direction.
- Sound horn to alert people in area.
- Check that there is no one in area around machine. There are restricted visibility areas behind machine so, if necessary, swing upper structure slowly to check that there is no one behind machine before traveling in reverse.
- When operating in areas with poor visibility, designate a flagman to direct work site traffic.
- Keep unauthorized personnel away from turning radius or travel path of the machine.

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

- Check that travel alarm works properly and that mirrors are clean, not damaged and properly adjusted.
- Always latch door and windows of operator's cabin in position (open or closed).
- On work sites where there is a hazard of flying or falling objects, or of objects entering operator's cabin, check that door and windows are securely closed. Install additional guards, if work site application requires them.



EX1400131

Figure 22

Never turn starter switch to "O" (OFF) position when traveling. This can lead to a loss of steering control.

Do not operate attachments while traveling.

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

Never travel over obstacles or excessive slopes that will cause machine to tilt severely. Avoid any slope or obstacle that can cause machine to tilt 10° or more to right or left, or 30° or more from front to rear.

Do not operate steering controls suddenly. Work equipment can hit ground and this can damage machine or structures in area.

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

Always operate within permissible water depth. Permissible water depth is up to centerline of upper track roller(s).

When passing over bridges or structures on private land, check that structure is strong enough to support weight of machine. Before traveling on public roads, check with appropriate authorities and follow their instructions.

Never exceed maximum permitted load for bridges.

Always operate machine with idler wheels to front under cabin and drive sprockets to rear.

Know permitted ground pressure. Ground pressure of the machine may change depending on attachment and load.

Keep height and length of attachment in mind.

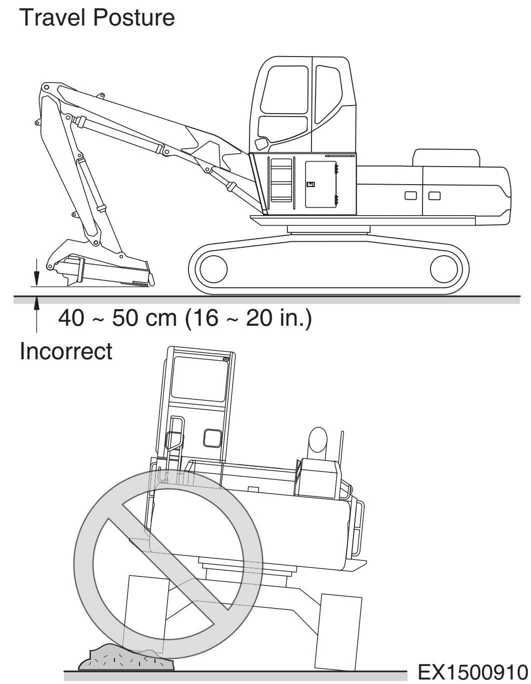


Figure 23

Lifting and Logging

The operator is responsible for any load carried when traveling on public roads and while working with the machine.

- Keep loads secure so they do not fall off while operating.
- Do not exceed maximum load for the machine. Machine operation will be affected when center of gravity changes, caused by extended loads and different attachments.

To lift loads safely the following must be evaluated by the operator and work site crew.

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

Always watch load. Bring load close to the machine before traveling any distances or swinging load. Logs must be held securely within the grapple. Do not pinch with the grapple tines. It would lead to loss of control and dropped loads.

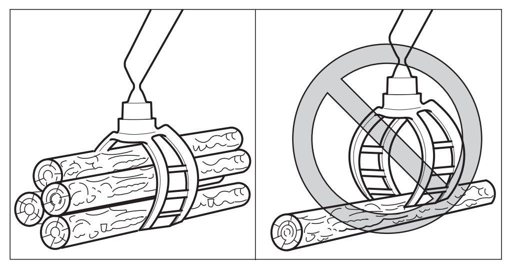
Lifting capacity decreases as load is moved further from the machine.

Set tracks at right angles to road shoulder or drop-off with sprocket at rear when performing operations to make it easier to move away from the work area.

Lifting and handling loads over the front and rear, rather than either side, has better stability of the machine.

Do not suddenly lower, swing, or stop work equipment. Haste can cause loss of stability and control. If tracks leave the ground, immediately lower the load and return the machine slowly to the ground.

- Do not move work tool over head of other personnel or over the operator's seat of dump trucks or other hauling equipment. The load may spill or work tool can hit dump truck causing property damage or cause death or serious injury.



EX1300849

Figure 24

Operation on Slopes

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

Improper traveling on steep slopes could result in machine tipping, roll-over or sliding down the slope. Always fasten your seat belt.

When possible, operate machine up slopes and down slopes. Avoid operating machine across slope.

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

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

Do not change travel direction on a slope. This could result in tipping or sliding sideways of machine.

Improper operation when working on slopes can cause a tip over. Use caution when swinging or operating work equipment on slopes.

Do not swing work equipment from uphill side to downhill side when work tool is loaded. This could cause machine to tip or roll-over.

In addition, lower work tool as far as possible, keep it pulled into front, and keep swing speed as slow as possible.

On slope, locate the drive sprockets downward the slope. Head the heaviest side of the machine uphill, as possible.

DO NOT mount a wire cable.

If the machine begins to slide down on a grade, immediately dump load and turn the machine downhill.

Be careful to avoid any ground condition which could cause the machine to tip. Tipping can occur when you work on hills, on banks, or on slopes. Tipping can also occur when you cross ditches, ridges, or travel over unexpected obstructions.

Keep the machine under control. Do not overload the machine beyond capacity.

- When traveling up a steep slope, extend work equipment to front to improve balance, keep work equipment approximately 20 ~ 30 cm (8 ~ 12 in) above ground, and travel at low speed.
- Do not turn on slopes or travel across slopes. Always go down to a flat place to change position of the machine, then travel backup the slope again.

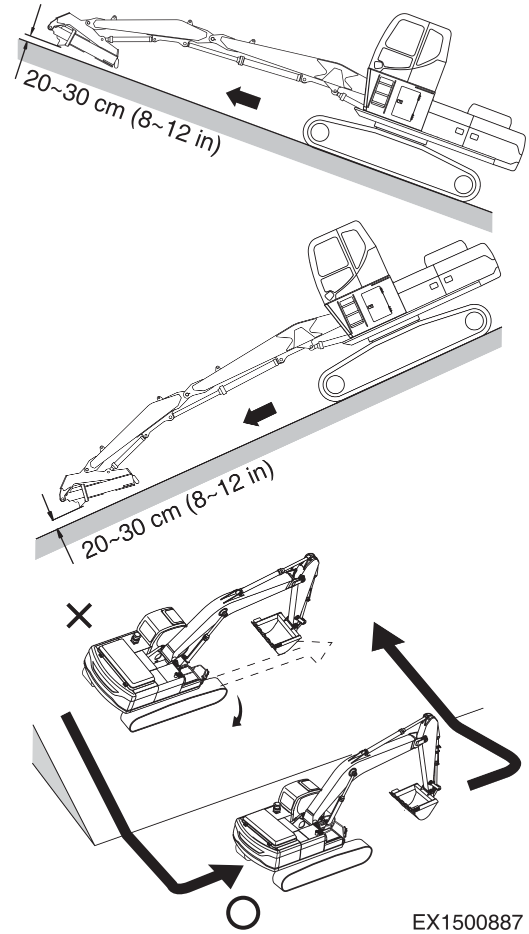


Figure 25

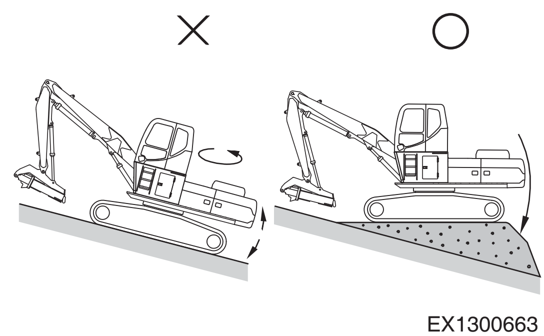


Figure 26

Towing

To prevent death or serious injury when towing, always do the following:

- Follow the instruction given in this manual.
- When performing preparation work for towing with two or more personnel, determine signals to use and correctly follow these signals.
- Always attach wire rope onto left and right hooks and secure in position.
- If engine on problem machine will not start or there is a failure in brake system, always contact your HYUNDAI distributor.
- Never go between towing machine and towed machine during towing operation.
- Do not perform towing on steep slopes, so select a place where slope is gradual. If there is no place where slope is gradual, perform operations to reduce angle of slope before starting towing operation.
- When towing a machine, always use a wire rope with a sufficient towing capacity.
- Do not use a wire rope that is kinked or frayed, or a wire rope with any loss of diameter. Wear leather gloves when handling a wire rope.
- Do not use lightweight towing hook for towing another machine.
- Make sure that towing eyes and towing devices are adequate for towing loads.
- Only connect wire rope to a drawbar or to a hitch.
- Operate the machine slowly and be careful not to apply any sudden load to wire rope.

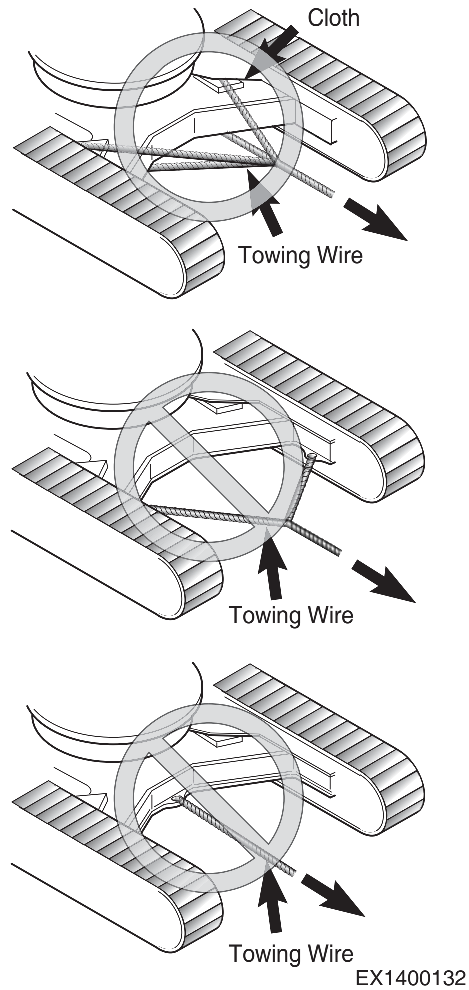


Figure 27

Attachment

Never let anyone ride on any work attachment, such as bucket, crusher, grapple, or clamshell (grab bucket). This creates a falling and crushing hazard, and can result in death or serious injury.

The clamshell, grapple, or magnet can swing in all directions. Move work levers (joysticks) in a continuous motion. Failure to move work levers (joysticks) in a continuous motion can cause clamshell, grapple, or magnet to swing into cabin or into a person in work area. This can result in death or serious injury.

- When using a fork or grapple, do not attempt to pick up an object with its tips. This could damage the machine or cause personal injury, if picked-up object slips off attachment.
- Do not use impact force of work equipment for demolition work. This could damage work equipment, cause broken materials to fly off or tipping. This could result in death or serious injury.
- Do not use work equipment or swing mechanism to pull load in any direction. This could cause the work equipment to move suddenly if the load releases and can result in death or serious injury.


EX1400133

Figure 28

Equipment Lowering with Engine Stopped

Before lowering any equipment with the engine stopped, clear the area around the equipment of all personnel and bystanders. The procedure to use will vary with the type of equipment to be lowered. Keep in mind most systems use a high-pressure fluid or air to raise or lower equipment. The procedure can cause high-pressure air, or hydraulic pressure, or some other media to be released to lower the equipment.

Wear appropriate personal protective equipment and follow the established procedure in the Operation Section of the manual.

Engine Stop

Turn engine starter switch to "O" (OFF) position and remove engine starter switch key.

Before lowering any equipment with engine stopped, clear area around equipment of all personnel and bystanders. This procedure will cause high-pressure air or hydraulic pressure to be released to lower equipment.

Do not stop engine immediately after the machine has been operated under load. This can cause overheating and accelerated wear of engine components.

After the machine is parked, allow engine to run for five minutes before stopping the engine. This allows hot areas of engine to cool gradually.

- Do not leave operator's seat when there is a raised load.

Parking Machine

Avoid making sudden stops, or parking machine wherever it happens to be at end of workday. Park machine on firm and level ground away from traffic and away from high walls, drop-offs and any area of potential water accumulation or runoff. If parking on inclines is unavoidable, block crawler tracks to prevent movement. Lower other working attachment completely to ground, or to an overnight support saddle. To prevent 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 machine clearly. Park machine so machine, flags, signs and fences do not obstruct traffic.

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

Always close door of operator's cabin and lock all equipment to prevent any unauthorized person from operating the machine.

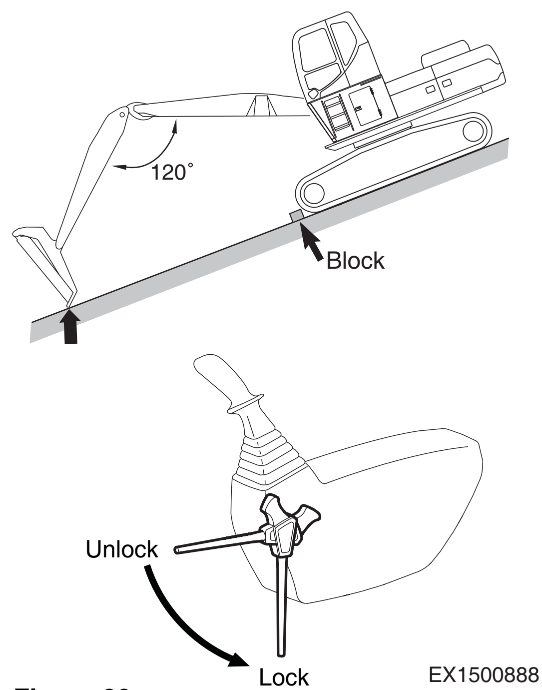


Figure 29

The hydraulic system remains pressurized, provided accumulator, is charged even when engine is not running. Accumulator pressure should decrease in a short time (approximately one minute). While hydraulic system maintains a charge, hydraulic work tools and machine controls remain functional.

Machine movement will occur if any controls are moved. This can result in death or serious injury.

Always move safety lever to "LOCK" position before stopping off engine or immediately after engine stops running.

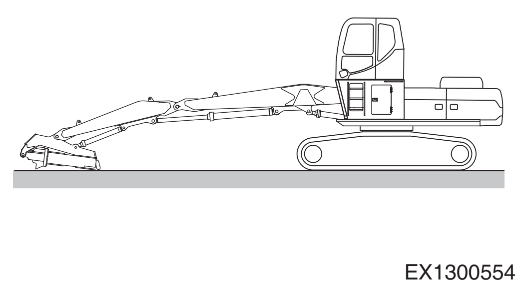


Figure 30

Preservation/Storing Machine

Perform the following if storing machine for more than one month.

Conditions	Maintenance Required
Cleaning	Pressure wash undercarriage and track assemblies. Inspect for damage or loose or missing parts.
Lubrication	Perform all daily lubrication procedures.
	Apply a coating of light oil to exposed plated metal surfaces, such as hydraulic cylinder rods, etc.
	Apply a coating of light oil to all control linkages and control cylinders (control valve spools, etc.)
Battery	Turn "OFF" the battery disconnect switch.
Cooling System	Inspect coolant recovery tank to make sure that antifreeze level in system is at correct level.
	Every 90 days, use a hydrometer to measure protection level of coolant. Refer to Operation & Maintenance Manual, to determine amount of protection cooling system requires. Add coolant as required.
Hydraulic System	Once a month, start engine and follow procedures in Operation & Maintenance Manual.

1. Complete the preceding steps.
2. Wash machine and touch up paint finish to avoid rusting.
3. Treat exposed parts with antirust agent, lubricate machine thoroughly and apply grease to unpainted surfaces like lifting and tilting cylinders etc.
4. Fill fuel tank and hydraulic oil tank to "FULL" marks.
5. Cover exhaust pipe (parking outside).
6. Make sure that coolant is at proper concentration for expected lowest temperatures.
7. Park machine on level, firm ground where there is no risk of freezing, landslide or flooding. Avoid parking machine on a slope.

   Keep in mind that theft and burglary risk can be minimized by:

   - Removing starter key when the machine is left unattended.
   - Locking doors and covers after working hours.
   - Turning off electrical current with battery disconnect switch.
   - Park machine where risk of theft, burglary and damage is minimized.
   - Removing valuables from cabin such as cellular phone, computer, radio and bags.

See Operation & Maintenance Manual, for more information.

Check After Long-term Parking

- All oil and fluid levels.
- Tension of all belts.
- Air pressure.
- Air cleaner.
- Batteries and electrical connections.
- Lubricate all greasing points.
- Wipe off grease from piston rods.
- Inspect for signs of nests (i.e. birds, rodents, etc.)
- Inspect safety labels (decals). Replace if damaged, worn, or missing.

MAINTENANCE

Improper operation and maintenance can result in death or serious injury. Read manual and safety decals before operating or maintaining the machine. Follow all instructions and safety messages.

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Follow instructions before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments, repairs or service. Untrained operators and failure to follow instructions can result in death or serious injury.

- Never service HYUNDAI equipment without instructions.
- Always lower bucket and blade to ground before doing any maintenance.
- Use correct procedure to lift and support machine.
- Cleaning and maintenance are required daily.
- Welding or grinding painted parts must be done in well ventilated areas.
- Wear a dust mask when grinding painted parts. Toxic dust and gas can be produced.
- Vent exhaust to outside when engine must be running for service.
- Exhaust system must be tightly sealed. Exhaust fumes are hazardous and can cause death or serious injury.
- Stop and allow engine to cool and clean engine of flammable materials before checking fluids.
- Never service or adjust machine with engine running unless instructed to do so in this manual.
- Avoid contact with leaking hydraulic fluid or diesel fuel under pressure. It can penetrate skin or eyes.
- Never fill fuel tank while engine running, while smoking, or when near open flame.
- Keep body, jewelry and clothing away from moving parts, electrical contact, hot parts and exhaust.
- Wear eye protection to guard from battery acid, compressed springs, fluids under pressure and flying debris when engines are running or tools are used. Use eye protection approved for welding.

- Lead-acid batteries produce flammable and explosive gases.
- Keep arcs, sparks, flames and lighted tobacco away from batteries.
- Batteries contain acid which burns eyes or skin on contact.
- Wear protective clothing. If acid contacts body, flush well with water. For eye contact flush well and get immediate medical attention from a physician familiar with this injury.
- The maintenance procedures which are given in this manual can be performed by the owner or operator without any specific technical training. Maintenance procedures which are not in this manual must be performed ONLY BY QUALIFIED SERVICE PERSONNEL. Always use genuine HYUNDAI replacement parts.
- Only authorized personnel should service and repair the machine. Do not allow unauthorized personnel into work area.
- Lower work equipment and stop engine before performing maintenance.
- Park machine on firm and level ground.
- Turn starter switch to "ON' position and keep safety lever in "UNLOCK" position. Cycle work levers (joysticks) back and forth, left and right at full stroke 2 to 3 times to eliminate remaining internal pressure in hydraulic circuit.
  Then move safety lever to "LOCK" position.
- Check that battery relay is "OFF" and main power is shut off. (Wait for approximately one minute after turning "OFF" engine starter switch key and press horn switch. If horn does not sound, the main power is shut off.)
- Put blocks under track to prevent the machine from moving.
- To prevent injury, do not perform maintenance with engine running. If maintenance must be done with engine running, perform maintenance with at least two workers and do the following:
  - One worker must always sit in the operator's seat and be ready to stop engine at any time. All workers must maintain contact with other workers.
  - When maintenance operations are near fan, fan belt, or other rotating parts, there is a potential hazard of being caught in rotating parts. Keep hands and tools away.
- Never drop or insert tools or other objects into rotating fan or fan belt. Parts can break off and hit someone.
- Do not touch any control levers or control pedals. If any control levers or control pedals must be operated, always give a signal to other workers and instruct them to move away.

- When performing maintenance of engine and you are exposed to engine noise for long periods of time, wear hearing protection while working.
- If noise from the machine is too loud, it can cause temporary or permanent hearing problems.
- Do not smoke when you service an air conditioner or if refrigerant gas is present.
- Inhaling fumes either from a flame or gas from a cigarette that has contacted air conditioner refrigerant can cause death or serious injury.
- Never put maintenance fluids into glass containers.
  Drain all liquids into a suitable containers.
- Unless instructed otherwise, perform maintenance with equipment in servicing position. Refer to this manual for procedure for placing equipment in servicing position.

Warning Tag

Alert others that service or maintenance is being performed by attaching a "DO NOT OPERATE" warning tag to the operator's cabin controls – and other machine areas, if required. Use of a chain or cable to keep the safety lever in the fully lowered "LOCK" position, complies with OSHA's lockout requirements.

"DO NOT OPERATE" warning tags, are available from your HYUNDAI distributor.

- Always attach "DO NOT OPERATE" warning tag to work equipment control lever in the operator's cabin to alert others that you are performing service or maintenance on the machine. Attach additional warning tags on the machine, if necessary.
- Keep warning tags in tool box while it is not used. If there is not tool box or in the owner manual storage pocket.
- If any other person starts engine, and operates control levers or control pedals while you are performing service or maintenance, it can result in death or serious injury.

Attach a "DO NOT OPERATE" warning tag to starter switch or to controls before servicing or repairing equipment.
Warning tags are available from your HYUNDAI distributor.

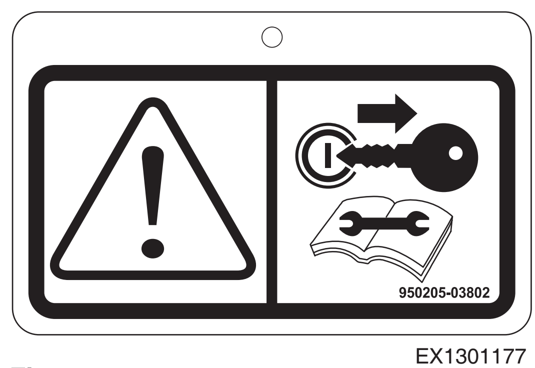


Figure 31

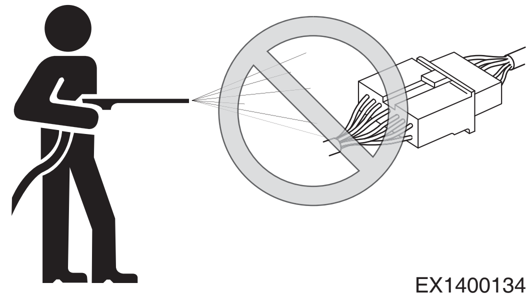
Cleaning

Clean machine before performing inspection and maintenance.

If inspection and maintenance are done when machine is dirty, it will become more difficult to locate problems, and you could slip on steps and work platform areas and injure yourself.

When washing machine, do the following:

- Wear shoes with nonslip soles to prevent slipping and falling.
- Wear safety goggles and protective clothing when washing machine with high-pressure steam or water.
- Do not spray water directly on electrical components (sensors, connectors). If water gets into electrical system, it can cause operation problems.
- Pick up any tools or hammers that are laying in workplace. Wipe up any grease or oil to prevent slippery substances, that can cause tripping or slipping.
- When cleaning cabin top window which is made of polycarbonate material, use tap water. Avoid use of organic solvents for cleaning, such as benzene, toluene or methanol. These solvents can cause a chemical reaction that will dissolve and damage the window.



EX1400134

Figure 32

Proper Tools and Clothing

Only use tools that are intended for the type of service to be done. Metal pieces from low quality or damaged tools, such as chisels or hammers, can break off and hit a service person in the eyes or face causing serious injury.

Disassembling Precautions

When using a hammer to remove pins, pins can fly out or metal particles may break off. Always do the following:

- Hitting hard metal pins or bearings with a hammer, can cause metal pieces to break or fly off resulting in serious injury. Always wear safety goggles and leather gloves. Keep other personnel away.

Use of Lighting

When checking fuel, oil, battery electrolyte, window washer fluid, or coolant, always use proper lighting equipment to prevent arcs or sparks that could cause a fire or explosion resulting in death or serious injury.

Fire and Explosion Prevention

Fuels, most lubricants and some coolant mixtures are flammable. Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire resulting in property damage or death or serious injury.

Store all fuels and all lubricants in properly marked and approved containers and keep away from all unauthorized personnel.

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

Tighten all fuel and oil caps.

Do not smoke while you refuel 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 electrical wires daily for wires that are loose or frayed. Tighten all loose, and repair or replace all frayed, electrical wires before operating machine.

Remove all flammable materials and debris from the engine compartment, exhaust system components and hydraulic lines.

HDO1015I

Figure 33

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Figure 34

Burn Prevention

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

Using gloves, loosen radiator cap slowly to release internal pressure before removing radiator cap.

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

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

Allow cooling system components to cool before draining cooling system.

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

Vent hydraulic tank only after engine has been stopped and hydraulic tank is cool. Using gloves, slowly tilt hydraulic tank air breather to relieve pressure.

Relieve all pressure in hydraulic oil system, in fuel system, or in cooling system before disconnecting any lines, hoses, fittings, or related components.

Batteries give off flammable fumes that can explode and start a fire.

Do not smoke while you are checking battery electrolyte level.

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

Always wear safety goggles and face protection when working with batteries.

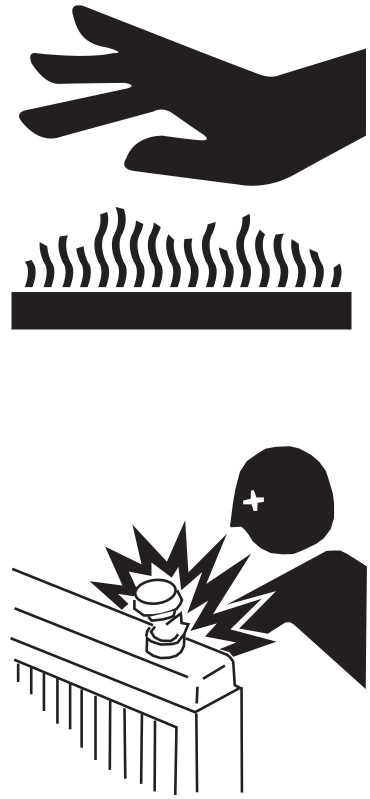

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Figure 35

Rubber That Contains Fluorides

Observe extra great care when it is suspected that you may have to handle rubber that contains fluorides.

Certain seals which have to withstand high operating temperatures (e.g. in engines, transmissions, axles, hydraulic motors and pumps) may be made from rubber that contains fluorides, which, when exposed to high heat (fire), forms hydrogen fluoride and hydrofluoric acid. This acid is very corrosive and cannot be rinsed or washed off from the skin. It causes very severe burns which take a long time to heal.

It usually means that damaged tissue must be surgically removed. Several hours may pass after contact with the acid, before any symptoms appear and therefore one is not given any immediate warning. The acid may remain on the machine parts for several years after a fire.

If swelling, redness or a stinging feeling appears and one suspects that cause may be contact with heated rubber that contains fluorides, contact a medical doctor immediately. If a machine, or part of a machine, has been exposed to fire or severe heat, it must be handled by specially trained personnel. In all handling of machines after a fire, thick rubber gloves and protective goggles must be used.

The area around a part which has been very hot and which may be made of rubber that contains fluorides must be decontaminated by thorough and ample washing with limewater (a solution or suspension of calcium hydroxide, i.e. slaked lime in water). After the work has been completed, the gloves must be washed in limewater and then discarded.

Rubber and Plastics

Polymer materials when heated, can form compounds that create a health hazard and can harm the environment. Scrapped rubber and plastics must never be burned. Extra precautions must be taken when servicing machines that have been in a fire or exposed to extreme heat.

If gas cutting or welding is to be done near such materials, the following safety instructions must be followed:

- Protect the material from heat.
- Use protective gloves, protective goggles and an approved respirator.

Waste Hazardous to the Environment

Painted parts or parts made of plastic or rubber which are to be scrapped must never be burned, but must be taken care of by an approved refuse handling plant.

Batteries, plastic objects and anything else which is suspected of being dangerous to the environment must be taken care of in an environmentally safe way.

Check List After Fire

When handling a machine which has been damaged by fire or been exposed to intense heat, the following protective measures must under all circumstances be followed:

Use thick, gloves made of rubber and wear goggles which are certain to protect your eyes.

Never touch burned components with your bare hands, as there is a risk that you may come into contact with melted polymer materials. First wash thoroughly with plenty of limewater (a solution or suspension of calcium hydroxide, i.e. slaked lime in water).

As a precaution, seals (O-rings and other oil seals) should always be handled as if they were made of rubber that contains fluorides.

Treat skin, which is suspected of having touched burned rubber that contains fluorides, with Hydrofluoric Acid Burn Jelly or something similar. Seek medical advice. Symptom may not appear until several hours afterwards.

Discard gloves, rags etc. which are suspected of having touched burned rubber that contains fluorides.

Welding Repairs

IMPORTANT

When disconnecting or connecting connectors between ECU/DCU and engine, or connector between ECU/DCU and the machine, always disconnect the battery to prevent damage to ECU/DCU.

If you do not follow this procedure, the ECU/DCU will be damaged and/or the engine will not operate properly.

When performing welding repairs, perform welding in a properly equipped place. Repairs must be performed by a qualified welder. Welding operations, can create potential hazards, including generation of gas, fire, or electric shock. Never let an unqualified welder do welding.

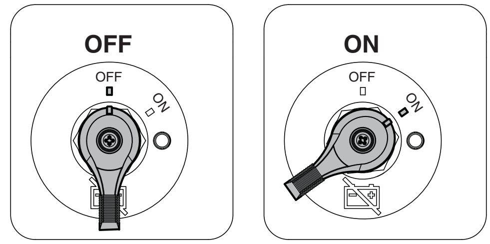
A qualified welder must do the following:

- To prevent battery explosion, turn battery disconnect switch to "OFF" position.
- Disconnect the connector between ECU/DCU and machine, and the connector between ECU/DCU and engine.
- Disconnect the negative (-) cable of battery.
- To prevent generation of gas, remove paint from location of the weld.
- If hydraulic equipment, piping or component ports close to them are heated, a flammable gas or mist could result in an explosion or fire. To prevent this, protect and insulate components from excessive heat.
- Do not weld on pipes or on tubes that contain flammable fluids. Do not flame cut pipes or tubes that contain flammable fluids. Before welding on pipes or tubes, or before flaming cut pipes or tubes, clean them thoroughly with a nonflammable solvent. Make sure pressure inside pipes or tubes does not cause a rupture of the component parts.
- If heat is applied directly to rubber hoses or piping under pressure, they may suddenly break, so cover and insulate them with a fireproof covering.
- Wear protective clothing.
- Make sure there is good ventilation.
- Remove all flammable objects and make sure a fire extinguisher is available.

Preparation for Electrical Welding on Body Structure

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

1. Turn battery disconnect switch to "OFF" position.
2. Disconnect the connector between ECU/DCU and machine, and the connector between ECU/DCU and engine.
3. Disconnect the negative (-) cable of battery.
4. Proceed with welding.
5. After welding, connect the connector between ECU/DCU and machine, and the connector between ECU/DCU and engine.
6. Connect the negative (-) cable of battery.
7. Clean battery compartment.
8. Turn battery disconnect switch to "ON" position.
9. Close battery compartment door.



EX1500481

Figure 36

Warning for Counterweight and Front Attachment Removal

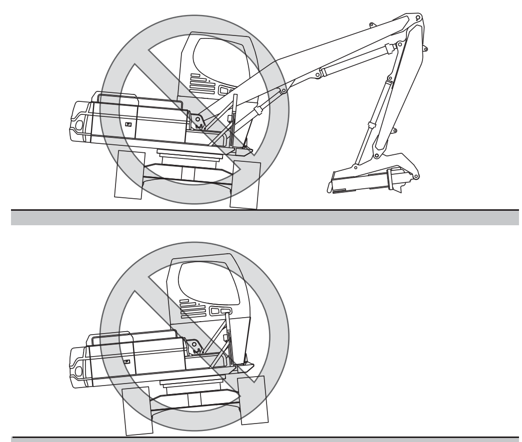
WARNING

AVOID DEATH OR SERIOUS INJURY

Removal of the machine counterweight, front attachment or any other part can affect the stability of the machine. This could cause unexpected movement, and result in death or serious injury.

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.



EX1500889

Figure 37

Lock Inspection Covers

When performing maintenance with inspection cover open, use lock bar to secure cover and prevent accidental lowering of the cover caused by wind or movement of the machine.

Working on Machine

When performing maintenance operations on machine, prevent tripping and falling by keeping area around your feet clean and free of objects and debris. Always do the following:

- Do not spill oil or grease.
- Do not leave tools laying around.
- Watch your step when walking.
- Never jump down from machine. When getting on or off machine, use steps and handrails, and maintain a three-point contact (both feet and one hand or both hands and one foot) to support yourself.
- If job requires it, wear protective clothing.
- To prevent injury from slipping or falling, when working on hood or covers, never stand or walk on areas except areas equipped with nonslip pads.
- If it is necessary to work under raised equipment or the machine, support work equipment and machine securely with blocks and stands strong enough to support weight of work equipment and machine.
- Do not work under the machine if track shoes are lifted off ground and the machine is supported only with work equipment. If any control levers are moved, or there is damage to hydraulic system, work equipment or the machine will suddenly drop causing death or serious injury.

Figure 38

Accumulator

The pilot control system is equipped with an accumulator. For a short period of time after engine has been stopped, accumulator will store a pressure charge that allow hydraulic controls to be activated. Activation of any controls will allow selected functions to operate under force of gravity.

When performing maintenance on pilot control system, release hydraulic pressure in system as described in Operation & Maintenance Manual.

The accumulator is charged with high-pressure nitrogen gas. If it is improperly handled it can explode causing death or serious injury. Always observe the following precautions:

- Do not drill or punch holes in accumulator or expose it to any flames, fire or external heat source.
- Do not weld on accumulator.
- When performing disassembly or maintenance of accumulator, or when disposing of accumulator, charged nitrogen gas must be properly released. Contact your HYUNDAI distributor for assistance.
- Wear safety goggles and leather gloves when working on an accumulator. Hydraulic oil under pressure can penetrate skin and result in death or serious injury. If fluid enters skin or eyes, get immediate medical attention from a physician familiar with this injury.

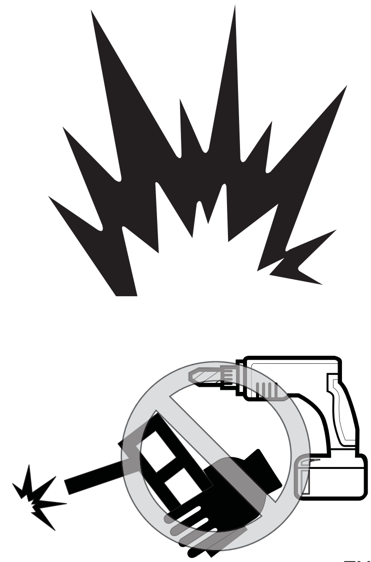


Figure 39

Compressed Air

- When cleaning filters, radiator or other components with compressed air, there is a hazard of flying particles that can result in serious injury.
- Always wear safety goggles, dust mask, leather gloves, and other protective devices.

Track Tension Adjustments

Track adjusting systems use grease under high-pressure to keep track under tension. Grease under high-pressure can penetrate body and result in death or serious injury. Watch track or track spring to see if track is being loosened.

NEVER LOOSEN track tension grease valve. To release pressure from crawler frame track tension assembly, you should NEVER attempt to disassemble track adjuster or attempt to remove track tension grease valve assembly.

Keep your face and body away from grease valve. Refer to Operation & Maintenance Manual, for proper procedure in this manual or Shop Manual.

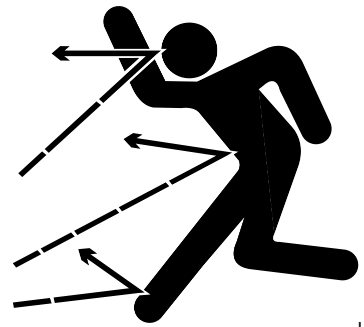

HAOA110L

Figure 40

Supports and Blocking for Work Equipment

Do not allow weight or equipment loads to remain suspended and unsupported.

Lower work group to ground before leaving operator's seat.

Do not use hollow, cracked or unsteady wobbling supports.

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

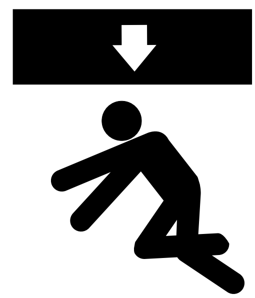

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Figure 41

High-pressure Lines, Tubes and Hoses

When inspecting or replacing high-pressure piping or hoses, check to verify that pressure has been released from circuit. Failure to release pressure can result in death or serious injury. Release pressure as described in Operation & Maintenance Manual.
Always do the following:

- Wear eye protection and leather gloves.
- Fluid leaks from hydraulic hoses or pressurized components can be difficult to see but has enough force to pierce skin and can result in death or serious injury. Always use a piece of wood or cardboard to check for suspected hydraulic leaks. Never use your hands or expose your fingers. Wear safety goggles.
- 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 correctly installed to prevent vibration, rubbing against other parts, and excessive heat during operation.
- Replace hose or components if any of the following problems are found:
  - Damage or leakage from hose end fitting.
  - Wear, damage, cutting of hose covering, or wire braiding is exposed on any hose.
  - Cover portion is swollen in any section.
  - The hose is twisted or crushed.
  - Foreign material is embedded in hose covering.
  - Hose end is deformed.
  - Connection fittings are damaged or leaking.

NOTE: *Refer to Operation & Maintenance Manual, for additional European regulations.*

High-pressure is generated inside engine fuel lines when engine is running. Before performing inspection or maintenance of fuel line system, wait for at least thirty seconds after stopping engine to let internal pressure drop and tip breather cap up to release residual pressure.

Oil or fuel leaks from high-pressure hoses can cause fire or improper operation, which can result in death or serious injury. If any loose bolts are found, stop work and tighten to specified torque. If any damaged hoses are found, stop operations immediately and contact your HYUNDAI distributor for replacement parts.

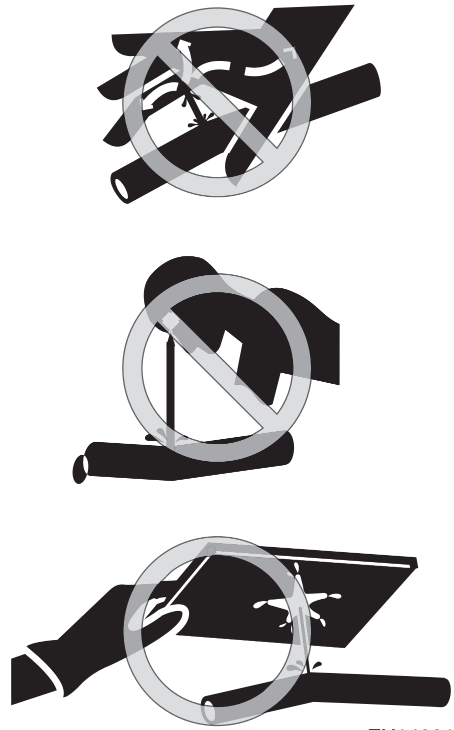

EX1400129

Figure 42

Battery

Battery Hazard Prevention

Battery electrolyte contains diluted sulfuric acid and generates hydrogen gas. Hydrogen gas is highly explosive, and improper handling can cause death or serious injury, or fire. Do not allow electrolyte to contact skin or eyes. Always wear safety goggles and protective clothing when servicing batteries. Wash hands after touching batteries and connectors. Use of acid-resistant gloves is recommended. Always observe the following precautions.

- Do not smoke or bring any flame near battery.
- When working with batteries, Always wear safety goggles, protective clothing, and acid-resistant gloves.
- If you spill battery electrolyte on yourself or your clothes, immediately flush area with water.
- If battery electrolyte gets into your eyes, flush them immediately with large quantities of water and get immediate medical attention from a physician familiar with this injury.
- If you accidentally drink battery electrolyte, call a poison prevention center immediately and get immediate medical attention from a physician familiar with this injury.
- When cleaning top surface of battery, wipe it with a clean, damp cloth. Never use gasoline, thinner, or any other organic solvent or detergent.
- Tighten battery caps.
- If battery electrolyte is frozen, do not charge battery or start engine with power from another source. This could cause the battery to explode and start a fire.
- When charging battery or starting with power from another source, let battery electrolyte thaw and check that there is no leakage of battery electrolyte before starting operation.
- Always remove battery from machine before charging.
- Do not use or charge battery if battery electrolyte level is below LOW LEVEL line. This can cause an explosion. Periodically check battery electrolyte level and add distilled water to bring electrolyte level to FULL LEVEL line.
- Before maintaining or working with batteries, turn starter switch to "O" (OFF) position.

EX1400136

Figure 43

Since there is a potential hazard that sparks could be generated, always do the following:

- Do not let tools, rings or other metal objects make any contact between battery terminals. Do not leave tools or other metal objects lying near battery.
- When disconnecting battery terminals, wait for approximately one minute after turning engine starter switch key to "O" (OFF) position, and be sure to disconnect grounding terminal; negative (-) terminal first. Conversely, when connecting them, begin with positive (+) terminal and then grounding (-) terminal, Make sure that all terminals are connected securely.
- Flammable hydrogen gas is generated when battery is charged. Remove battery from machine, take it to a well ventilated place, and remove battery caps, before charging it.
- After charging, tighten battery caps securely.
- After charging, secure battery back in machine.

When repairing or welding electrical system, wait for approximately one minute after turning engine starter switch key "OFF". Then disconnect negative (-) terminal of battery to stop flow of electricity.

ENVIRONMENT AND CIRCUMSTANCES

Work Site Areas Requiring Extra Caution

- Do not operate too close to edge of a quay, ramp, etc.
- Do not operate too close to edge of a steep slope or drop-off. Take care when working in a place where machine may tip over.
- Do not operate on soft ground or near riverbanks that could collapse or where ground may not support weight of machine.
- Observe changes in ground and traction conditions after a rain or other changes in weather.

Drop-off or Edge

When working at edge of a machine or near a drop-off, the machine could tip over, which can result in death or serious injury. Always fasten your seat belt. Check ground conditions of work site before operating to prevent the machine from falling or roll-over, and to prevent ground, stockpiles, or banks from collapsing.

Do not travel too close to edge of a drop-off.

Poor Visibility

For good visibility, always do the following:

- When working in dark areas, attach working lights and front lights to the machine. If necessary, set up additional lighting at work site.
- Stop operations when visibility is poor, such as in fog, mist, snow, and rain. Wait for visibility to improve before starting operation.

To avoid hitting work equipment and damaging other property, always do the following:

- When working in tunnels, on bridges, under electrical wires, or when parking the machine or performing other operations in places with limited height, be careful not to hit and damage other equipment or property.
- To prevent hitting objects, operate machine at a slow speed when working in confined spaces, indoors, or in crowded areas.
- Do not swing bucket over the top of personnel or over operator's cabin of truck.

Loose or Soft Ground

Do not operate on soft ground or near edge of drop-offs, overhangs, and deep ditches. The ground can collapse because of the weight of the machine causing the machine to fall or roll-over.

Check ground conditions before beginning work with the machine. If ground is soft, reposition the machine before operating.

Do not panic and do not raise work tool, if ground should begin to collapse. Lower work equipment to improve stability of machine.

High-voltage Cables

Do not travel or operate machine near electrical cables or overhead power lines. There is a hazard of electric shock, which can cause property damage and result in death or serious injury. The other attachment does not have to make physical contact with power lines for current to cause an electrocution.

Use a spotter and hand signals to stay away from power lines not clearly visible to operator. On work sites where machine may operate close to electrical cables, always do the following:

- Remember that electrical voltage determines what the minimum distance is to stay away from the power line. See the following table for minimum distances when working near electrical power lines. Electrical flashover can occur and damage machine and cause death or serious injury.

Voltage	Minimum 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")

- Always contact the power company responsible before beginning work near high voltage power lines.

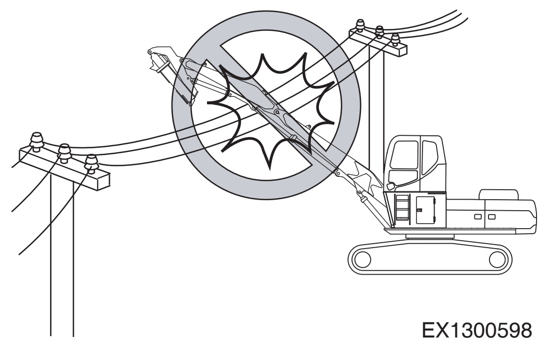


Figure 44

Working in Water

IMPORTANT

Do not exceed maximum permissible water depth. The water level must not reach higher than centerline of upper track roller(s) (1, Figure 45).

After working in water, lubricate all lubrication points on undercarriage, which have been underwater so water is removed. Check that no water has entered travel gearboxes and undercarriage components.

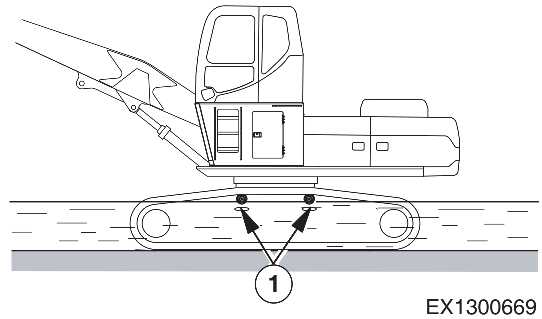


Figure 45

Working in Contaminated Environment

When working within area which is contaminated or where there is a health risk, check local regulations and contact your HYUNDAI distributor for assistance with identifying what additional safety precautions need to be taken.

Operation in Extreme Conditions

Operation In Extreme Cold

In extremely cold weather, avoid sudden travel movements and stay away from even slight slopes. The machine could slide down the slope.

Snow accumulation could hide potential hazards and slippery surfaces.

The jolting shocks and impact loads caused by bumping or bottoming boom or attachment could cause severe stress in very cold temperatures. Reducing work cycle rate and workload may be necessary.

If machine is to be operated in extremely cold weather temperatures, certain precautions must be taken. The following paragraphs detail checks to be made to be certain machine is capable of operating at these temperatures.

1. Keep batteries fully charged to prevent freezing. If distilled water is added to batteries, run engine at least one hour to mix electrolyte solution.
   When temperature drops below -10°C, efficacy of the battery is reduced accordingly. Insulation of the battery prevents reduction of efficacy, and supports improvement of starting power of the starter.

WARNING

AVOID DEATH OR SERIOUS INJURY

Explosion of the battery can cause death or serious injury. Never attempt to directly heat the battery with open fire.

2. Keep engine in good mechanical condition for easy starting and good performance during adverse weather.
3. Use engine oil with proper specifications for expected temperatures. Refer to Operation & Maintenance Manual, in this manual or Shop Manual for details.
4. Always keep the fuel tank fully filled after completion of the operation. Always drain water from the fuel tank before and after the operation. In addition, check the water separator, and drain it if required. The fuel filter, if frozen, may interrupt the flow of fuel. Periodically remove water from the fuel tank, drain water from the filter, and replace the filter upon regular basis. To prevent fuel from being clogged because of formation of wax in fuel, make sure that wax formation point of fuel is lower than atmospheric temperature.

WARNING

AVOID DEATH OR SERIOUS INJURY

Explosion of the fuel tank can cause serious injury or death. Never attempt to directly heat the fuel tank with open fire.

5. Lubricate entire machine according to Operation & Maintenance Manual, in this manual or lubrication chart on machine.
6. Start engine and allow it to reach normal operating temperature before operating.
   - If mud and ice collects and freezes on any of moving parts while machine is idle, apply heat to thaw frozen material before attempting to operate machine.
   - Operate hydraulic units with care until they have reached a temperature which enable them to operate normally.
   - Check all machine controls and functions to be sure they are operating correctly.
7. An extra outer air filter must be kept in operator's cabin to replace element that could become iced and cause restricted airflow to engine.

8. Clean off all mud, snow and ice to prevent freezing. Cover machine with a tarp if possible, keep ends of tarp from freezing to ground.

Operation in Extreme Heat

Continuous operation of machine in high temperatures can cause machine to overheat. Monitor engine and hydraulic system temperatures and stop machine to let it cool, when necessary.

1. Make frequent inspections and services of fan and radiator. Check coolant level in radiator. Check grilles and radiator fins for accumulation of dirt, debris and insects which could block cooling passages.
   - Formation of scale and rust in cooling system occurs more rapidly in extremely high temperatures. Change antifreeze each year to keep corrosion inhibitor at full strength.
   - If necessary, flush cooling system periodically to keep passages clear. Avoid use of water with a high alkali content which increases scale and rust formation.
2. Check level of battery electrolyte daily. Keep electrolyte above plates to prevent damage to batteries. Use a slightly weaker electrolyte solution in hot climates. Batteries self-discharge at a higher rate if left standing for long periods at high temperatures. If machine is to stand for several days, remove batteries and store in a cool place.

IMPORTANT

Do not store acid type storage batteries near stacks of tires. Acid fumes can damage rubber.

3. Service fuel system as directed in "Check Fuel Level" and "Check for Leaks in Fuel System", of Operation & Maintenance Manual. Check for water content before filling fuel tank. High temperatures and cooling off cause condensation in storage drums.
4. Lubricate as specified in Operation & Maintenance Manual, in this manual or Lubrication Decal on machine.
5. Do not park machine in sun for long periods of time. If possible, park machine under cover to protect it from sun, dirt and dust.
   A. Cover machine if no suitable shelter is available. Protect engine compartment and hydraulics from dirt and debris.
   B. In hot, damp climates, corrosion will occur on all parts of machine and will be accelerated during rainy season. Rust and paint blisters will appear on metal surfaces and fungus growth on other surfaces.

C. Protect all unfinished, exposed surfaces with a film of preservative oil. Protect cables and terminals with ignition insulation compound.
Apply paint or suitable rust preventive to damaged surfaces to protect them from rust and corrosion.

Operation In Dusty and Sandy Areas

Operation of machine can cause dust in almost any area. However, when in predominantly dusty or sandy areas, additional precautions must be taken.

1. Keep cooling system fins and cooling areas clean. Blow out with compressed air, if possible, as often as necessary.

WARNING

AVOID DEATH OR SERIOUS INJURY

Wear goggles when using compressed air to prevent face or eye injury.

2. Use care when servicing fuel system to prevent dust and sand from entering tank.
3. Service air cleaner at frequent intervals, check air restriction indicator daily and keep dust cup and dust valve clean. Prevent dust and sand from entering engine parts and compartments as much as possible.
4. Lubricate and perform services outlined on current lubrication chart on machine and Operation & Maintenance Manual. Clean all lubrication fittings before applying lubricant. Sand mixed with lubricant becomes very abrasive and accelerates wear on parts.
5. Protect machine from dust and sand as much as possible. Park machine under cover to keep dust and sand from damaging unit.

Operation in Rainy or Humid Conditions

Operation under rainy or humid conditions is similar to that as in extreme heat procedures previously listed.

1. Keep all exposed surfaces coated with preservative oil. Pay particular attention to damaged or unpainted surfaces. Cover all paint cracks and chip marks as soon as possible to prevent corrosive effects.

Operation in Saltwater Areas

Saltwater and saltwater spray is very corrosive. When operating in saltwater areas, or in or around snow, observe the following precautions:

1. When exposed to saltwater, dry machine thoroughly and rinse with freshwater, as soon as possible.

2. Keep all exposed surfaces coated with preservative oil. Pay attention to damaged paint surfaces.
3. Keep all painted surfaces in good repair.
4. Lubricate machine as prescribed on lubrication chart on machine or Operation & Maintenance Manual, in this manual. Shorten lubricating intervals for parts exposed to salt water.
5. Check operating controls to ensure proper functionality and that they return to "NEUTRAL" when released.

Operation at High Altitudes

Operation instructions at high altitudes are the same as those provided for extreme cold. Before operating at high altitudes, engine fuel and air mixture may have to be adjusted according to appropriate engine manual.

1. Check engine operating temperature for evidence of overheating. The radiator cap must make a perfect seal to maintain coolant pressure in cooling system.
    - If battery electrolyte is frozen, do not charge battery or start engine with a different power source. There is a potential hazard that could cause a battery explosion or fire.
    - Before charging or starting engine with a different power source, thaw battery electrolyte and check for any leakage of electrolyte before starting.

Operation During Electrical Storms

During electrical storms, do not enter or exit machine.

- If you are off machine, keep away from machine until storm passes.
- If you are in cabin, remain seated with machine stationary until storm passes. Do not touch controls or anything metal.

Exhaust Ventilation

Engine exhaust gases can cause unconsciousness, loss of alertness, judgment and motor control. This can result in death or serious injury.

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

Check for and be aware of any open windows, doors or ductwork where exhaust may be carried, or blown by wind, exposing others to hazardous exhaust gases.


ARO1770L

Figure 46

Ventilation for Enclosed Area

If it is necessary to start engine within an enclosed area, or when handling fuel, flushing oil, or paint; open doors and windows to ensure that adequate ventilation is provided to prevent gas poisoning.

Diesel engine exhaust contains products of combustion which can be harmful to your health.

Always run engine in a well ventilated area. If you are in an enclosed area, vent exhaust to outside.

Asbestos Information

WARNING

AVOID DEATH OR SERIOUS INJURY

Avoid exposure to dust containing asbestos as it can cause death or serious injury to the lungs and other organs (mesothelioma, lung and other cancers, and asbestosis).

Asbestos dust can be HAZARDOUS to your health if it is inhaled. Materials containing asbestos fiber can be present on work sites. Breathing air that contains asbestos fiber can ultimately cause serious or fatal lung damage or diseases such as mesothelioma, lung and other cancers, and asbestosis. To prevent lung damage from asbestos fiber, observe the following precautions:

- Use an approved respirator that is approved for use in an asbestos-laden atmosphere.
- Use water for cleaning to keep down dust.
- Always observe any regulations related to work site and working environment.
- Avoid brushing or grinding materials that contain asbestos.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter can also be used.
- Comply with applicable laws and regulations for workplace.
- Stay away from areas that might have asbestos particles in air.

Silica Dust Information

WARNING

AVOID DEATH OR SERIOUS INJURY

Avoid exposure to dust containing crystalline silica particles as it can cause serious injury to the lungs (silicosis).

Cutting or drilling concrete containing sand or rock containing quartz can result in exposure to silica dust. Do not exceed Permissible Exposure Limits (PEL) to silica dust as determined by OSHA or other work site rules, laws and regulations. Use a respirator, water spray or other means to control dust. Silica dust can cause lung disease and is known to the state of California to cause cancer.

Disposal of Hazardous Materials

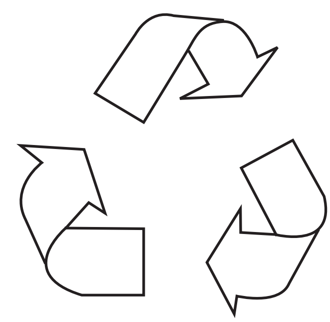
Physical contact with used motor oil or gear oil could create a health risk. Wipe oil from your hands promptly and wash off any remaining residue.

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

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

Improperly disposing of waste can threaten environment. Potentially harmful fluids must be disposed of according to local regulations.

Use all cleaning solutions with care. Report all necessary repairs.



FG009156

Figure 47

Specifications

Specifications

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Specifications

GENERAL DESCRIPTION

The forestry machine has three main component sections:

- The Upper Structure
- The Lower Undercarriage and Track Frames
- The Forestry Machine Front-end Attachment

The following illustration identifies main components and their locations. (See Figure 1 on page -4.)

COMPONENT LOCATIONS

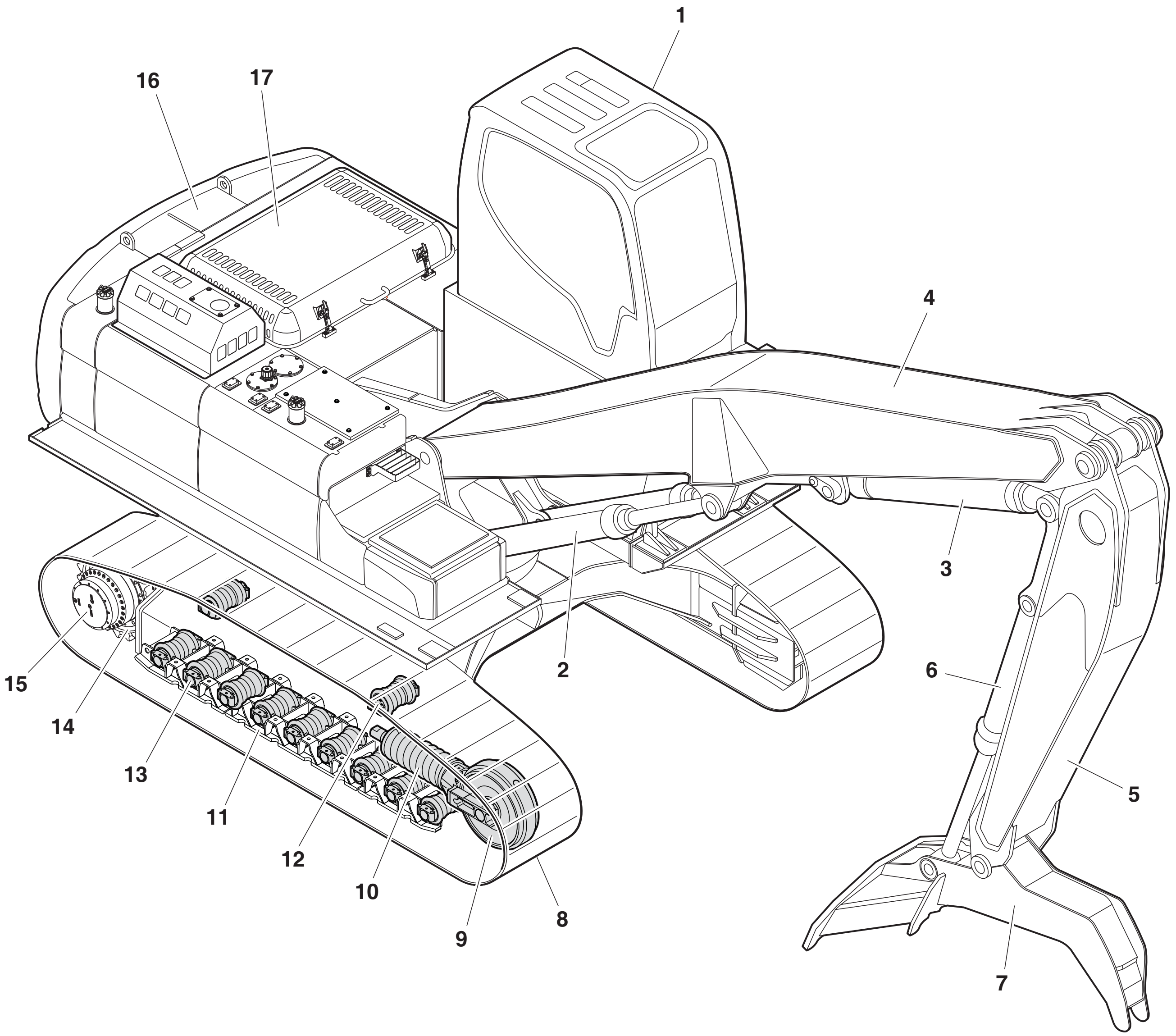


Figure 1

Reference Number	Description
1	Cabin
2	Hoist Cylinder
3	Stick Cylinder
4	Hoist
5	Arm
6	Heel Cylinder
7	Heel Rack
8	Track Link and Shoe
9	Idler

Reference Number	Description
10	Track Adjuster
11	Track Guard
12	Upper Roller
13	Lower Roller
14	Sprocket
15	Travel Motor
16	Counterweight
17	Hood

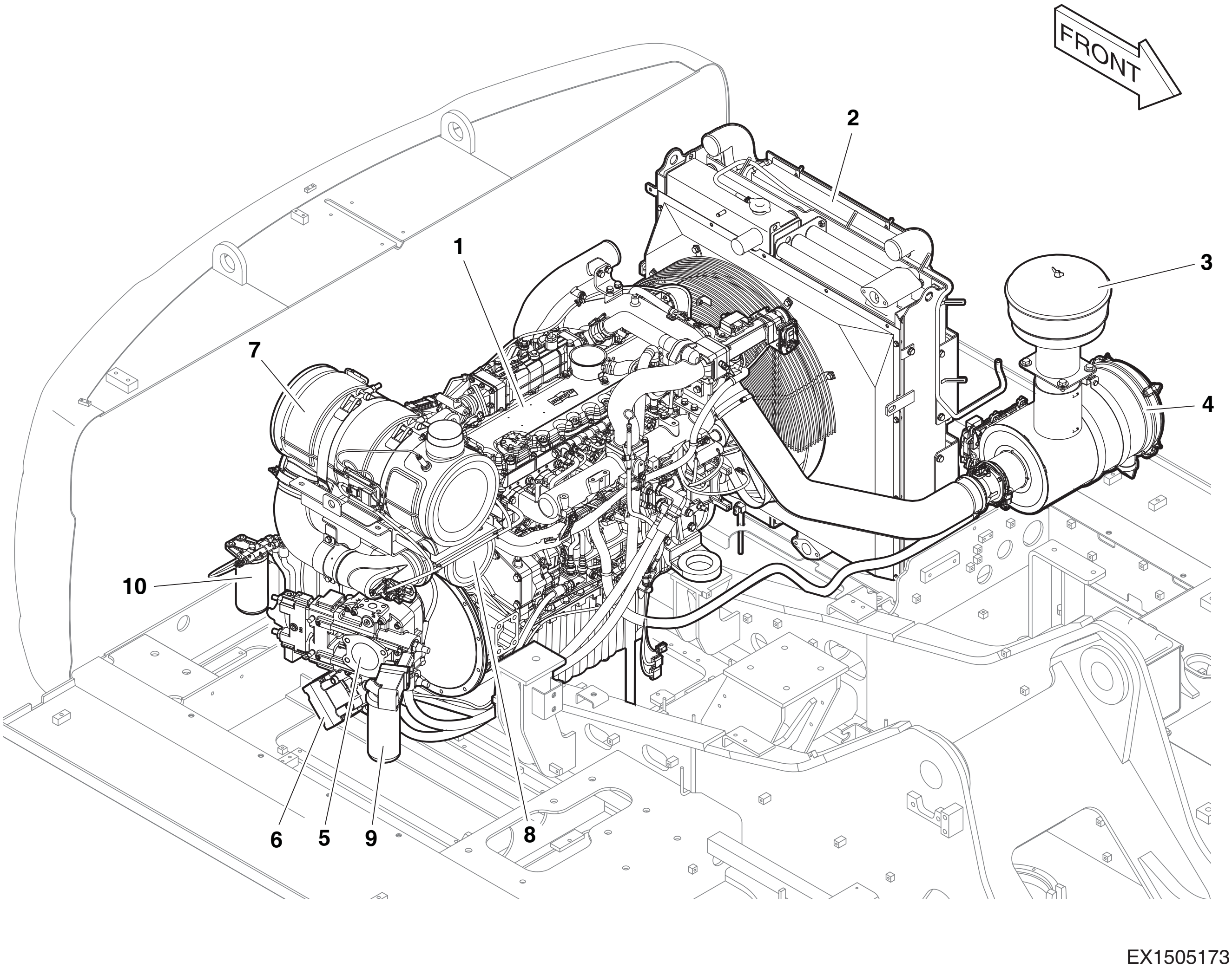


Figure 2

Reference Number	Description
1	Engine
2	Radiator
3	Precleaner
4	Air Cleaner
5	Main Pump

Reference Number	Description
6	Gear Pump (Rotating)
7	SCR Muffler
8	SCR Catalyst
9	Engine Oil Filter
10	Main Fuel Filter

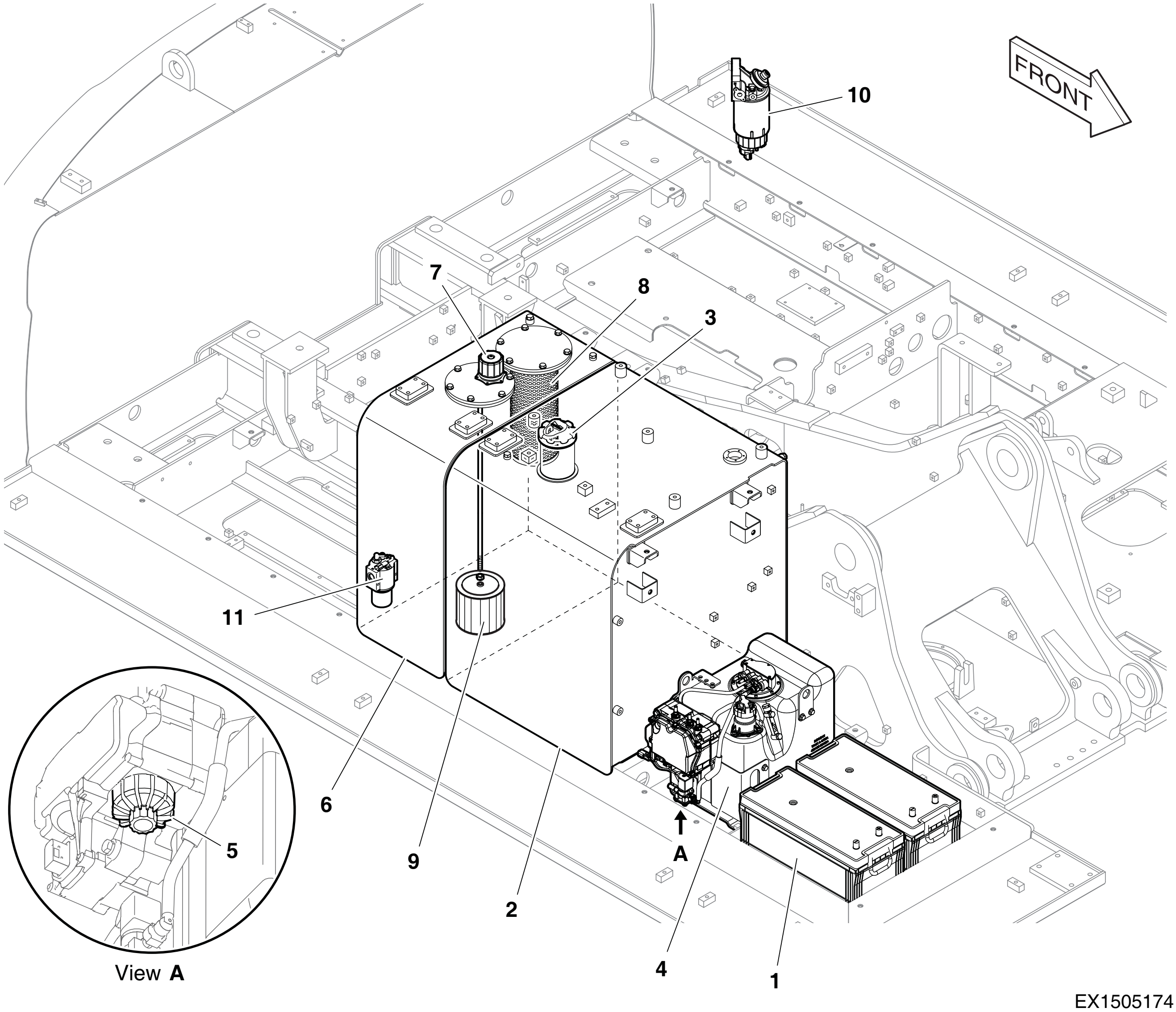


Figure 3

Reference Number	Description
1	Battery
2	Fuel Tank
3	Fuel Cap
4	Urea Tank
5	DEF (AdBlue) Filter
6	Hydraulic Oil Tank

Reference Number	Description
7	Air Breather
8	Return Filter
9	Suction Filter
10	Water Separator and Pre Fuel Filter (Fuel Prefilter)
11	Pilot Filter

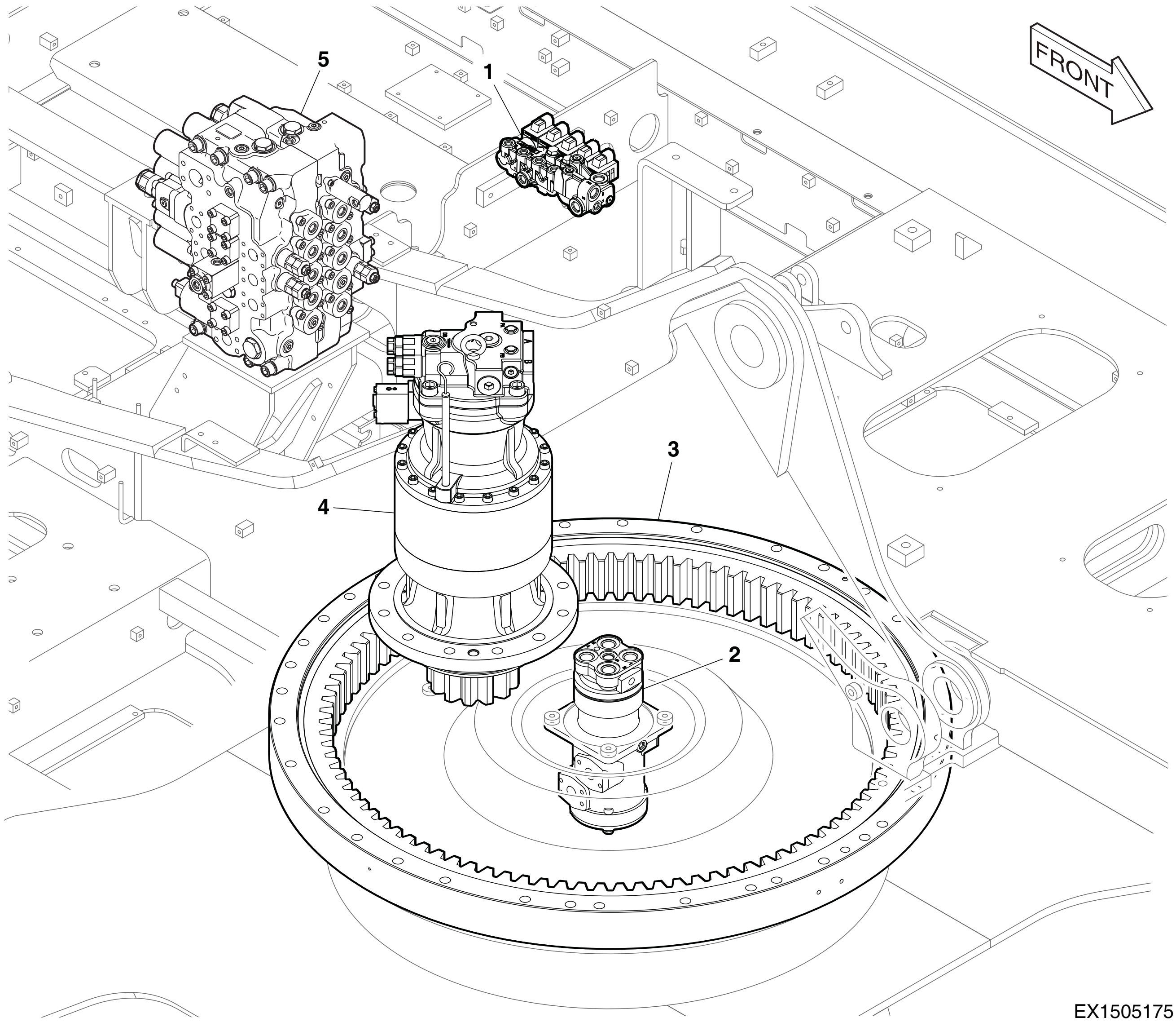


Figure 4

Reference Number	Description
1	Solenoid Valve
2	Center Joint
3	Swing Bearing

Reference Number	Description
4	Swing Device
5	Control Valve

OVERALL DIMENSIONS

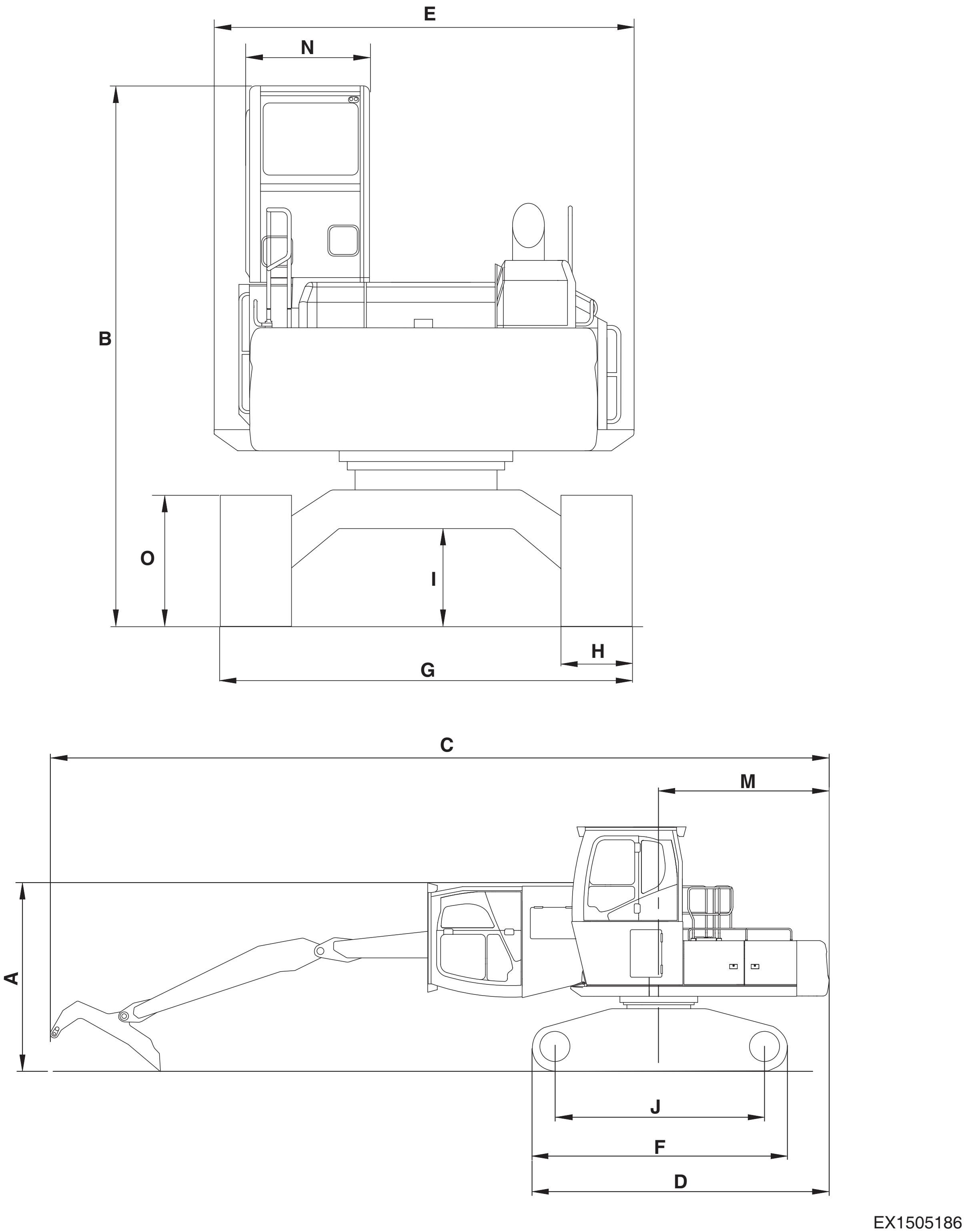


Figure 5

Item		Dimension
A	Shipping Height	3,453 mm (11' 4")
B	Overall Height	4,530 mm (14' 10")
C	Shipping Length	13,947 mm (45' 9")
D	Shipping Length (W/O Attachment)	5,308 mm (17' 5")
E	Upper Structure Width	3,226 mm (10' 7")
F	Track Length	4,613 mm (15' 2")
G	Shipping Width	3,600 mm (11' 10")
H	Undercarriage Width	700 mm (2' 4")
I	Car Body Clearance	711 mm (2' 4")
J	Tumbler Distance	3,680 mm (12' 1")
M	Tail Swing Radius	3,000 mm (9' 10")
N	Cab Guard Width	1,105 mm (3' 8")
O	Track Height	1,176 mm (3' 10")

WORKING RANGE

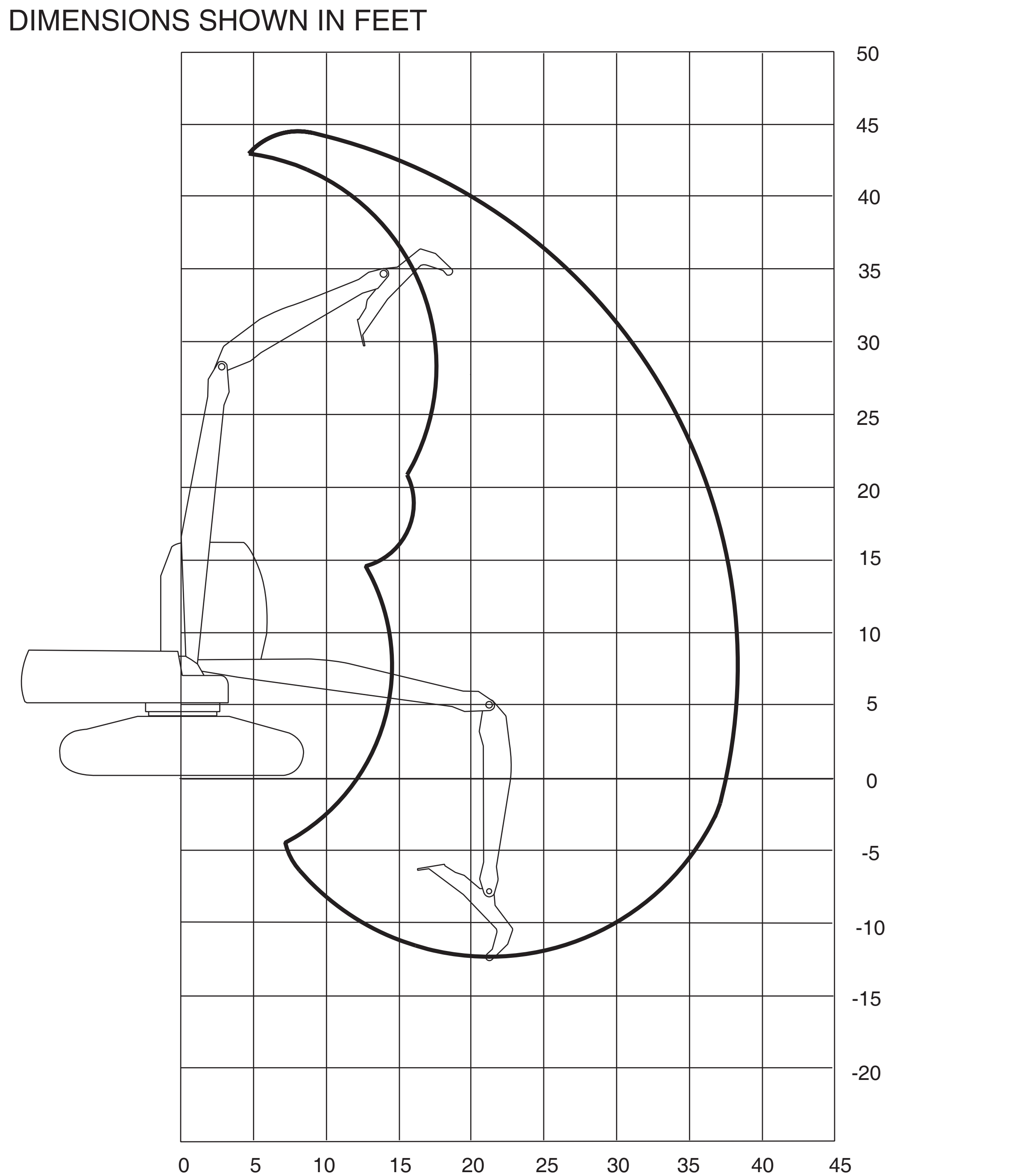


Figure 6

Max. Reach @ Ground Level 11,700 mm (38' - 5")

Max. Arm Height 13,000 mm (42' - 6")

GENERAL SPECIFICATIONS

Shipping Weight (Log Loader)		27.7 tons (61,068 lb)
		Includes 10% fuel, Boom 6,150 mm (20' 2"), Arm 3,660 mm (12' 0"), Heel and 700 mm double grouser shoes
Shipping Weight (Road Builder)		30.1 tons (66,359 lb)
		Includes 10% fuel, Boom 5,700 mm (18' 8"), Arm 2,900 mm (9' 6") Bucket and 700 mm double grouser shoes
Operating Weight		Add weight of full fuel tank and operator.
Major Component Weights		Boom 2,280 kg (5,027 lb)
		Arm 1,050 kg (2,315 lb)
		Boom Cylinders 213 kg (470 lb) each
		Arm Cylinder 374 kg (825 lb)
		Heel Cylinder 118 kg (260 lb)
		Counterweight 4,400 kg (9,700 lb)
		Upper Turntable 8,804 kg (19,409 lb)
		Lower - below Swing Bearing 11,890 kg (26,213 lb)
Digging Forces (At Power Boost, ISO)		
Fuel Tank Capacity		1,000 L (264.2 U.S. gal)
Hydraulic System Capacity		280 L (74.0 U.S. gal)
Hydraulic Reservoir Capacity		131 L (34.6 U.S. gal)
		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		Double Grouser
Ground Pressure Ratings:		
700 mm D.G Log Loader		0.55 kg/cm^2 (7.82 psi)
700 mm D.G Road Builder		0.52 kg/cm^2 (7.40 psi)
Transport Dimensions		
Overall Shipping Length (Standard Boom and Arm)	Log Loader	13,947 mm (45' 9")
	Road Builder	9,770 mm (32' 1")
Overall Shipping Width (Standard Shoes)		3,600 mm (11' 10")
Overall Shipping Height (Cabin Tilting Position - Log Loader)	Log Loader	3,453 mm (11' 4")
	Road Builder	3,015 mm (9' 11")
Track Shipping Length		4,613 mm (15' 2")
Transport Trailer Capacity		52 tons, minimum load capacity
Transport Loading Ramp		
Allowable Slope		15° angle **CAUTION:** Refer to Transport Maximum Procedure for Safe Shipping Instructions.

APPROXIMATE WEIGHT OF WORKLOAD MATERIALS

IMPORTANT

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

Material	Density 1,200 kg/m^3 (2,000 lb/yd^3), or less	Density 1,500 kg/m^3 (2,500 lb/yd^3), or less	Density 1,800 kg/m^3 (3,000 lb/yd^3), or less	Density 2,100 kg/m^3 (3,500 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)	-
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)	-	-	-

Material	Density 1,200 kg/m^3 (2,000 lb/yd^3), or less	Density 1,500 kg/m^3 (2,500 lb/yd^3), or less	Density 1,800 kg/m^3 (3,000 lb/yd^3), or less	Density 2,100 kg/m^3 (3,500 lb/yd^3), or less
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)	-	-
Sulfur, broken	529 kg/m^3 (891 lb/yd^3)	-	-	-

PERFORMANCE TESTS

Use operational performance test procedure to quantitatively check all system and functions on the machine.

Purpose of Performance Tests

1. To comprehensively evaluate each operational function by comparing the performance test data with the standard values.
2. According to the evaluation results, repair, adjust, or replace parts or components as necessary to restore the machine's performance to the desired standard.
3. To economically operate the machine under optimal conditions.

Kinds of Tests

1. Base machine performance test is to check the operational performance of each system such as engine, travel, swing, and hydraulic cylinders.
2. Hydraulic component unit test is to check the operational performance of each component such as hydraulic pump, motor, and various kinds of valves.

Performance Standards

"Performance Standard" is shown in tables to evaluate the performance test data.

Precautions for Evaluation of Test Data

1. To evaluate not only that test data is correct, but also in what range the test data is.
2. Be sure to evaluate the test data based on the machine operation hours, kinds and state of work loads, and machine maintenance conditions.

The machine performance does not always deteriorate as the working hours increase. However, the machine performance is normally considered to reduce in proportion to the increase of the operation hours. Accordingly, restoring the machine performance by repair, adjustment, or replacement shall consider the number of the machine's working hours.

Definition of "Performance Standard"

1. Operation speed values and dimensions of the new machine.
2. Operational performance of new components adjusted to specifications. Allowable errors will be indicated as necessary.

PREPARATION FOR PERFORMANCE TESTS

Observe the following rules to perform performance tests accurately and safety.

The Machine

1. Repair any defects and damage found, such as oil or water leaks, loose bolts, cracks etc, before starting to test.

Test Area

1. Select a hard and flat surface.
2. Secure enough space to allow the machine to run straight more than 20 m (65 ft 7 in), and to make a full swing with the front attachment extended.
3. If required, rope off the test area and provide signboards to keep unauthorized personnel away.

Precautions

1. Before starting to test, agree upon the signals to be employed for communication among coworkers.

   Once the test is started, be sure to communicate with each other using these signals, and to follow them without fail.
2. Operate the machine carefully and always give first priority to safety.
3. While testing, always take care to avoid accidents because of landslides or contact with high voltage power lines. Always confirm there is sufficient space for full swings.
4. Avoid polluting the machine and the ground with leaking oil. Use oil pans to catch escaping oil. Pay special attention to this when removing hydraulic pipings.

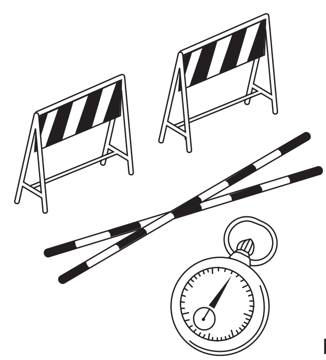


Figure 7

Make Precise Measurement

1. Accurately calibrate test instruments in advance to obtain correct data.
2. Perform tests under the exact test conditions prescribed for each test item.
3. Repeat the same test and confirm that test data obtained can be produced repeatedly. Use mean values of measurements if necessary.

OPERATIONAL PERFORMANCE STANDARD TABLE

Log Loader

Item	Model		Unit	Measuring Conditions	Performance Standard
Engine Speed	No Load	Power+ Mode	rpm	SPC Off	1,900 ±25
			rpm	SPC Off + A/I On	1,800 ±25
		Power Mode	rpm	SPC Off	1,700 ±25
		Standard Mode	rpm	SPC Off	1,650 ±25
		Economy Mode	rpm	SPC Off	1,600 ±25
		Low Idle (Auto Warm Up Off)	rpm	Auto Warm Up On Condition • Coolant Temperature Below 15°C Auto Warm Up Off Condition • Coolant Temperature Above 30°C • 10 minutes Spent After Startup • The Dial on the rpm Gauge Moved	800 ±25
		Low Idle (Auto Warm Up On) • It may occur for a little while after the engine starts up in winter.			1,200 ±25
	Load (P+ SPC Off)	1 Pump Relief	rpm	*Standard	above 1,800
		2 Pump Relief			above 1,800
	Revolution at Boom Up or Arm Dump	Power+ Mode	rpm	Dial Max. SPC Off	above 1,800
		Power Mode	rpm		1,680 ±25
		Standard Mode	rpm		1,630 ±25
		Economy Mode	rpm		1,580 ±25
		1,300 rpm (Power+)	rpm	Adjust Dial, SPC Off	1,280 ±25
		Low	rpm	Dial Min.	Should not stop engine
	Auto Idle	above Ambient Temp. 10°C	rpm	A/I On	800 ±20
		below Ambient Temp. 10°C	rpm		1,100 ±20
	Fan Revolution Speed	High Idle	rpm	*Standard	1,800 ±50
EPOS	EPPR Valve Current for Pump	Power+ Mode	mA	SPC Off Minimum Value at Arm Crowd	300 ±30
		Power Mode	mA		325 ±30
		Standard Mode	mA		355 ±30
		Economy Mode	mA		395 ±30
		Auto Idle	mA	Idle	650 ±30
		Low Idle	mA		700 ±30
Pressure Set	Main	Relief	bar	*Standard	324 +10
		Relief Power Up	bar		343 +10
	Swing	Relief (at Motor)	bar	*Standard	294 +10
		Relief (at Pump)	bar		304 +10

Item	Model		Unit	Measuring Conditions	Performance Standard
Pressure Set	Option	Rotating Relief	bar	*Standard	80 ±25
		1/2 Way Relief (at Pump)	bar	*Standard, 150 lpm, 220 bar, Monitor	252 ±25
Front Speed	Boom	Up	sec	*Standard (SPC Off)	5.2 ±0.5
		Down	sec		5.1 ±0.5
	Arm	Crowd	sec		3.1 ±0.3
		Dump	sec		5.1 ±0.5
	Heel	Rack IN	sec		2.0/1.7 ±0.2
		Rack OUT	sec		2.9/2.6 ±0.3
Swing	Swing Speed	Swing Speed	sec	*Standard, Swing Single 3 Revolution (SPC Off)	16.5 ±1.7
	Swing Coasting	Swing Coasting	mm	After 180° Swing, Bearing Outer Race	870(75°) ±174
Cylinder	Front	Boom Down	mm/5min	Max. reach posture, heel rack IN posture, height of horizontal boom pin and heel pin Additional weight 3.5t to heel	below 5
		Arm Crowd	mm/5min		below 5
		Rack OUT	mm/5min		below 20
Travel	Travel Speed on Flat (20 m)	1st Gear	sec	*Standard	26.2 ±2.6
		2nd Gear	sec		15.8 ±1.6
	Jack-up (3 turns)	1st Gear	sec	*Standard	38.2 ±3.8
		2nd Gear	sec		22.9 ±2.3
	Travel Deviation (20 m)	1st Gear	mm	*Standard Forward/Reverse Each	below 150
		2nd Gear	mm		below 150

- Standard Condition: P Plus Mode, SPC Off, Engine Dial Max. Auto Idle Off, Air Conditioner Off, Working Mode, Oil 50 ±5°C, Coolant 80 +10°C

Item	Model		Unit	Measuring Conditions	Performance Standard
Engine Speed	No Load	Power+ Mode	rpm	SPC Off	1,900 ±25
			rpm	SPC Off + A/I On	1,800 ±25
			rpm	SPC On	1,700 ±25
		Power Mode	rpm	SPC Off	1,700 ±25
			rpm	SPC On	1,600 ±25
		Standard Mode	rpm	SPC Off	1,650 ±25
			rpm	SPC On	1,550 ±25
		Economy Mode	rpm	SPC Off	1,600 ±25
			rpm	SPC On	1,500 ±25
		Lifting Mode	rpm	-	1,500 ±25
		Low Idle (Auto Warm Up Off)	rpm	Auto Warm Up On Condition • Coolant Temperature Below 15°C Auto Warm Up Off Condition • Coolant Temperature Above 30°C • 10 minutes Spent After Startup • The Dial on the rpm Gauge Moved	800 ±25
		Low Idle (Auto Warm Up On) • It may occur for a little while after the engine starts up in winter.			1,200 ±25
	Load (P+ SPC Off)	1 Pump Relief	rpm	*Standard	above 1,800
		2 Pump Relief			above 1,800
	Revolution at Boom Up or Arm Dump	Power+ Mode	rpm	Dial Max. SPC Off	above 1,800
		Power Mode	rpm		1,680 ±25
		Standard Mode	rpm		1,630 ±25
		Economy Mode	rpm		1,580 ±25
		1,300 rpm (Power+)	rpm	Adjust Dial, SPC Off	1,280 ±25
		Low	rpm	Dial Min.	Should not stop engine
	Auto Idle	above Ambient Temp. 10°C	rpm	A/I On	800 ±20
		below Ambient Temp. 10°C	rpm		1,100 ±20
	Fan Revolution Speed	High Idle	rpm	*Standard	1,800 ±50
EPOS	EPPR Valve Current for Pump	Power+ Mode	mA	SPC Off Minimum Value at Arm Crowd	300 ±30
		Power Mode	mA		325 ±30
		Standard Mode	mA		355 ±30
		Economy Mode	mA		395 ±30
		Lifting Mode	mA		300 ±30
		Auto Idle	mA	Idle	650 ±30
		Low Idle	mA		700 ±30

Item	Model		Unit	Measuring Conditions	Performance Standard
Pressure Set	Main	Relief	bar	*Standard	324 +10
		Relief Power Up	bar		343 +10
	Swing	Relief (at Motor)	bar	*Standard	294 +10
		Relief (at Pump)	bar		304 +10
	Option	Rotating Relief	bar	*Standard	80 ±25
		1/2 Way Relief (at Pump)	bar	*Standard, 150 lpm, 220 bar, Monitor	222 ±25
		EPPR Valve Current	mA		250 ±30
Front Speed	Boom	Up	sec	*Standard (SPC Off)	2.9 ±0.3
		Down	sec		2.3(3.0) ±0.2
	Arm	Crowd	sec		3.7 ±0.4
		Dump	sec		2.4 ±0.2
	Bucket	Crowd	sec		2.7 ±0.3
		Dump	sec		2.2 ±0.2
Swing	Swing Speed	Swing Speed	sec	*Standard, Swing Single 3 Revolution (SPC Off)	16.5 ±1.7
	Swing Coasting	Swing Coasting	mm	After 180° Swing, Empty Bucket, Bearing Outer Race	870(75°) ±174
Cylinder	Front	Boom Down	mm/5min	Max. reach posture, bucket crowd posture, weight bucket (1.5 times of bucket capacity) should not be natural lowering at lock valve	below 5
		Arm Crowd	mm/5min		below 5
		Bucket Dump	mm/5min		below 20
Travel	Travel Speed on Flat (20 m)	1st Gear	sec	*Standard	26.2 ±2.6
		2nd Gear	sec		15.8 ±1.6
	Jack-up (3 turns)	1st Gear	sec	*Standard	38.2 ±3.8
		2nd Gear	sec		22.9 ±2.3
	Travel Deviation (20 m)	1st Gear	mm	*Standard Forward/Reverse Each	below 150
		2nd Gear	mm		below 150

- Standard Condition: P Plus Mode, SPC Off, Engine Dial Max. Auto Idle Off, Air Conditioner Off, Working Mode, Oil 50 ±5°C, Coolant 80 +10°C

OPERATIONAL PERFORMANCE TEST

Hydraulic Cylinder Cycle Time

Summary

1. Check the overall operational performance of the front attachment hydraulic system (between the hydraulic pumps and each cylinder) by measuring the cycle time of the boom, arm, bucket, and bucket dump (open/close) cylinders with the empty bucket.
2. Bucket must be empty.

Preparation

1. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).

Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
High Idle	Power Plus Mode	Working Mode	OFF

2. Position the front attachment as described in the following. Then, measure the operating time until cylinder reaches the stroke end by fully moving the control lever.

   A. Boom cylinder

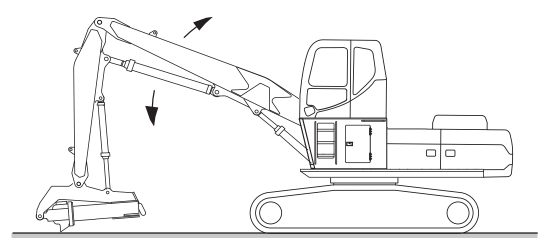
   1) Boom up speed

      Rapidly operate the bucket from the ground, and measure the time it takes for the boom to reach the end point.

   2) Boom down speed

      Rapidly operate the bucket with the boom reached the end point, and measure the time it takes for the bucket to reach the ground.

   3) Measuring available displacement of the cylinder: Measure and record the extension of the cylinder rod from when the bucket is resting on the ground to when the boom cylinder is extended to its maximum length.



EX1505001

Figure 8

B. Arm cylinder

1) Arm crowd speed

Rapidly operate the arm while kept fully dumped (extended), and measure the time it takes for the arm to fold fully.

2) Arm dump speed

Rapidly operate the arm maintained in the fully folded position, and measure the time it takes for the arm to extend fully.

3) Measuring available displacement of the cylinder: Measure and record the extension length of the cylinder rod from the point at which the arm cylinder is fully extended (crowded) to the point at which the arm cylinder is fully folded (dumped).

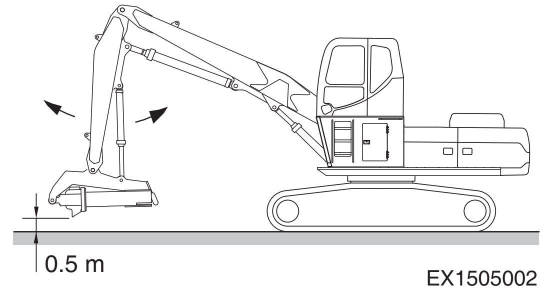


Figure 9

C. Heel cylinder

1) Heel rack in speed

Rapidly operate the heel while fully crowded (extended), and measure the time it takes for the heel to fold fully.

2) Heel rack out speed

Rapidly operate the heel while fully folded, and measure the time it takes for the heel to extend fully.

3) Measuring available displacement of the cylinder: Measure and record the extension length of the cylinder rod from the point at which the heel cylinder is fully extended (crowded) to the point at which the heel cylinder is fully folded (dumped).

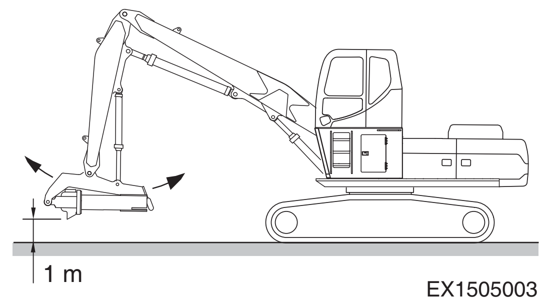


Figure 10

NOTE: *Record the details of any abnormal noise heard during measurement, or any abnormal conditions observed during operation, on a blank measurement record sheet.*

Travel Speed

Summary

Measure the time required for the machine to travel a 20 m (65.6 ft) test track.

Preparation

1. Adjust the track sag on both side tracks equally.
2. Prepare a flat and solid test track 20 m (65.6 ft) in length with extra length of 3 ~ 5 m (9.8 ~ 16 ft) on both ends for machine acceleration and deceleration.

IMPORTANT

The end of heel will hit the boom if the heel is rolled-in with the arm fully rolled-in.

As for this condition: arm fully rolled-in + heel fully rolled-in, set the heel at fully rolled-in and a perform arm roll-in operation.

3. Hold the heel 0.3 ~ 0.5 m (12 ~ 20 in) above the ground with the arm and heel rolled-in.
4. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).

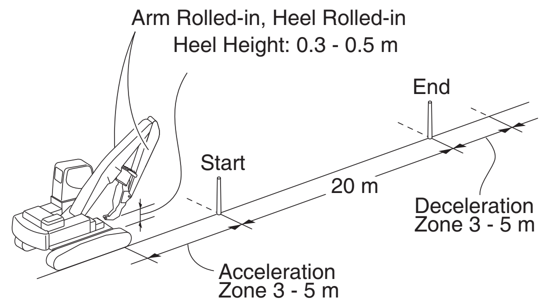


Figure 11

Measurement

1. Measure both the slow and fast speeds of the machine.
2. Measurement conditions are as below.

Travel Mode Switch	Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
Low Mode	High Idle	Power Plus Mode	Working Mode	OFF
High Mode	High Idle	Power Plus Mode	Working Mode	OFF

3. Start traveling the machine in the acceleration zone with the travel levers to full stroke.
4. Measure the time required to travel 20 m (65.6 ft)
5. After measuring the forward travel speed, turn the upper structure 180° and measure the reverse travel speed.
6. Perform the measurement three times and calculate the average values.

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

Track Revolution Speed

Summary

Measure the track revolution cycle time with the track raised off ground.

Preparation

1. Adjust the track sag of both side tracks to be equal.
2. Put the mark on the track to be measured, by using a piece of chalk.
3. Swing the upper structure 90° and lower the heel to raise the track off ground. Keep the boom-arm angle between 90 ~ 110° as shown place blocks under the machine frame.

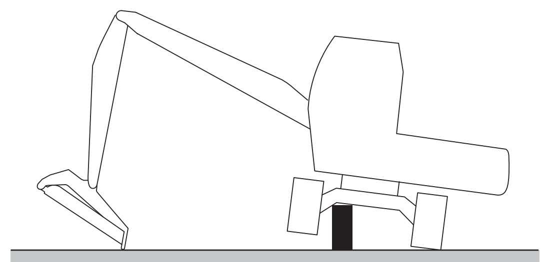


Figure 12

CAUTION

AVOID INJURY

Secure support the raised track using wooden blocks.

4. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).

Measurement

1. Measure the both tracks on forward and reverse directions at each travel mode.
2. Measurement conditions are as below.

Travel Mode Switch	Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
Low Mode	High Idle	Power Plus Mode	Working Mode	OFF
High Mode	High Idle	Power Plus Mode	Working Mode	OFF

3. Operate the travel control lever of the raised track to full stroke.
4. Measure the time required for 3 revolutions in both directions after a constant track revolution speed is obtained.
5. Perform the measurement three times and calculate the average values.

NOTE: *Record the details of any abnormal noise heard during measurement, or any abnormal conditions observed during operation, on a blank measurement record sheet.*

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

NOTE: *The measurement data obtained through the raised track revolution test may have wide variations. Therefore, the evaluation based on the results obtained from the 20 m travel speed check described before is more recommendable.*

Mistrack Check

Summary

1. Allow the machine to travel 20 m (65.6 ft). Measure the maximum tread deviation from the tread chord line drawn between the travel start and end points to check the performance equilibrium between both sides of the travel device systems (from the main pump to the travel motor).
2. If measured on a concrete surface, the tread deviation has a trend to decrease.

Preparation

1. Adjust the track sag of both tracks to be equal.
2. Provide a flat, solid test yard 20 m (65.6 ft) in length, with extra length of 3 - 5 m (9.8 - 16 ft) on both ends for machine acceleration and deceleration.

IMPORTANT

The end of heel will hit the boom if the heel is rolled-in with the arm fully rolled-in.

As for this condition: arm fully rolled-in + heel fully rolled-in, set the heel at fully rolled-in and a perform arm roll-In operation.

3. Hold the heel 0.3 - 0.5 m (12 - 20 in) above the ground the arm and heel rolled-in.
4. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°C).

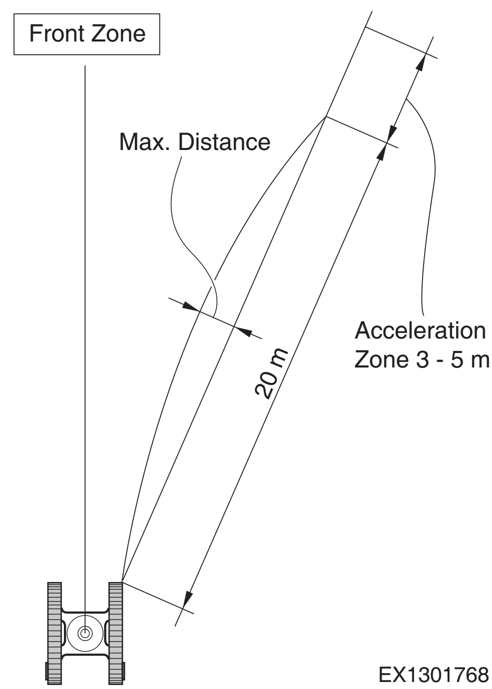


Figure 13

Measurement

1. Measure the amount of mistracking in both fast, and slow travel speeds.
2. Measurement conditions are as below.

Travel Mode Switch	Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
Low Mode	High Idle	Power Plus Mode	Working Mode	OFF
High Mode	High Idle	Power Plus Mode	Working Mode	OFF

3. Start traveling the machine in the acceleration zone with the travel levers al full stroke.

4. Measure the maximum distance between a straight 20 m (65.6 ft) tread chord line and the tread made by the machine.
5. After measuring the tracking in forward travel, turn the upper structure 180° and measure in reverse travel.
6. Perform the measurement three times and calculate the average values.

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

Swing Speed

Summary

Measure the time required to swing three complete turns.

Preparation

1. Check the lubrication of the swing gear and swing bearing.
2. Place the machine on flat, solid ground with ample space for swinging. Do not conduct this test on slopes.
3. With the heel empty, position the front attachment as follows.
   With the arm cylinder fully retracted, and the heel cylinder fully extended, raise the boom so heel pin height is flush with the boom foot pin height.

   NOTE: *In case of no place to be measured, measure with the boom raised and the arm rolled-in.*
4. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).

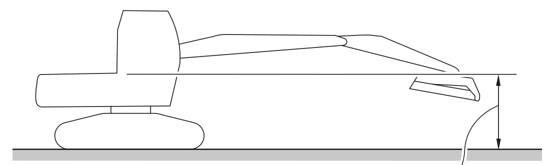


Figure 14

CAUTION

AVOID INJURY

Prevent personal injury. Always make sure that area is clear and that co-workers are out of the swing area before starting the measurement.

Measurement

1. Measurement conditions are as below.

Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
High Idle	Power Plus Mode	Working Mode	OFF

2. Operate swing control lever fully.
3. Measure the time required to swing 3 turns in one direction. (Record the stopwatch measurement to the second decimal place.)
4. Operate swing control lever fully in the opposite direction and measure the time required for 3 turns.
5. Perform the measurement three times and calculate the average values.

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

Swing Function Drift Check

Summary

Measure the swing drift on the bearing outer circumference when stopping after a 360° full-speed swing.

Preparation

1. Check the lubrication of the swing gear and swing bearing.
2. Place the machine on flat, solid ground with ample space for swinging. Do not conduct this test on a slope.
3. Position the front attachment as follow.
   With the arm cylinder fully retracted, and the heel cylinder fully extended, raise the boom so heel pin height is flush with the boom foot pin height.
4. Put the matching marks on the swing bearing and on the track frame by using a tape, as illustrated.

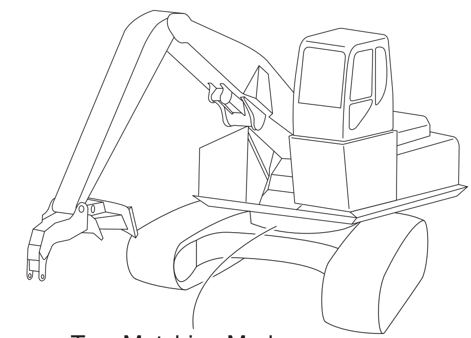


Figure 15

5. Swing the upper structure 360°.
6. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).

CAUTION

AVOID INJURY

Prevent personal injury. Always make sure that area is clear and that co-workers are out of the swing area before starting the measurement.

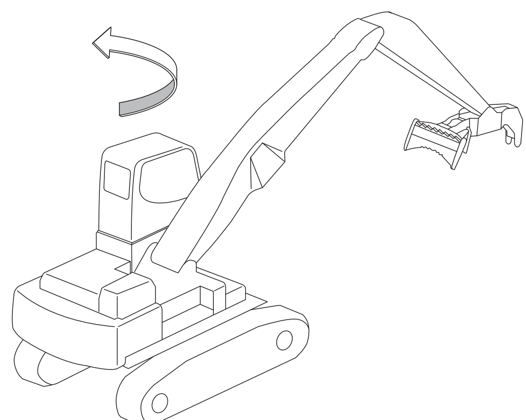


Figure 16

Measurement

1. Measurement conditions are as below.

Engine Control Dial	Power Mode Switch	Work Mode	Auto-idle Switch
High Idle	Power Plus Mode	Working Mode	OFF

2. Operate swing control lever fully and return it to the neutral position when the mark on upper structure aligns with that on track frame after swinging 360°.
3. Measure the time distance between the two marks.
4. Align the marks again, swing 360°, and then test in the opposite direction.
5. Perform the measurement three times and calculate the average values.

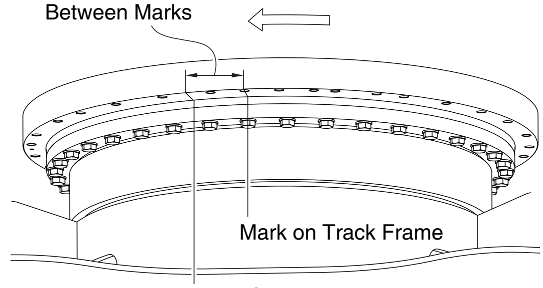


Figure 17

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

Cylinder Creep

Summary

To define how to measure the drift of each cylinder installed on a log loader's front end and standards to evaluate the measurement.

Preparation

1. Record the model type of the front end mounted on the machine under test. The standard front end type is the basic option for testing.
2. Position the machine on a level ground with a gradient of 1% or below.
3. It is recommended to perform the test indoor but an outdoor test is also possible when conducted at a wind speed of 2 m/s or less.
4. The test should be performed at an ambient air temperature of 20°C (68°F) in principle, but all test results are considered valid as long as they have been made at a hydraulic oil temperature higher than the reference value.
5. Maintain the hydraulic oil temperature at 50 ±5°C (122 ±41°F).
6. Prepare a tapeline.
7. The machine's posture (Figure 18)
    A. Heel weight: Additional weight 3.5 ton to heel.
    B. Position the arm cylinder with the rod 50 mm retracted from the fully extended position.
    C. Position the heel rack "IN" posture.
    D. The height of the heel pin is the same as the boom foot pin.

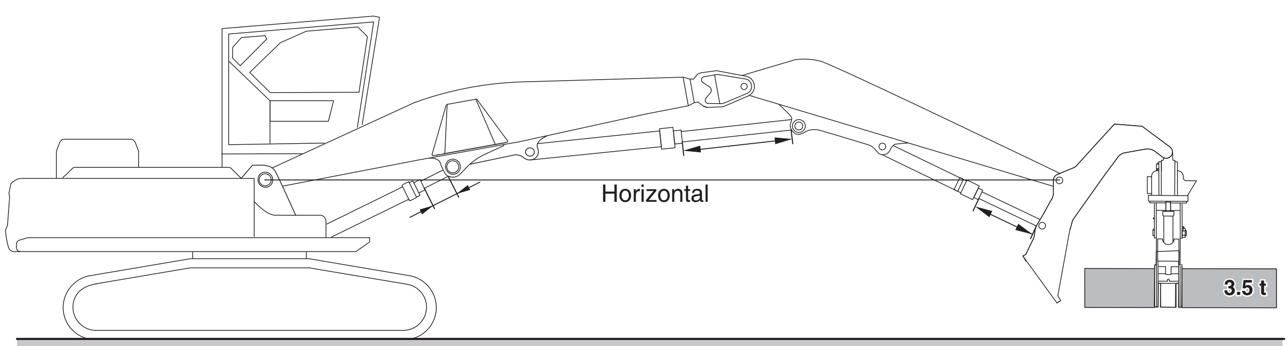
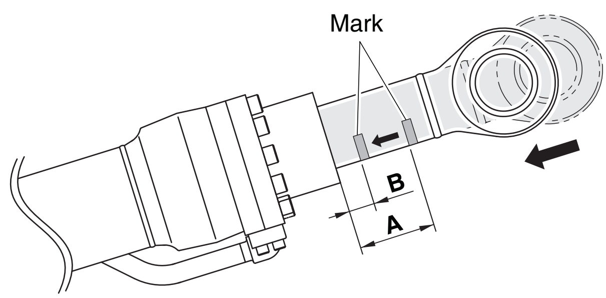


Figure 18 Log loader Posture with the Maximum Reach

Measurement

1. Stop the engine.
2. Before measuring the drift of the cylinder, measure the temperatures of the hydraulic tank and cylinder tube.
3. Mark in appropriate location of the cylinder.
4. Measure the distance A.
5. Wait for 5 minutes.
6. Measure the distance B.
7. Drift value of the cylinder can be calculated as follows:
    - A - B
8. After measuring the drift of the cylinder, measure the temperatures of the hydraulic tank and cylinder tube.



<Boom, Arm and Heel Cylinders Retraction “**A-B**”>

DS1702062

Figure 19 How to Measure a Cylinder’s Displacement

NOTE: *If the temperature of the hydraulic oil is found out of range for warming up (50 ±5°C/122 ±41°F) on the completion of the test, perform the test once again. And if the drift of a cylinder is measured to be high, measure its holding pressure.*

Evaluation

Refer to "Operational Performance Standard Table" on page -16.

General Maintenance

General Maintenance Instructions

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

General Maintenance Instructions

WELDING PRECAUTIONS AND INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

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

AVOID DEATH OR SERIOUS INJURY

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 result. Always consult HYUNDAI **After Sales Service before welding on integral components (loader arm, frames, car body, track frames, upper structure, 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.**

WARNING

AVOID DEATH OR SERIOUS INJURY

Always perform welding procedures with proper safety equipment and adequate ventilation in a dry work area. Keep a fire extinguisher near and wear personal protective equipment.

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Observe the following safety instructions:

1. **Use adequate safety shielding and keep away from fuel and oil tanks, batteries, hydraulic piping lines or other fire hazards when welding.**
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 then operator's cabin window areas or any other assemblies could be damaged by weld spatters. Use adequate shielding protection in front of the assembly.**
5. **During welding 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 of removal from a freshly opened container.**

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 tolerances between moving parts (e.g. pistons and cylinders, or shoes and swash plates), 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 because of neglect or careless maintenance, could all produce sufficient fluid loss to cause damage or improper operation.

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 shows 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 lessen 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.

Before starting the machine, a daily walk-around safety inspection, including a quick visual inspection 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 workloads, fluid circulating under high-pressure) make it extremely critical that dust, grit or any other 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 maintenance service or repair is being performed.

NOTE: *If the unit is being used in an extreme temperature environment (in subfreezing climates or in high temperature, high humidity tropical conditions), frequent purging of moisture condensation from the hydraulic reservoir drain tap must 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 filters 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 because of a mechanical problem inside the pump. However, pressure loss could also be because of cavitation or air leakage, or other faults in the hydraulic system.*

Check the exterior case's oil drain line in the main pumps. If no metallic particles are found, make sure there is no air in the system. Unbolt and remove 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 troubleshooting or service is being performed, it's important to remember that 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 noncombustible, evaporative type, low residue solvent and thoroughly clean exterior surfaces of assemblies before any part of the circuit is opened 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. 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 suddenly put a stop to normal hydraulic function. You can prevent having to make these types of repairs by the 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.*

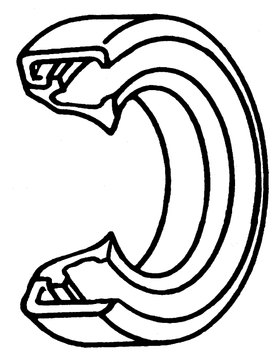


Figure 1

CLEANING AND INSPECTION

General Instructions

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 installed parts such as thrust bearing, matched parts, etc.

WARNING

AVOID DEATH OR SERIOUS INJURY

Do not inhale vapors or allow solvent type cleaners to contact skin. Keep solvent away from open flame, arcs or sparks or other sources of ignition that could start a fire.

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 airstream 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 lightweight 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 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 and on oil seals to assure an oil tight install 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. 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 no twisted splines, and that shafts are normal condition.

   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 the bearing has been turning in its housing or on its shaft.

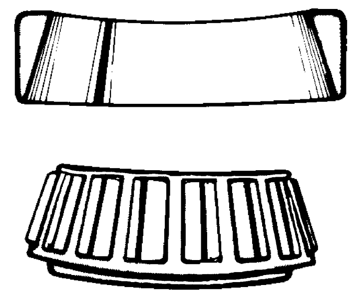
If available, use magna-flux or similar process for checking for cracks that are not visible.

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

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

Normal Bearing

Smooth even surfaces with no discoloration or marks.

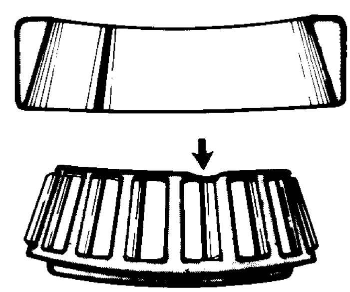


HASA620S

Figure 2

Bent Cage

Cage damage because of improper handling or tool usage.



HASA460S

Figure 3

Replace bearing.

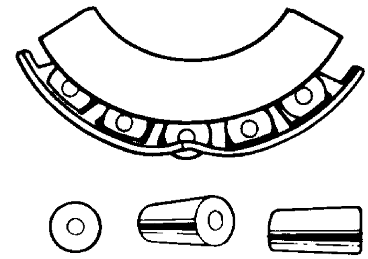

HASA470S

Figure 4

Galling

Metal smears on roller ends because of overheat, lubricant failure or overload.

Replace bearing - check seals and check for proper lubrication.

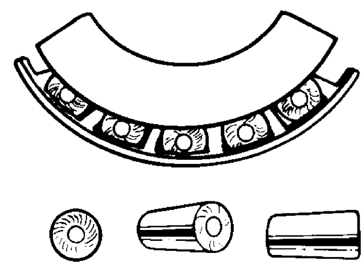

HASA480S

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.

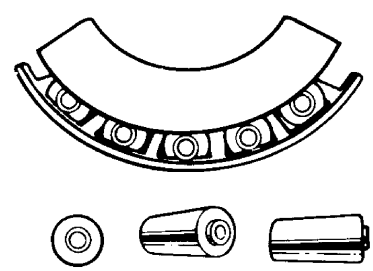
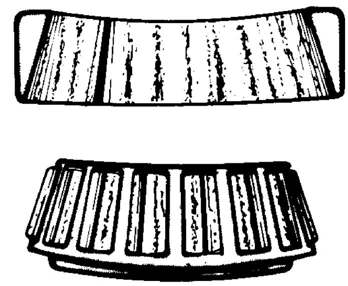

HASA490S

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.



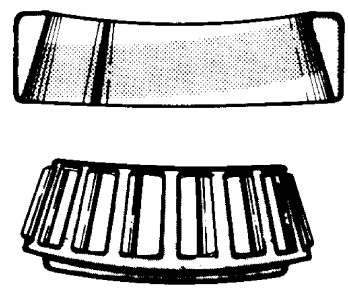
HASA500S

Figure 7

Misalignment

Outer race misalignment because of foreign object.

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



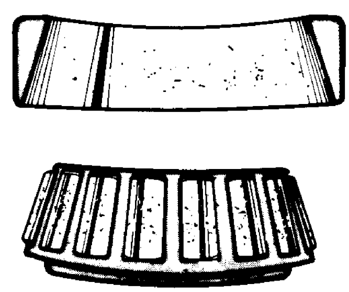
HASA510S

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.



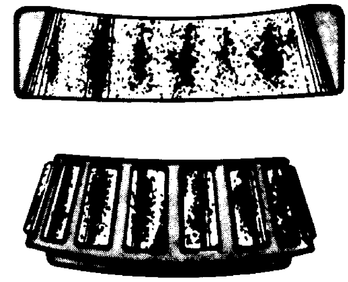
HASA520S

Figure 9

Fatigue Spalling

Flaking of surface metal resulting from fatigue.

Replace bearing - clean all related parts.



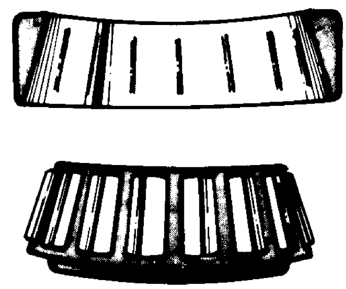
HASA530S

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.



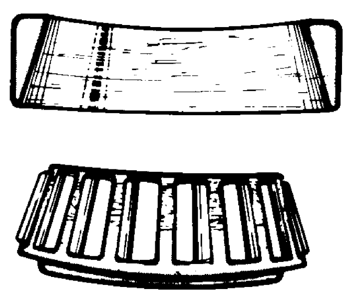
HASA540S

Figure 11

Cage Wear

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

Replace bearings - check seals.



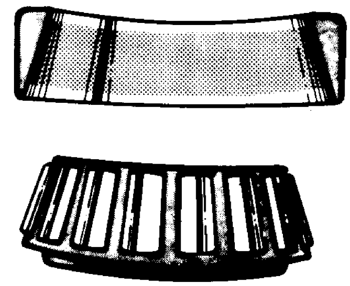
HASA550S

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.



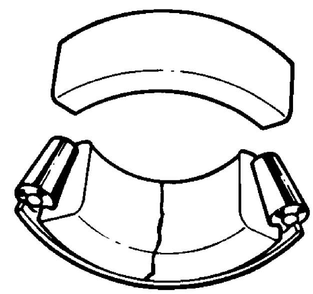
HASA560S

Figure 13

Cracked Inner Race

Race cracked because of improper installation, cocking or poor bearing seat.

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



HASA570S

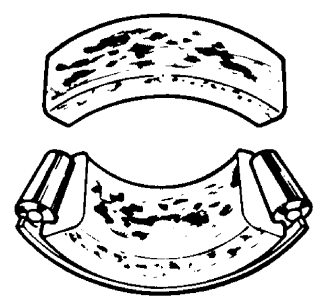
Figure 14

Smears

Smearing of metal because of slippage caused by poor installation, lubrication, overheating, overloads or handling damage.

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

Replace shaft if damaged.



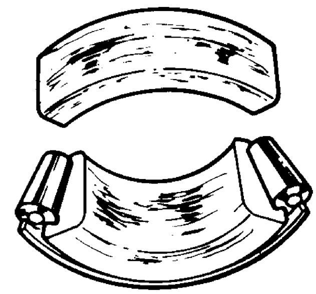
HASA580S

Figure 15

Frettage

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

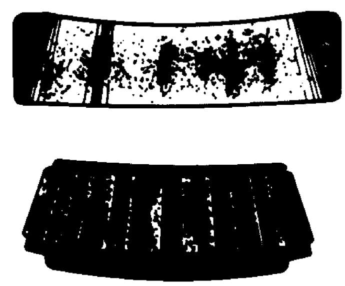
Heat Discoloration

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 overheating damage is indicated. Check seals and other related parts for damage.



HASA600S

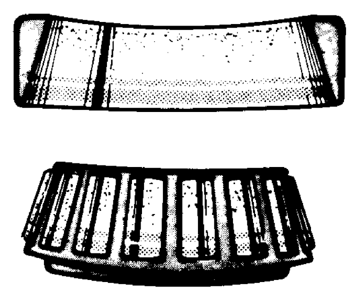
Figure 17

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

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

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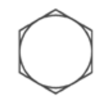
Standard Torques

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 (13.23)	5.20 (37.61)	7.50 (54.24)	7.00 (50.63)	10.00 (72.33)	11.50 (83.17)	12.00 (86.79)	17.00 (122.96)	20.00 (144.66)
M14 x 1.5	4.10 (29.65)	4.30 (31.10)	6.60 (47.73)	5.70 (41.22)	8.30 (60.03)	7.50 (54.24)	11.10 (80.28)	12.50 (90.41)	13.00 (94.02)	18.50 (11.26)	22.00 (158.12)
M16 x Std.	5.60 (40.50)	6.00 (43.39)	9.00 (65.09)	8.00 (57.86)	11.50 (83.17)	10.50 (75.94)	15.50 (112.11)	17.90 (129.47)	18.50 (133.81)	26.00 (188.05)	31.00 (224.22)
M16 x 1.5	6.20 (44.84)	6.50 (47.01)	9.70 (70.16)	8.60 (62.20)	12.50 (90.41)	11.30 (81.73)	17.00 (122.96)	19.50 (141.04)	20.00 (144.66)	28.00 (202.52)	35.50 (256.77)
M18 x Std.	7.80 (56.41)	8.30 (60.03)	12.50 (90.41)	11.00 (79.56)	16.00 (115.72)	14.50 (104.87)	21.00 (151.89)	27.50 (198.90)	28.50 (206.14)	41.00 (296.55)	43.00 (311.01)
M18 x 1.5	9.10 (65.82)	9.50 (68.71)	14.40 (104.15)	12.50 (90.41)	18.50 (133.81)	16.70 (120.79)	24.50 (177.20)	27.50 (198.90)	28.50 (206.14)	41.00 (296.55)	49.00 (354.41)
M20 x Std.	11.50 (83.17)	12.00 (86.79)	18.00 (130.19)	16.00 (115.72)	22.00 (159.12)	19.00 (137.42)	31.50 (227.83)	35.00 (253.15)	36.00 (260.38)	51.00 (368.88)	60.00 (433.98)
M20 x 1.5	12.80 (92.58)	13.50 (97.64)	20.50 (148.27)	18.00 (130.19)	25.00 (180.82)	22.50 (162.74)	35.00 (253.15)	39.50 (285.70)	41.00 (296.55)	58.00 (419.51)	68.00 (491.84)
M22 x Std.	15.50 (112.11)	16.00 (115.72)	24.50 (177.20)	21.00 (151.89)	30.00 (216.99)	26.00 (188.05)	42.00 (303.78)	46.00 (332.71)	49.00 (354.41)	67.00 (484.61)	75.00 (542.47)
M22 x 1.5	17.00 (122.96)	18.50 (133.81)	28.00 (202.52)	24.00 (173.59)	34.00 (245.92)	29.00 (209.75)	47.00 (339.95)	52.00 (44.76)	56.00 (405.04)	75.00 (542.47)	85.00 (614.80)
M24 x Std.	20.50 (148.27)	21.50 (155.50)	33.00 (238.68)	27.00 (195.29)	40.00 (289.32)	34.00 (245.92)	55.00 (397.81)	58.00 (419.51)	63.00 (455.67)	82.00 (593.10)	92.00 (655.43)
M24 x 2.0	23.00 (166.35)	35.00 (253.15)	37.00 (267.62)	31.00 (224.22)	45.00 (325.48)	38.00 (202.52)	61.00 (441.21)	67.00 (484.61)	74.00 (535.24)	93.00 (672.66)	103.00 (744.99)

TORQUE VALUES FOR STANDARD U.S. FASTENERS

Type	SAE 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.

0.9 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 where **SPECIAL TORQUE VALUES** are not given.

NOTE: *Torque values listed throughout this manual are lubricated (wet) threads; values must be increased 1/3 for nonlubricated (dry) threads.*

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 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, 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 ±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

ORFS SWIVEL NUT RECOMMENDED TORQUE

Dash Size	Hose I.D.	Thread Size	Torque (kg.m) Recommended
4	1/4"	9/16"	2.4 - 2.6
6	3/8"	11/16"	3.3 - 3.9
8	1/2"	13/16"	5.1 - 5.7
12	3/4"	1 3/16"	11.7 - 12.7
16	1"	1 7/16"	15.3 - 17.3
20	1 1/4"	1 11/16"	18.0 - 20.0

TORQUE VALUES FOR SPLIT FLANGES

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

NOTE: *Over torquing bolts will damage the flanges and/or bolts, which can 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:

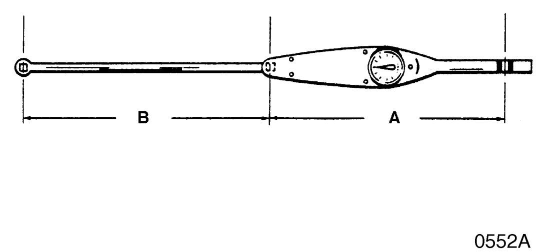


Figure 1

I = A x 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 there is no added deflection or "give" in the joint between the extension and torque wrench. Readings may also be inaccurate:*

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

Other Uses for Torque Wrench Extension Tools

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

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

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

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

Tightening Torque Specifications (Metric)

(For coated threads, prelubricated assemblies.)

IMPORTANT

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. HYUNDAI does not specifically approve a specific manufacturer or brand name, but the following table of "Loctite" applications is included for which cross-references to other manufacturer's products should also be widely available.

IMPORTANT

Use primer "T" or "N" for all cold weather assembly of fastener adhesives, with Threadlocker 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 0.762 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.

Engine

Engine

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

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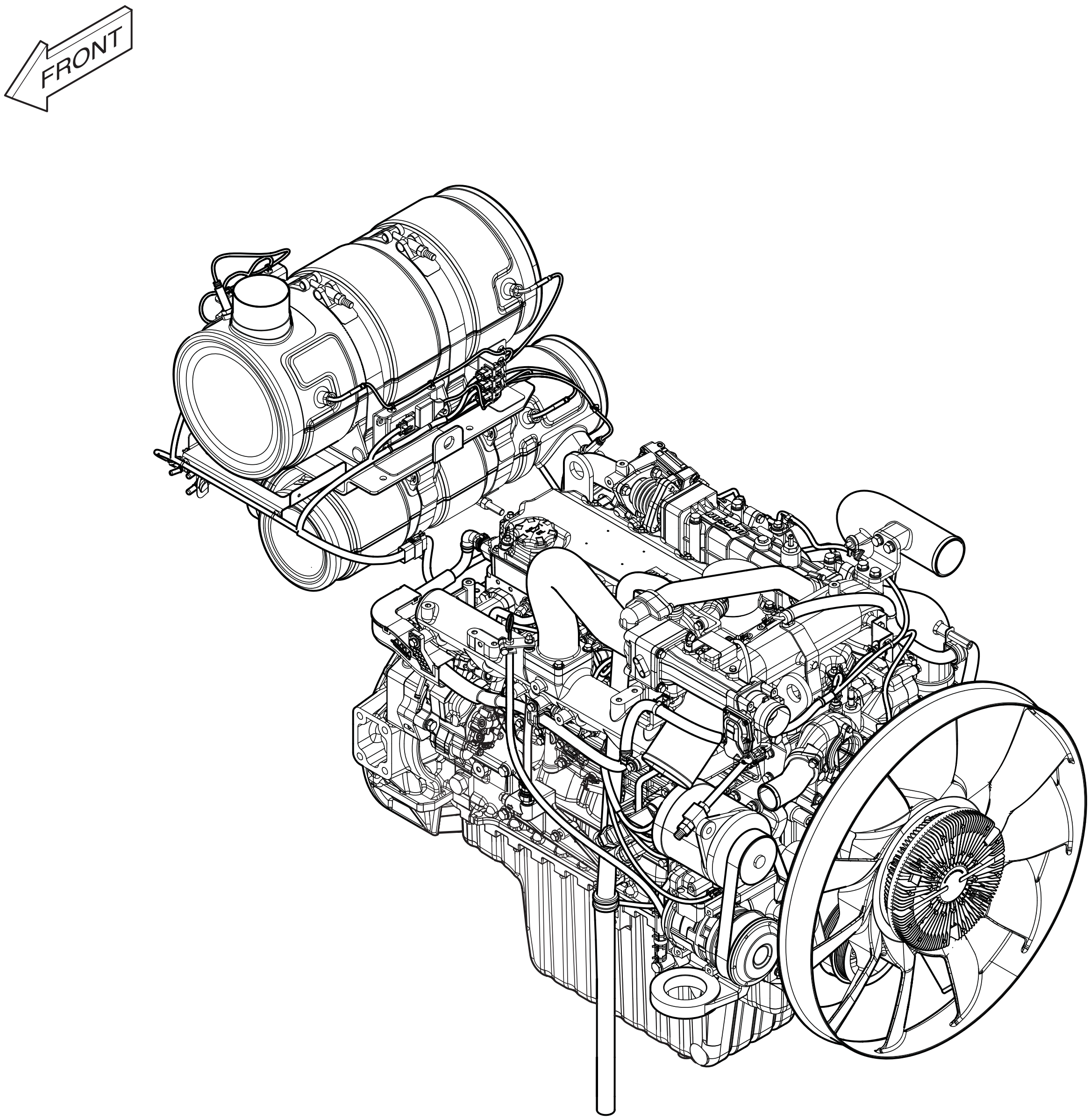
Engine

OVERVIEW



EX1403491

Figure 1

GENERAL INFORMATION

General Description

This manual provides the most efficient methods for engine maintenance as well as quick, efficient methods to determine the cause of engine faults to ensure that any actions taken by professionally certified maintenance technicians are done in the most efficient and efficient way possible. If maintenance is performed by unskilled technicians, or maintenance without the specified tools and facilities, serious bodily injury or critical faults in engine performance may occur. Regular inspection and maintenance are required to maintain long-term optimal engine conditions and best performance. In the event that a part must be replaced, only genuine parts as defined by the parts the list (Parts Book) should be used. HYUNDAI shall not be held liable for any critical damage or faults which may be caused by the use of unauthorized or remanufactured parts. The maintenance methods stated in this Operation and Maintenance Manual are the most efficient and safest work procedures. Some work procedures require special tools.

For questions about genuine parts and special tools, please contact us.

This manual includes 'Danger', 'Warning', and 'Caution' in order to reduce possible injuries and engine faults which may occur while performing maintenance. If workers do not follow the instructions, critical faults in engine performance and operation or serious bodily injury may occurred. 'Danger', 'Warning', and 'Caution' instructions must be followed. However, we inform you that it is not possible to describe all possible and unexpected dangers which may arise while performing engine maintenance.

Cautions for Starting the Engine

1. Before starting the engine, please read this manual carefully and fully understand 'Danger', 'Warning', and 'Caution'. If you cannot fully understand it or have any question, please contact us.
2. For safety reasons, attach "Warning" signs around engines in operation to keep people other than workers from accessing the engines. Let engine operators know that they are responsible for the safety of the engine room.
3. Only authorized people may start and operate engines. Unauthorized people should not be allowed to handle engines.
4. Do not access running or rotating parts while the engine is in operation.
5. Be careful not to touch or contact the engine during operation since it becomes hot during operation.
6. Exhaust gas is poisonous. Fully ventilate before starting engine. If the space is airtight, ensure that it is well ventilated.

Cautions for Inspection and Repair

1. Inspection and repair of engine should be performed only when the engine is stopped. Otherwise, burns or safety accidents may occur, so do not perform inspection or repair while the engine is running.
2. If it is absolutely necessary to perform inspection or repair on the operating engine, do not get close to the rotating parts.

DANGER

AVOID DEATH

When accessories such as necklaces, rings, watches, or gloves become stuck in rotating parts while the engine is running, serious bodily injury may occur.

WARNING

AVOID DEATH OR SERIOUS INJURY

Do not exchange or disassemble a pipe or horse (from the engine fuel circuit, engine oil circuit, coolant circuit, or compressed air circuit) while the engine is running. The leaked liquid may cause bodily injuries.

3. Use an engine oil drain container that is large enough to prevent the overflow of engine oil while draining engine oil.
4. Open the engine coolant cap after fully cooling the engine to exchange or replenish coolant.

WARNING

AVOID DEATH OR SERIOUS INJURY

If the coolant cap is opened while the engine is still hot, hot water will spurt out and may cause burns. Open the engine coolant cap after fully cooling the engine.

5. Fuel is highly flammable. Smoking or use of fire around an engine may cause fire.

WARNING

AVOID DEATH OR SERIOUS INJURY

Only refuel when the engine is stopped.

6. Mark and separately manage the containers for storing coolant from beverage containers for avoiding confusion. See a doctor immediately in case of drinking coolant.
7. Follow the instructions provided by the battery manufacturer when checking or handling batteries.

WARNING

AVOID DEATH OR SERIOUS INJURY

Battery fluid is corrosive and dangerous because of its explosiveness and toxicity. Therefore, it should only be handled by a skilled technician who specializes in battery fluid.

8. Only certified professional technicians should repair and maintain engines.
9. Only appropriate tools should be used. If the jaws of a wrench are worn out, the wrench might slip during use, causing safety accidents.
10. Do not allow other persons to stay or pass under an engine when lifting the engine with a crane. Before lifting the engine, ensure that there is no one around the engine and reserve enough safety space.
11. Before inspecting or replacing the electrical apparatus, disconnect the battery ground wire first. Connect the battery ground wire after completing all required work for checking or replacing the electrical apparatus in order to prevent a short circuit.
12. Before performing electric welding works, turn off engine, block the power supply to the engine, and remove the wire harness connector connected to the engine control unit (ECU).
13. Do not give any electric or mechanical shocks or perform welding works on the electrical apparatus or the ECU.

General Repair

1. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.

   Before performing fuel line work, check the common rail pressure and engine temperature by using the failure diagnosis device.
2. Disconnect the battery ground wire from to prevent damage of wires and sensors caused by a short circuit.
3. Engine oil and coolant may damage paint and should be stored in a separate container and marked for safe management.
4. Store the disassembled parts in a specified space to avoid damage or pollution.

5. Use specified and special tools for efficient and safe repair.
6. If parts need to be replaced, use only genuine parts for replacement. Using unauthorized or remanufactured parts may cause critical damage and faults in engine performance.
7. Replace parts such as cotter pins, gaskets, O-rings, seal rings, oil seals, and washers with new ones during repairs. Reuse of parts may be the cause of engine faults and engine may not operate properly.
8. Group and store disassembled parts in disassembling order. The strength, shape, and screw torque of bolts and nuts are different according to their assembly position. Please divide and store them accordingly to these characteristics.
9. Clean disassembled parts to remove foreign substances before inspecting or reassembling parts. Use compressed air to clean the oil holes or holes.
10. Thinly spread oil or grease on rotating parts or parts requiring lubrication, before assembling them.
11. If required, use a specified adhesive to assemble gaskets to prevent water or oil from leaking.
12. Assemble bolts and nuts with the specified tightening torque.
13. After completing repairs, conduct a final inspection and perform a test operation to check if all works have been successfully completed.

Other Safety Instructions and Environmental Pollution

Observe the following instructions to protect workers from danger and to prevent the environmental pollution while performing engine repairs.

1. Good ventilation and low humidity should be maintained in the work space.
2. The workspace should be clean, in good order, and no flammables are allowed in the workshop.
3. Smoking is strictly forbidden in the workshop.
4. Workers should wear working clothes, protective goggles, and safety shoes.
5. Workers are not allowed to wear accessories such as necklaces, rings, watches, and earrings.
6. Start the engine in a well-ventilated space and fully ventilate the space before starting engine to prevent carbon monoxide poisoning.
7. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.

8. Do Not work on rotating or running parts once the engine has been started.
9. Discard oil according to the regulations set forth by the relevant authorities.
10. If engine oil or fuel leaks on the floor or is improperly discharged, serious environmental pollution of sea, river or underground water may occur.
11. Discard the undiluted anticorrosive agent, antifreeze, filter elements, and cartridges as special wastes.
12. Discard coolant and special waste according to the regulations of the appropriate authorities.

WARNING

AVOID DEATH OR SERIOUS INJURY

Failure to observe the regulations of the relevant authorities violates environmental pollution regulations and may be subject to legal penalties.

Use of Genuine Parts

An engine consists of many parts which are mechanically harmonized. To prevent engine faults in advance and use engines with best performance for a long period, maintenance and replacement of expendable parts should be conducted regularly.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which HYUNDAI shall not be held liable.

Engine Maintenance

Prevention of Damage and Abrasion

Using an engine for any purposes other than the designed purpose may cause critical faults in engine performance for which HYUNDAI shall not be held liable. For details concerning the usage and purpose of the engine, please direct questions to our Sales Team. Do not adjust, convert, or change the ECU without our authorization.

If a problem is found in an engine, figure out and solve the cause to prevent the critical faults in advance.
Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which HYUNDAI shall not be held liable.

Consider the following while managing engines.

1. Use clean, specified, and qualified fuel only. Use fuel recommended in this Operation and Maintenance Manual.

CAUTION

AVOID INJURY

Using inappropriate or unspecified fuel may cause critical damage and faults in engine performance.

2. Do not operate an engine without lubrication oil or coolant. Use only the products (engine oil, cooling water, anticorrosive agent, and etc) recommended by HYUNDAI.
3. Always keep surroundings of the engine clean.
4. Use fuel recommended in this Operation and Maintenance manual.
5. Conduct inspections and exchanges regularly according to the regular inspection table.
6. If the engine is overheated, do not stop it immediately, but operate it at idle status for five minutes or more to lower the engine temperature to the proper level.

WARNING

AVOID DEATH OR SERIOUS INJURY

If the radiator cap is opened while the engine is still hot, hot water will spurt out and may cause burns.

7. Check the engine oil level on a flat surface. Do not exceed the maximum on the oil level gauge.

CAUTION

AVOID INJURY

Immediately replenish engine oil when the engine oil level is below the lower limit of the engine oil gauge.

8. If there are gauges for battery, oil pressure and coolant and temperature, check if they indicate a normal status.
9. Do not operate engine without coolant.

CAUTION

AVOID INJURY

Always use coolant mixed with antifreeze. If coolant without antifreeze is used, the coolant may freeze causing the coolant passage in the cylinder block to freeze and damaging the engine.

Prevention of Pollution

Consider the following to manage engine without causing environmental pollution.

1. Discharge oil and coolant using collection containers.
2. Discard oil and coolant according to the regulations of the relevant authorities.
3. Be careful not to let discharged oil and cooling water flow into the ground or the sewer. Otherwise, serious pollution of the drinking water source may occur.
4. Classify the oil, filters, and filter cartridges as environmental pollution wastes and discards them according to regulations.
5. Classify the antifreeze, cooling water, and anticorrosive agent as hazardous wastes and discards them according to the regulations.

Handling of Engine Oil

Prolonged and repeated contact of skin with engine oil may cause skin to dry out and contract, causing dermatitis. Engine oil includes substances toxic to the human body. Handle engine oil by observing the following safety rules:

1. Do not expose skin to new engine oil for a long time.
2. Always wear working clothes and gloves.
3. If skin comes in contact with engine oil, immediately wipe it off with water, soap or hand cleaners.
4. Do not clean skin with gasoline, fuel, thinner, or solvent.
5. Apply a skin protective cream after cleaning from oil.
6. Do not put oil-stained gloves or cloth in ones pocket.

WARNING

AVOID DEATH OR SERIOUS INJURY

Discard oil according to the regulations set forth by the relevant authorities. Disposing of discharged oil into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of engine oil without observing the handling regulations, will be punished.

Inspection and Repair of the Engine

Checking Engine Parts after Prolonged Operation

Wear, corrosion, or degradation of engine elements and assemblies may occur, causing lowered performance of engine parts. To maintain high engine performance, check the engine after prolonged operation to enhance the durability of the engine.

Unexpected faults may occur in some weak engine parts after normal operation of the engine, when operation time is prolonged. In this case, it is difficult to maintain high engine performance by simply repairing some parts. We recommend the entire part be replaced or repaired in order to find out the causes more accurately and maintain high engine performance.

To prevent engine failure in advance and use the engine safely for a long period, perform periodic replacements and inspections.

It is recommended to perform engine adjustments and preventive inspections during spring after the engine was exposed to winter or cold weather. This allows economic, long-term use of the engine without faults. As the following parts affect the engine output and performance, these parts should be regularly checked and inspected.

1. Parts affecting intake and exhaust
    - Air filter
    - Intercooler
    - Turbocharger, muffler
    - EGR cooler and valve
    - Other parts
2. Parts affecting lubrication and cooling
    - Air filter
    - Oil filter
    - Antifreeze
    - Other parts

Inspection and Repair of Turbocharger

As performance of supercharger significantly affects the engine performance, regular inspections and repairs should be performed and inspection and maintenance regulations should be observed.

Intake Unit

Be careful when handling the air filter in the intake unit. If oil level of the wet air filter is below the specified level, filtering performance is degraded. On the other hand, if the oil level is higher, oil may flow into the case, and it may become polluted. In regards to the dry air filter, intake resistance should be small to ensure the smooth intake of air.

Exhaust Unit

If exhaust emission is leaked from the part connecting the exhaust tube and the turbocharger, the supercharger efficiency is lowered, causing degraded engine output and, if serious, burning of related parts. As parts related to exhaust and turbocharger are used at high temperature, be careful not to mix the bolts and nuts with other parts when performing repair.

Lubrication System

Inspection and replacement of the lubrication system should be performed according to the replacement schedule of oil and oil filter. Overheated engine oil can affect not only the engine itself, but also the engine performance.

ENGINE IDENTIFICATION

Engine Data Plate

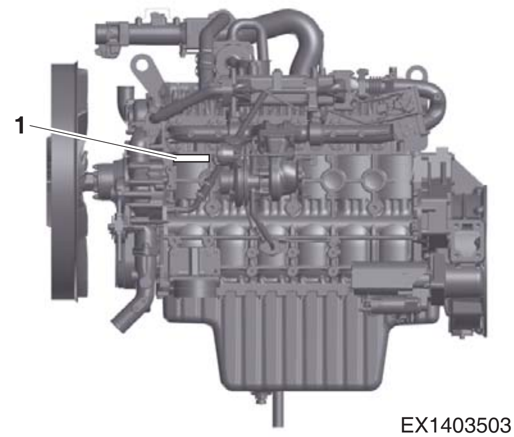


Figure 2

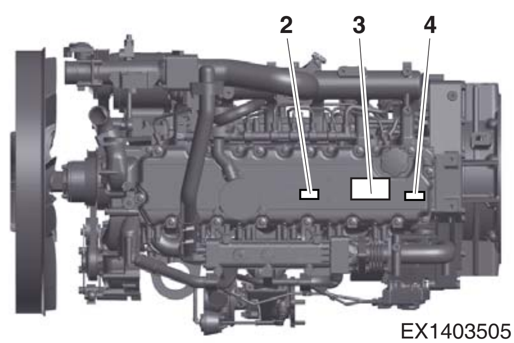


Figure 3

1. **Engine Numbering**

   This decal indicates the model name and suffixes that contain the engine's information.

   See Figure 2 for information on each set of numbers.

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
(A) (B) (C) (D)

A. Sales Model Name (4 ~ 7 digits)
B. Production Year (1digit)
C. Serial Number (5 digits)
D. Engine Suffix(2 digits)

ex) DL06P 418423E1

EX1403504

Figure 4

2. **Quality Inspection Sticker**

This decal displays a barcode for checking the engine's basic information and quality data.

3. **Emission Label**

This decal shows information on the region's emission regulations.

- NA

4. **Engine Oil**

This decal specifies oil specification applicable to the engine.

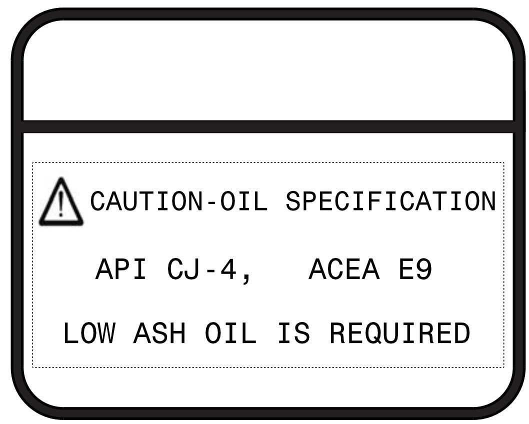


Figure 8 EX1403509

ENGINE SPECIFICATION

Items		Specification
Engine	Type	4-Cycle Water Cooled, Waste Gate Turbocharge, Air to Air Intercooled Direct Injection
	Emission	US EPA Tier 4 Final (EU Stage IV)
	Model	DL 06P
	Injection System	Extra High-pressure Fuel Injection System
	Rated Net Power	167 HP (169 PS) @ 1,800 rpm (SAE J1995)
Valve Clearance	Intake Valve	0.3 mm
	Exhaust valve	0.4 mm
Number of Cylinders and Configuration		6, Straight
Rotating Direction (from Flywheel)		Counterclockwise
Oil Pressure	Max. Permitted	6.1 kg/cm^2 (6 bar, 87 psi)
	Min. Permitted at Idling Speed	1.5 kg/cm^2 (1.5 bar, 21.7 psi)
Using Lubrication Oil		API CJ-4 or Higher
Oil Filter		Paper Filter
Interval Between Oil Changes		500 h
Working Principle		4 Stoke Engine
Cylinder Diameter		100 mm
Piston Stroke		125 mm
Displacement		5,890 cc
Compression Ratio		17.4:1
Low Idle Speed		800 rpm
Max. Full Load Speed		2,000 rpm
Weight, without Coolant and Oil		644 kg
Cooling System	Volume, Excluding Radiator	13,000 cc
	Coolant Temperature	90 ~ 95°C
	Number of Thermostats	1
	Thermostat, Opening Temperature	83°C
Electrical System	Type	1-pin, 24 V, DC
	Starter Motor (Standard Equipment)	1-pin, 24 V, 6 kW
	Alternator (Standard Equipment)	1-pin, 24 V, 80 A

ENGINE PERFORMANCE CURVES

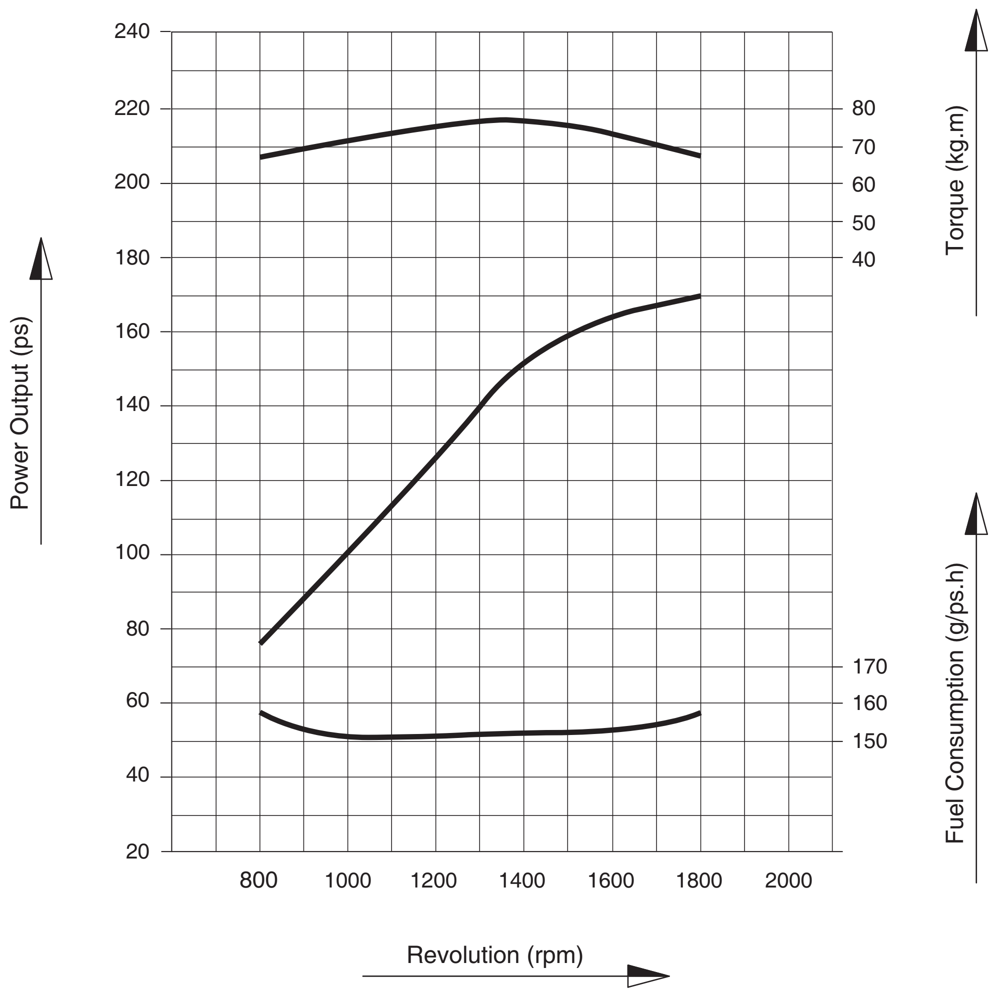


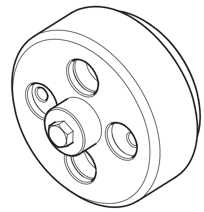
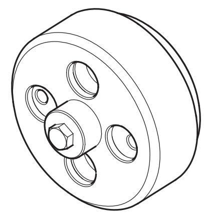
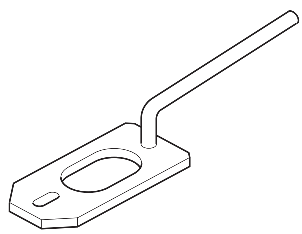
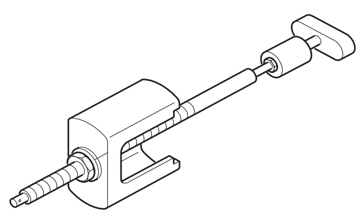
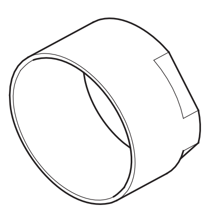
Figure 9

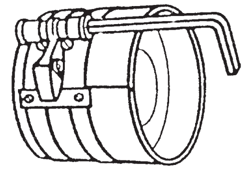
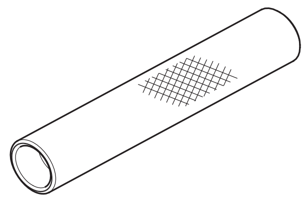
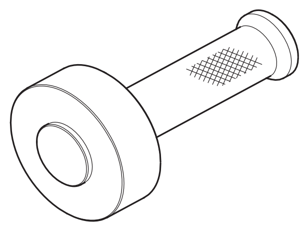
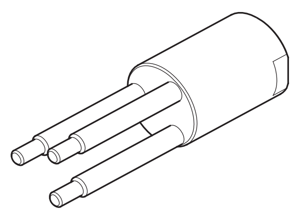
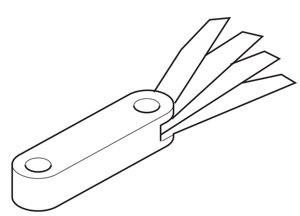
EX1404284

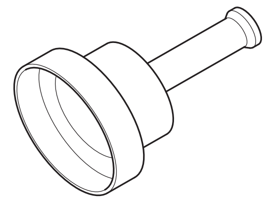
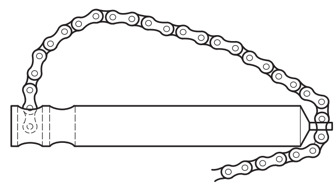
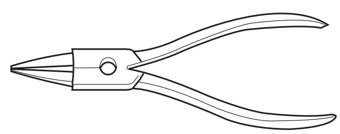
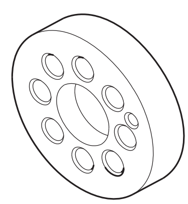
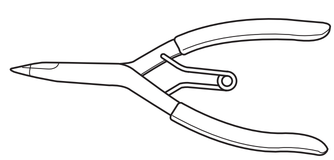
Performance Standard	KS R 1004
Power (Max. Rated)	167 HP (169 PS, 124 kW)/ 1,800 rpm
Max. Torque	755 N.m (77 kg.m, 557 ft lb)/ 1,400 rpm
Fuel Consumption (Max. Rated)	156.7 g/ps.hr

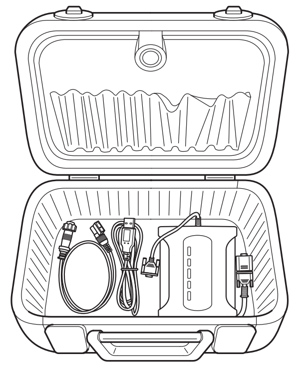
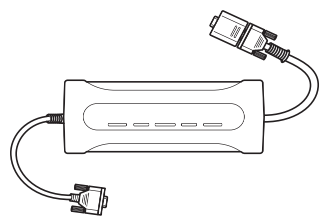
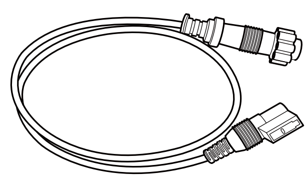
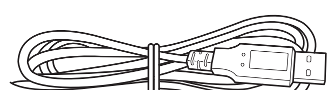
NOTE: *DEF consumption is approximately 5% of fuel consumption.*

SPECIAL TOOLS

Number	Designation	Picture	Tool Board
EF.121-299	Oil Seal Installation Jig (Front)	 EX1403581	
EF.121-300	Oil Seal Installation Jig (Rear)	 EX1403581	
EF.123-065	Valve Spring Compressor	 EX1403582	
EF.123-365A	Cylinder Liner Disassembly Tool	 EX1403583	
EF.121-250	Piston Inserting Tool (Only for DL06 Engine)	 EX1403584	

Number	Designation	Picture	Tool Board
EF.120-208	Piston Inserting Tool (for all Engine Models)	 EX1403585	
EF.121-253	Valve Stem Seal Inserting Tool (for all Engine Models)	 EX1403586	
EF.121-181	Camshaft Hole Cover Punch	 EX1403587	
EF.121-252	Step Idle Gear Pin Installation Jig	 EX1403588	
60.99901-0027	Feeler Gauge	 EX1403589	

Number	Designation	Picture	Tool Board
EF.121-260	Wear Ring Punch (Rear)	 EX1403590	
65.98801-0001	Filter Wrench	 EX1403591	
T7610001E	Snap Ring Pliers	 EX1403592	
EF.121-259	Crankshaft Gear Inserting Jig	 EX1403593	
T7621010E	Piston Ring Pliers	 EX1403732	

Number	Designation	Picture	Tool Board
860104-01045	Diagnostic Device	 EX1403595	
860104-01046	UVIM (CAN Module) (for Diagnostic Device)	 EX1403597	
860104-01047	14-pin Connector (for Diagnostic Device)	 EX1403596	
860104-01048	USB (for Diagnostic Device)	 EX1403598	

TIGHTENING TORQUES

Major Parts Tightening Torque

The specifications in the tables below show the major parts tightening torque for screws, nuts and unions. The values are to be used unless other values are specified in the inspection information. Always check whether there are special tightening torques given in the descriptions for the respective areas in the inspection information before using the general values for normal and special tightening torques respectively.

The following conditions apply:

- A tolerance of ±15 % applies to all values unless otherwise specified.
- All contact surfaces are to be clean and free of paint.
- Bolts and nuts are normally not lubricated regardless of surface treatment. All exceptions are specified in the inspection information.

Major Parts	Size (Diameter x Pitch)	Tightening Torques		
		N.m	kg.m	ft lb
Cylinder Block Bearing Cap Bolt	M16 x 2.0	294 ±20	30 ±2	217 ±14
Oil Spray Nozzle	M10 x 1.25	20.6 + 4.9	2.1 + 0.5	15.2 + 3.6
Flywheel Housing Mounting Bolt	M12 x 1.5	109.8 + 9.8	11.2 + 1.0	81 + 7.2
Crank Pulley Mounting Bolt	M14 x 1.5	196 + 2	20 + 0.2	144.7 + 1.4
Shock Absorber	M10 x 1.5	60.8 + 4.9	6.2 + 0.5	44.8 + 3.6
Flywheel Mounting Bolt	M14 x 1.5	196 + 20	20 + 2.0	144.7 + 14
Connecting Rod Cap Bolt	M12 x 1.5	95.6 + 2.45	9.75 + 0.25	70.5 + 1.8
Cylinder Head Bolt	M13 x 1.5	49 + 90° + 90° + 90°	5 + 90° + 90° + 90°	36.2 + 90° + 90° + 90°
Cylinder Head Cover Bolt	M8	21.6 + 4.9	2.2 + 0.5	15.9 + 3.6
Injector Cable Mounting Nut	M4	1.47 + 0.1	0.15 + 0.01	1.08 + 0.07
Rocker Arm Bracket Mounting Bolt	M8 x 1.25	36.3 + 4.9	3.7 + 0.5	26.8 + 3.6
Rocker Arm Adjusting Nut	M10 x 1.0	49 + 4.9	5.0 + 0.5	36.2 + 3.6
Oil Pump Cover	M8	21.6 + 4.9	2.2 + 0.5	15.9 + 3.6
Oil Pump Mounting Bolt	M10 x 1.5	43 + 4.9	4.4 + 0.5	31.8 + 3.6
Oil Cooler Mounting Bolt	M8	21.6 + 4.9	2.2 + 0.5	15.9 + 3.6
Oil Pan Mounting Bolt	M8	21.6 + 4.9	2.2 + 0.5	15.9 + 3.6
Oil Drain Plug	M30 x 1.5	98 + 9.8	10 + 1.0	72.3 + 7.2
Exhaust Manifold Mounting Bolt	M8	49 + 4.9	5.0 + 0.5	36.2 + 3.6
Intake Manifold Mounting Bolt	M10 x 1.5	43 + 4.9	4.4 + 0.5	31.8 + 3.6
Start Motor	M12 x 1.5	78.5 + 9.8	8.0 + 1.0	57.6 + 7.2
Alternator Bracket Mounting Bolt	M12 x 1.5	75.5 + 4.9	7.7 + 0.5	55.7 + 3.6

Major Parts	Size (Diameter x Pitch)	Tightening Torques		
		N.m	kg.m	ft lb
Coolant Temperature Sensor	M12 x 1.5	21.6 (Max. 24.5)	2.2 (Max. 2.5)	15.9 (Max. 18.1)
Engine Mounting Bracket	M10 x 1.5	60.8 + 4.9	6.2 + 0.5	44.8 + 3.6
Fuel High-pressure Pump Gear Nut (CP Pump)	M18 x 1.5	107.9 ±4.9	11 ±0.5	79.6 ±3.6
Fuel Injector Mounting Bracket Bolt	M8	30.4	3.1	22.4
Fuel High-pressure Pump Mounting Bolt (Cylinder Block)	M8	43.1 + 4.9	4.4 + 0.5	31.8 + 3.6
Fuel High-pressure Connector Nut	M22 x 1.5	49 + 4.9	5 + 0.5	36.2 + 3.6
Common Rail Mounting Bolt	M8	21.6 + 4.9	2.2 + 0.5	15.9 + 3.6
Fuel High-pressure Pipe - High-pressure Fuel Connector	M14 x 1.5	27.5 + 4.9	2.8 + 0.5	20.3 + 3.6
Fuel High-pressure Pipe - Common Rail	M14 x 1.5	24.5 + 4.9	2.5 + 0.5	18.1 + 3.6
Fuel High-pressure Pipe - Fuel High-pressure Pump	M14 x 1.5	20.6 + 4.9	2.1 + 0.5	15.2 + 3.6
Fuel Filter Mounting Bolt	M10	43.1 + 4.9	4.4 + 0.5	31.8 + 3.6

Tightening Torque for General Bolts

Keep the following torque values for bolts not specified in the Tightening Torque for Major Parts table.

Dia. x Pitch (mm)	Hardness										
	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)
	Elastic Limit (kg/mm^2)										
	20	24	32	30	40	36	46	54	64	90	106
	Tightening Torque (kg.m)										
M5	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	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	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	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	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	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	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 1.5	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	3.70 (26.76)	3.90 (28.20)	6.00 (13.23)	5.20 (37.61)	7.50 (54.24)	7.00 (50.63)	10.00 (72.33)	11.50 (83.17)	12.00 (86.79)	17.00 (122.96)	20.00 (144.66)
M14 x 1.5	4.10 (29.65)	4.30 (31.10)	6.60 (47.73)	5.70 (41.22)	8.30 (60.03)	7.50 (54.24)	11.10 (80.28)	12.50 (90.41)	13.00 (94.02)	18.50 (11.26)	22.00 (158.12)
M16	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	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	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	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	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 1.5	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)

NOTE: *The standard torque values specified above are based on 70% of a bolt's elastic limit. The tensile force is calculated by multiplying the tensile strength by the cross-sectional area of a screw. A special screw should be tightened to about 85% of the standard torque. For example, a screw coated with MoS2 should be tightened to about 60% of the standard torque.*

Tightening Torque of Plug Screw

M10	M12	M14	M16	M18	M22	M24	M26	M30
5.0	5.0	8.0	8.0	10.0	10.0	12.0	12.0	15.0

Hollow Screw (4-Hole) Tightening Torque

M8	M10	M12	M14	M16	M18	M22	M26	M30	M38
0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0

ENGINE DISASSEMBLY

Engine Disassembly

CAUTION

AVOID INJURY

- **Prepare the necessary tools and genuine parts before engine disassembly.**
- **Prepare a shelf to keep removed parts.**
- **Keep the working area well lighted and clean.**
- **Keep your hands clean at all times during service.**
- **Keep parts removed from the engine in the removal order.**
- **Make sure that removed parts are not mixed and do not touch each other.**

Disassemble the engine according to the following procedure:

1. Drain coolant.
    A. Check that the engine and radiator is sufficiently cooled down.
    B. Place a container in front of the coolant drain plug.
    C. Remove the radiator cap.
    D. Turn to open the drain valve on the bottom of the radiator to drain coolant.
    E. Remove the coolant drain plugs from the cylinder block.
    F. Drain coolant into the prepared container.
    G. After draining coolant, install the drain plug.

DANGER

AVOID DEATH

- **Never open the radiator cap while the engine is hot. If opening the radiator cap while the engine is still hot, hot coolant may spurt, resulting in a severe burn. Open the radiator cap after confirming that the engine is sufficiently cooled down.**
- **Put a label on the coolant container not to get mixed with other containers. If you swallow coolant, seek professional medical help immediately.**

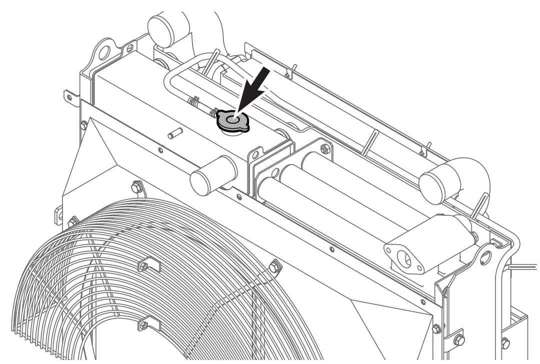


Figure 10 EX1404285

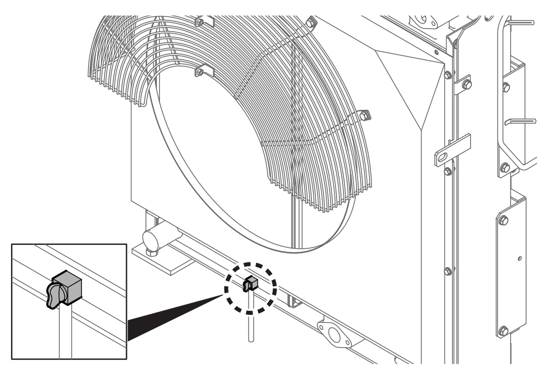


Figure 11 EX1404306

WARNING

AVOID DEATH OR SERIOUS INJURY

Used coolant should be discarded according to the local regulations. Never discard used engine oil to the ground, ditch, sewer, river, sea, etc. Such action can pollute the environment. Discarding used engine oil improperly can result in punishment due to violation of the corresponding regulation.

CAUTION

AVOID INJURY

When changing coolant, make sure that it is not left on any belt or electric part.

2. Separate the dipstick.
   A. Pull out the dipstick.
3. Drain engine oil.
   A. Place a container under the engine to collect drained engine oil.
   B. Remove the drain plug from the oil pan and drain engine oil into the prepared container.
   C. Remove the oil filler cap.
   D. Remove the engine oil filter.
   E. After draining engine oil, install the engine oil filter and drain plug.

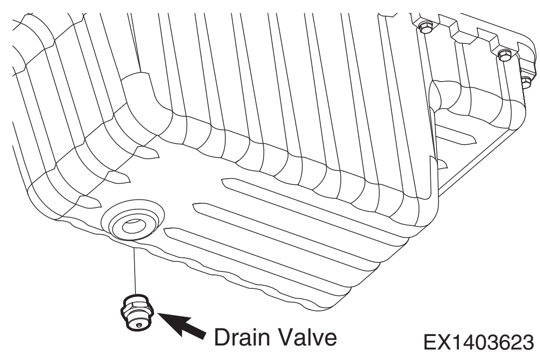


Figure 12

WARNING

AVOID DEATH OR SERIOUS INJURY

Used oil should be discarded according to the local regulations. Never discard used engine oil to the ground, ditch, sewer, river, sea, etc. Such action can pollute the environment. Discarding used engine oil improperly can result in punishment due to violation of the corresponding regulation.

4. Remove the intercooler.
   A. Remove all the hoses and air pipes from the intercooler.
   B. Unscrew the intercooler mounting bolts to remove the intercooler.

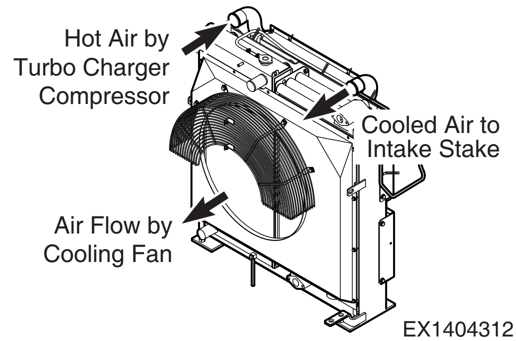


Figure 13

5. Remove the cooling fan.
   A. Remove the fan guide and bracket.
   B. Unscrew the flange mounting bolt to remove the flange and cooling fan.

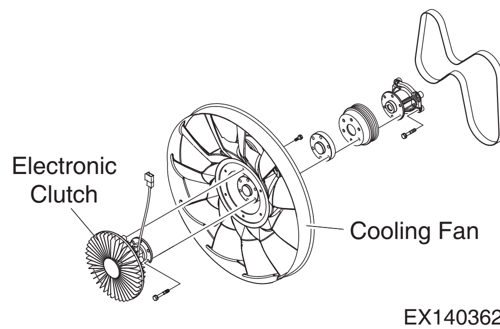


Figure 14

6. Remove the belt.
   A. Unscrew the tension adjusting bolts and mounting bolts of the A/C compressor, air compressor and alternator.
   B. Remove the belt.

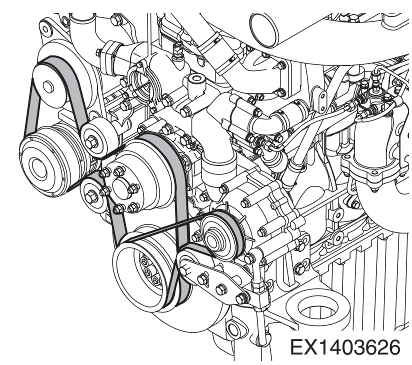


Figure 15

7. Remove the engine from the machine.
8. Disconnect the cables and harnesses of the engine from each sensor.
9. Remove the alternator and A/C compressor.
   A. Unscrew the mounting bolt to remove the alternator.
   B. Unscrew the idle puller mounting bolt to remove the A/C compressor.

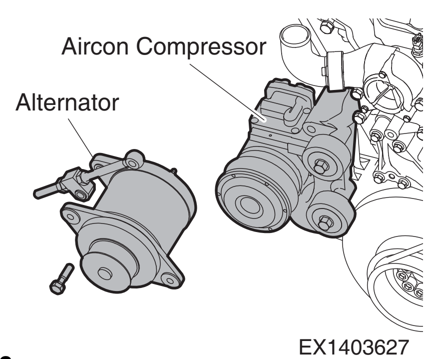


Figure 16

10. Remove the breather.

    A. Unscrew the mounting clamp screw to disconnect the rubber hose.

    B. Remove the breather valve assembly.

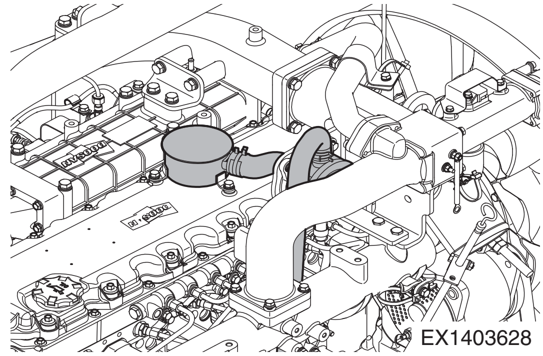


Figure 17

11. Disconnect the air pipe and remove the air heater block.

    A. Unscrew the mounting bolt to disconnect the air pipe and remove the air heater block.

⚠ CAUTION

AVOID INJURY

Never let foreign materials enter the turbocharger.

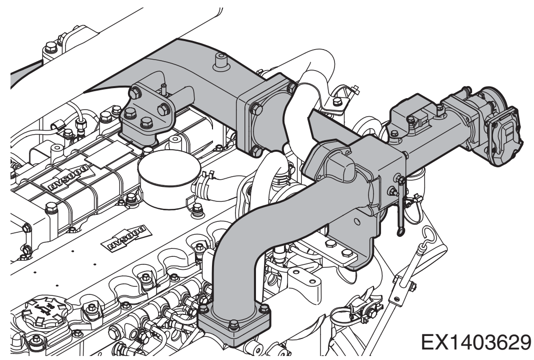


Figure 18

12. Remove the fuel filter.

    A. Unscrew the hollow screw from the fuel filter and disconnect the fuel hose.

    B. Unscrew the fuel filter mounting bolt to remove the fuel filter.

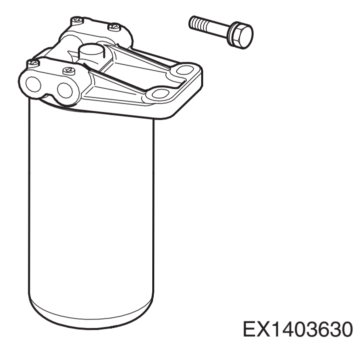


Figure 19

13. Disconnect the intake stake.

    A. Unscrew the mounting bolt to disconnect the air hose.

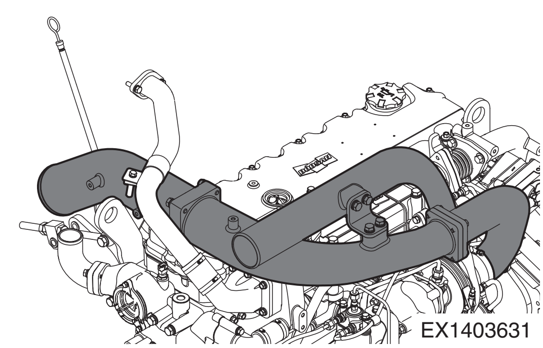


Figure 20

14. Separate the intake manifold.

    A. Unscrew the intake manifold mounting bolts to remove the intake manifold from the cylinder block.

    B. Remove the gasket and clean the gasket mounting surface thoroughly with a scraper.

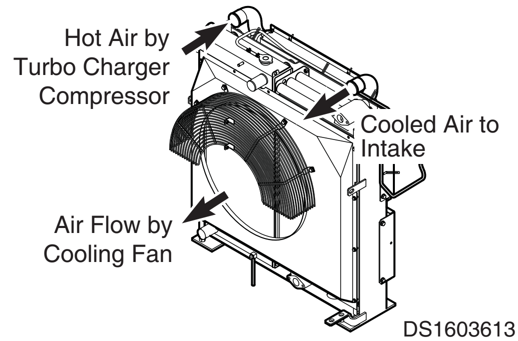


Figure 21

15. Remove the common rail and high-pressure pipe.

    A. Disconnect the high-pressure pipe between the fuel high-pressure connector and common rail.

    B. Unscrew the common rail mounting bolts to remove the common rail.

CAUTION

AVOID INJURY

- **Seal the common rail thoroughly after removing it to prevent foreign materials from entering it.**
- **Once the fuel high-pressure pipe is disconnected, it cannot be reused.**

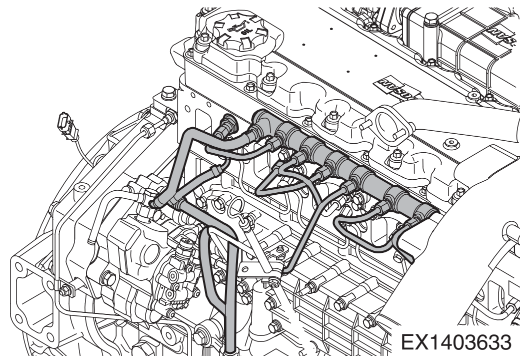


Figure 22

16. Remove the fuel high-pressure pump.

    A. Unscrew the fuel high-pressure pump mounting bolts to remove the fuel high-pressure pump.

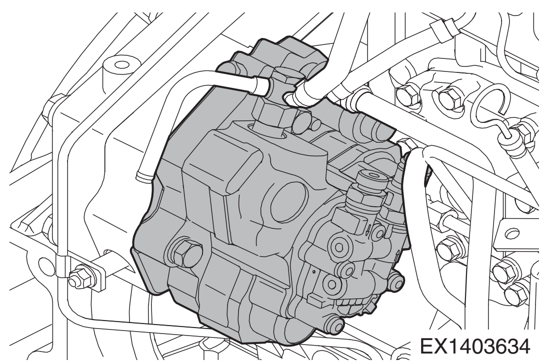


Figure 23

17. Remove the EGR valve.

    A. Unscrew the EGR valve mounting bolts to remove the EGR valve and exhaust manifold.

    B. Unscrew the mounting bolts to remove the exhaust pipe from the EGR cooler.

    C. Disconnect the coolant pipe from the EGR valve.

CAUTION

AVOID INJURY

Seal the EGR valve and exhaust pipe thoroughly after removing them to prevent foreign materials from entering them.

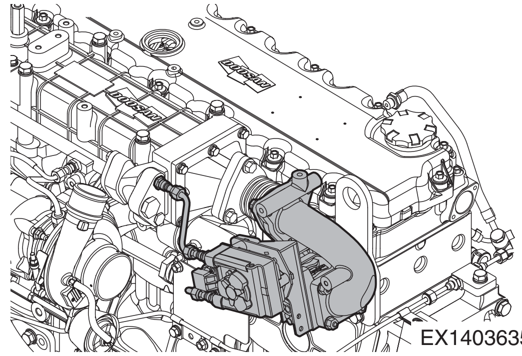

EX1403635

Figure 24

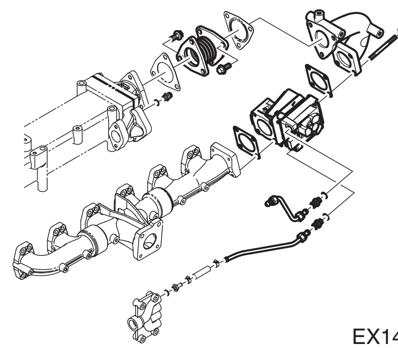

EX1403636

Figure 25

18. Remove the EGR cooler.

    A. Unscrew the EGR cooler and bracket connecting bolt to separate the EGR cooler.

    B. Disconnect the pipe and hose from the EGR cooler.

CAUTION

AVOID INJURY

Seal the EGR cooler thoroughly after removing it to prevent foreign materials from entering it.

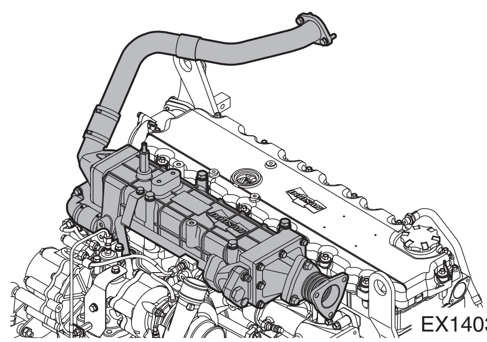

EX1403637

Figure 26

19. Remove dosing module.

    Unscrew the mounting bolt of the dosing module to remove it from the UREA tank.

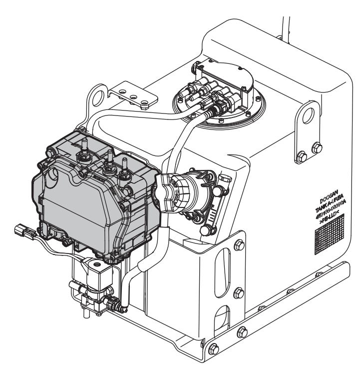

EX1404191

Figure 27

20. Remove the turbocharger.

    A. Disconnect the intake stake from the turbocharger.

    B. Disconnect the coolant hose from the turbocharger.

    C. Disconnect the oil feed pipe and oil drain pipe between the cylinder block and turbocharger.

    D. Unscrew the turbocharger mounting bolts to separate the turbocharger from the exhaust manifold.

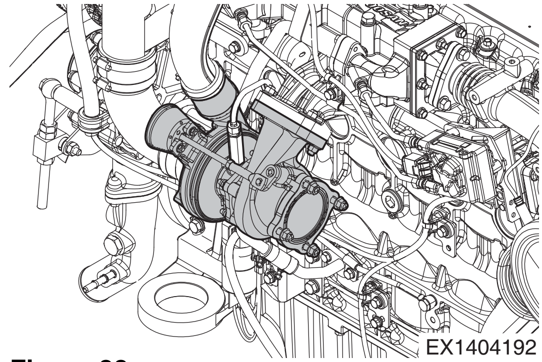


Figure 28

21. Remove the exhaust manifold.

    A. Unscrew the exhaust manifold mounting bolts to remove the exhaust manifold.

CAUTION

AVOID INJURY

Do not reuse the removed gasket.

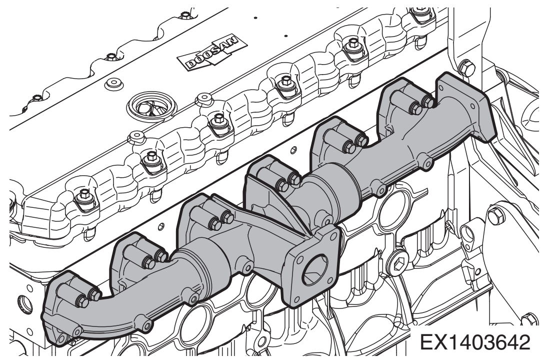


Figure 29

22. Disconnect the coolant pipe and thermostat.

    A. Unscrew the coolant pipe mounting bolt to disconnect the coolant pipe from the thermostat housing.

    B. Remove the coolant thermostat and O-ring.

    C. Clean the gasket mounting surface of the coolant pipe with a scraper thoroughly.

CAUTION

AVOID INJURY

Make sure that the gasket residual does not enter the coolant passage.

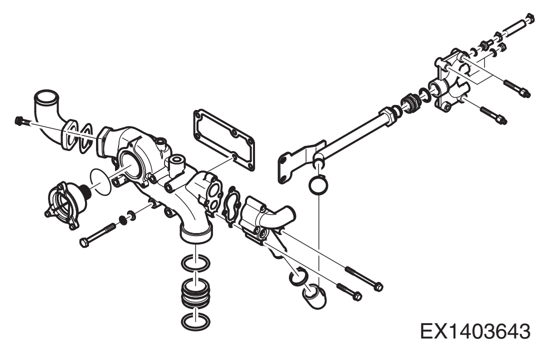


Figure 30

23. Remove the coolant pump.

    A. Unscrew the bracket mounting bolts for the coolant pump and oil cooler.

    B. Unscrew the bolt (1 ea) for the oil cooler.

    C. Unscrew the coolant pump mounting bolts to remove the coolant pump.

    D. Remove the O-ring for the coolant pump.

CAUTION

AVOID INJURY

Do not reuse the O-ring.

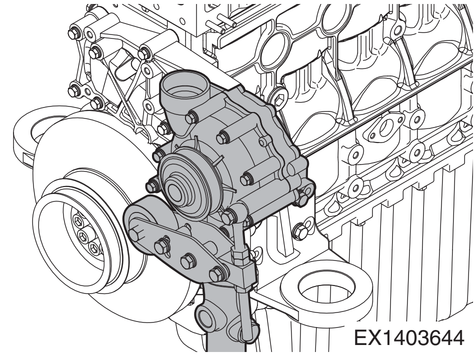


Figure 31

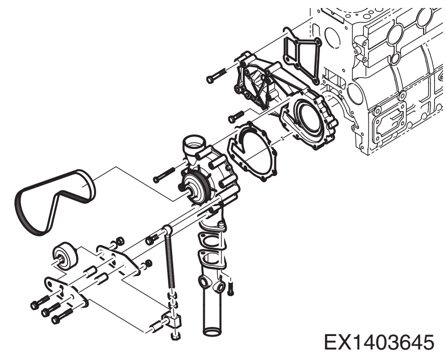


Figure 32

24. Remove the start motor.

    A. Unscrew the start motor mounting nut and remove the start motor with care. Be careful not to damage its gear.

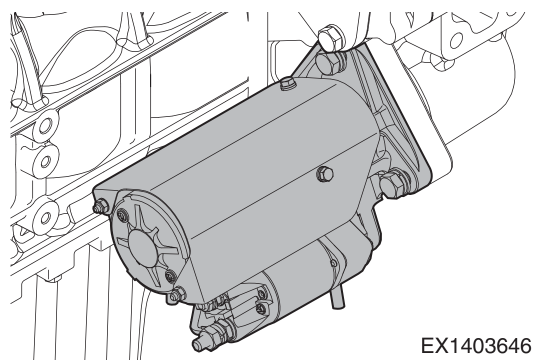


Figure 33

25. Remove the oil filter.

    A. Remove the oil filter cartridge using a special service tool.

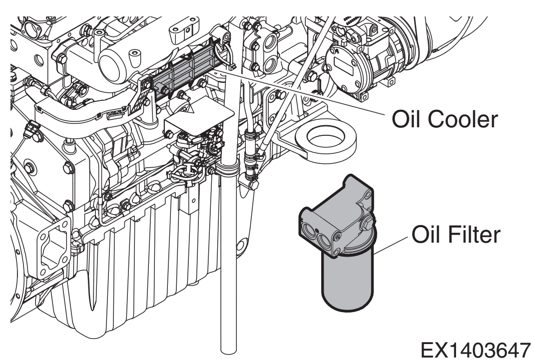


Figure 34

26. Remove the vibration damper.

    A. Unscrew the mounting bolts of the vibration damper and crank pulley in the reverse order to remove the vibration damper assembly.

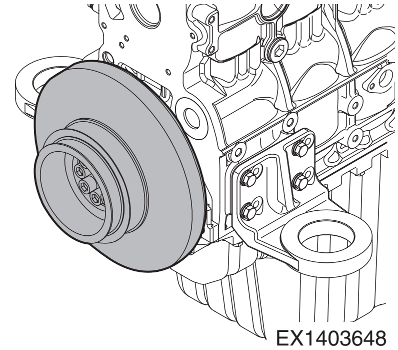


Figure 35

27. Remove the cylinder head cover.

    A. Unscrew the cylinder head cover mounting bolts to remove the cylinder head cover.

    B. Unscrew the intermediate cover mounting bolts to remove the intermediate cover.

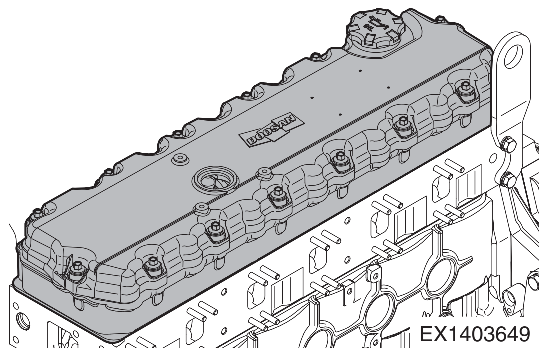


Figure 36

28. Remove the rocker arm.

    A. Unscrew the rocker arm bracket mounting bolts in the reverse order to remove the rocker arm assembly.

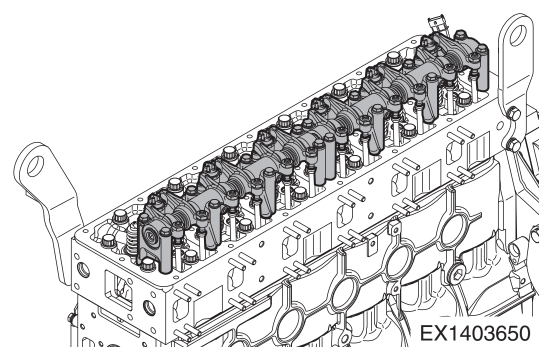


Figure 37

29. Remove the push rod.

    A. Remove the push rod.

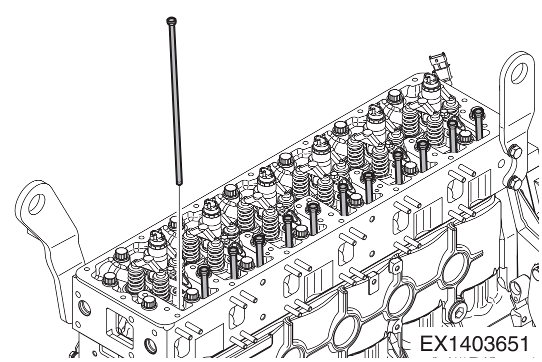


Figure 38

30. Remove the fuel injector.

    A. Unscrew the fuel high-pressure connector mounting bolts to disconnect the fuel high-pressure connector.

    B. Remove the harness from the injector.

    C. Unscrew the injector mounting bracket bolts to remove the injector.

CAUTION

AVOID INJURY

Be careful not to damage the nozzle during removing the injector.

    D. Remove the seal ring from the nozzle hole from the cylinder head.

CAUTION

AVOID INJURY

To remove the injector, unscrew the fuel high-pressure connector mounting nut to disconnect the fuel high-pressure connector completely. Then, unscrew the caliper mounting bolt to remove the injector.

31. Remove the cylinder head.

    A. Unscrew the cylinder head bolts in the reverse order of tightening to remove the cylinder head.

       – Step 1: Unscrew the bolt for 1 to 2 threads.

       – Step 2: Unscrew the bolt completely to remove it.

    B. Remove the cylinder head bolts in these two steps.

    C. Keep the removed bolts in order with care, being careful not to damage their threads.

CAUTION

AVOID INJURY

Make sure that the bolts are not hit by each other.

    D. Remove the cylinder head gasket.

    E. Remove foreign materials from the surface of the cylinder head and block.

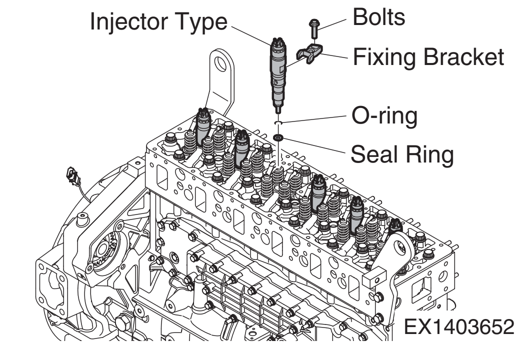


Figure 39

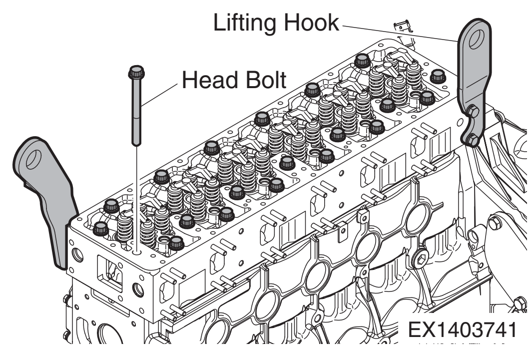


Figure 40

CAUTION

AVOID INJURY

Be careful not to damage the mating surface.

F. Unscrew the mounting bolt of the lifting hook from the cylinder head to remove the lifting hook.

32. Remove the valve and valve stem seal.

A. Press the valve spring and retainer with the valve spring compressor to remove the valve cotter.

B. Remove the valve spring and retainer.

C. Remove the calipers.

D. Use a general service tool to remove the valve stem seal.

CAUTION

AVOID INJURY

Do not reuse the valve stem seal.

E. Remove valve.

F. Unscrew the mounting bolt of the lifting hook from the cylinder block to remove the lifting hook.

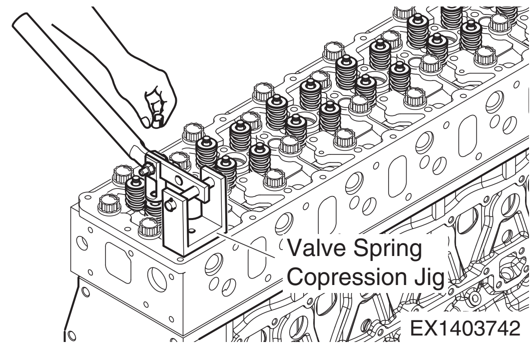


Figure 41

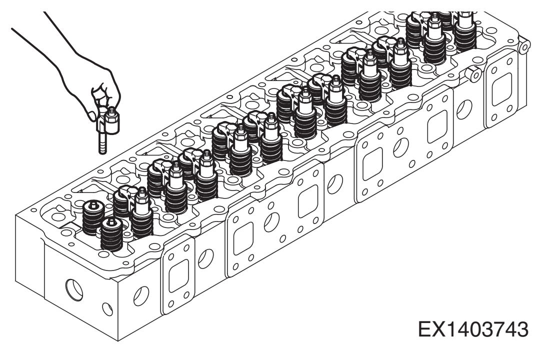


Figure 42

33. Remove the oil cooler.

A. Unscrew the oil cooler mounting bolts to remove the oil cooler.

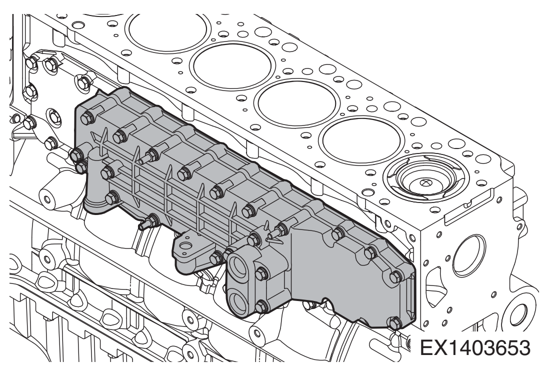


Figure 43

34. Remove the oil pan.

 A. Unscrew the oil pan mounting bolts to remove the oil pan.

 B. Remove the oil pan gasket.

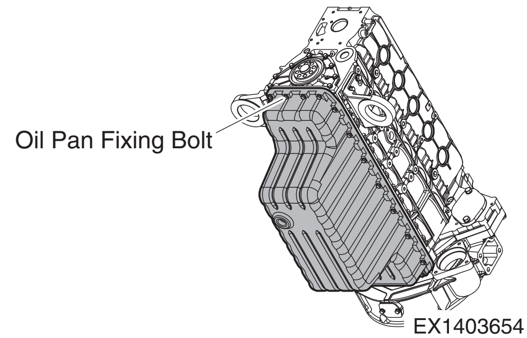


Figure 44

35. Remove the front oil seal and cover.

 A. Remove the oil seal using a oil seal removing tool.

 B. Unscrew the gear case cover mounting bolt to remove the oil seal cover.

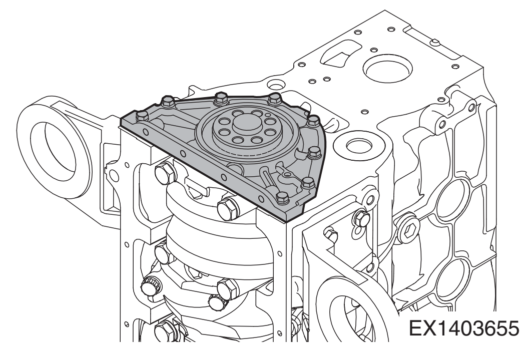


Figure 45

36. Remove the oil pump and disconnect the pipe.

 A. Unscrew the oil suction pipe mounting bolt to remove the bracket.

 B. Unscrew the oil pump pipe mounting bolts to disconnect the suction pipe and feed pipe.

 C. Unscrew the oil pump mounting bolts to remove the oil pump.

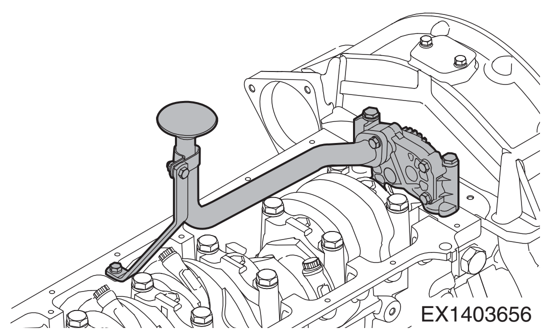


Figure 46

37. Remove the flywheel.

 A. Unscrew the flywheel mounting bolts and install the guide bolt to remove the flywheel.

 B. Unscrew the bolts in the reverse order of their tightening to remove the flywheel.

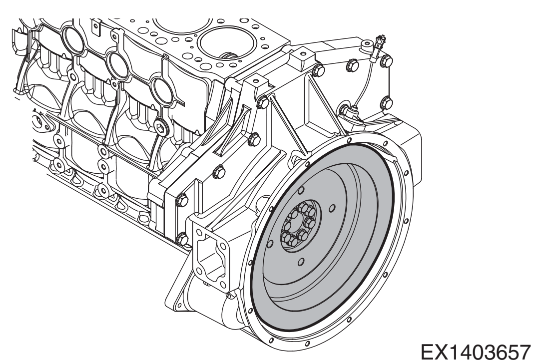


Figure 47

38. Flywheel housing

    A. Unscrew the flywheel housing mounting bolts to remove the flywheel housing.

    B. Remove the flywheel housing oil seal.

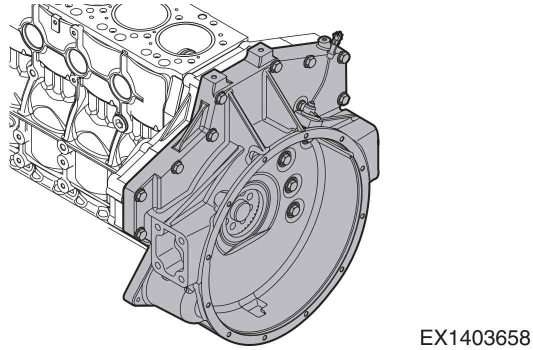


Figure 48

39. Remove the cam gear and idle gear.

    A. Unscrew the camshaft gear mounting bolts to remove the camshaft gear.

    B. Unscrew the idle gear mounting bolts to remove the idle gear.

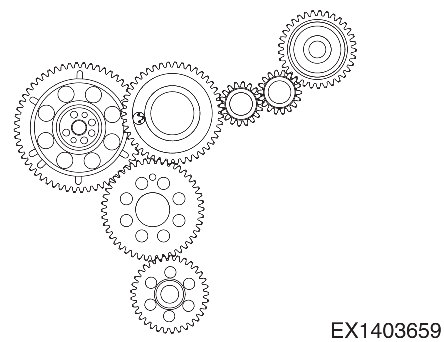


Figure 49

40. Remove the timing gear case.

    A. Unscrew the timing gear case mounting bolts.

    B. Tap the left and right sides on the back of the contact surface of the timing gear case with a urethane hammer gently to remove the timing gear case.

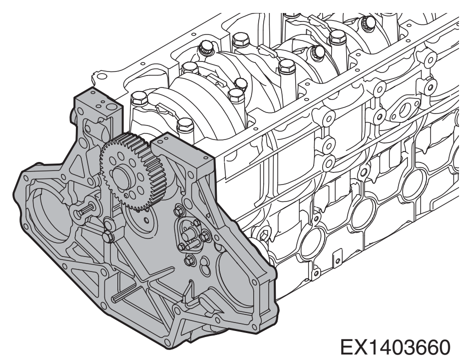


Figure 50

41. Remove the piston and connecting rod.

    A. Unscrew the connecting rod cap bolts in the reverse order of their tightening.

       NOTE: *Unscrew these bolts in two steps as the cylinder head bolts.*

    B. Tap the top and bottom of the connecting rod cap with a urethane hammer lightly to remove the bearing cap and bearing.

    C. Push the connecting rod from the oil pan side toward the cylinder head with a wooden stick to separate the piston assembly.

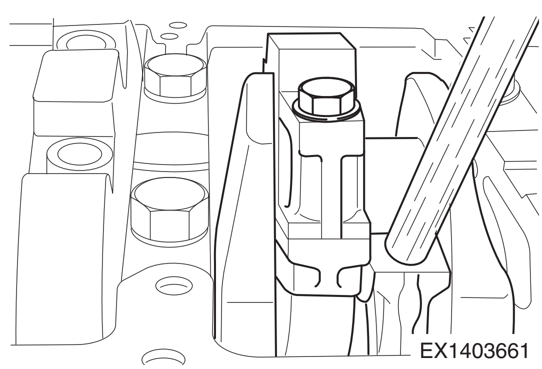


Figure 51

D. Keep the removed pistons in the corresponding cylinder order and make sure that they are not hit by each other.

E. Install the connecting rod caps to their corresponding connecting rods loosely. Be careful not to mix them.

42. Remove the piston.

A. Remove the snap ring of the piston pin using pliers.

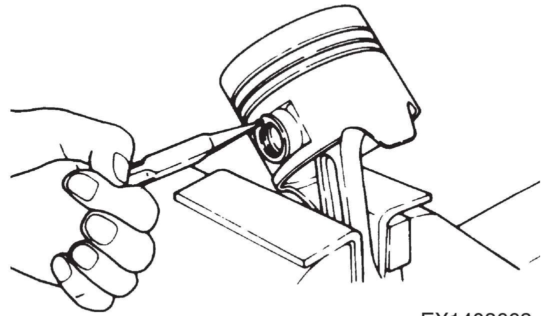

EX1403662

Figure 52

B. Tap the piston pin with a wooden stick gently to remove the piston.

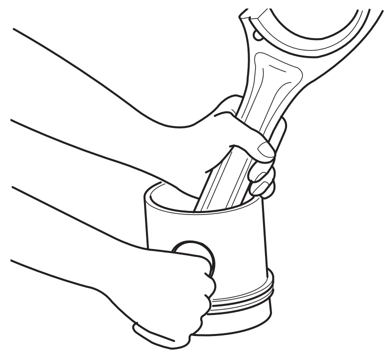

EX1403663

Figure 53

C. Remove the piston ring using piston ring pliers.

D. Remove carbon from the piston completely and clean it.

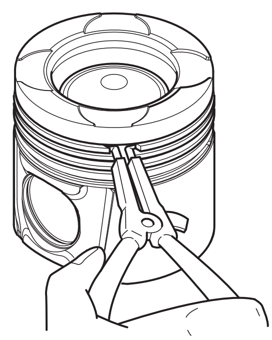

EX1403664

Figure 54

43. Remove the bearing cap.

    A. Unscrew the bearing cap mounting bolts in the reverse order of their tightening to remove the bearing cap.

       NOTE: *Unscrew these bolts with the same method for the cylinder head bolts.*

    B. Keep the bearing caps in order.

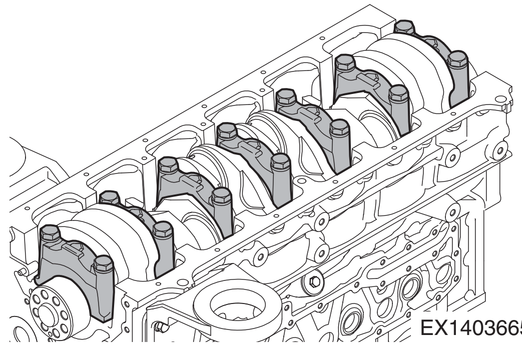


Figure 55

44. Remove the crankshaft.

    A. Fit the bolts to both sides of the crankshaft temporarily.

    B. Connect a rope to the bolts and lift the crankshaft with a crane. Be careful not to damage the crankshaft.

    C. Store the removed crankshaft on a safe special shelf so that it is not deformed or damaged.

    D. Remove and store the main bearings in order.

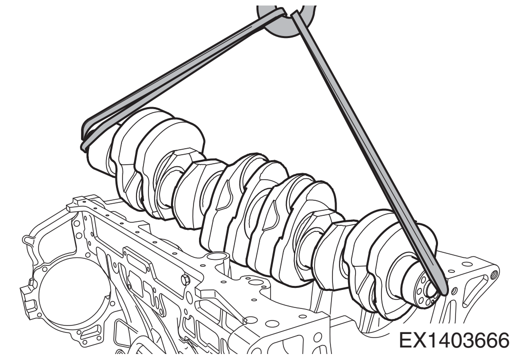


Figure 56

CAUTION

AVOID INJURY

- **Make sure that the main bearing and bearing caps are not mixed.**
- **Fit the main bearings to their bearing caps temporarily to prevent mixing.**

45. Remove the oil spray nozzle.

    A. Unscrew the oil spray nozzle valve mounting screw to remove the oil spray nozzle.

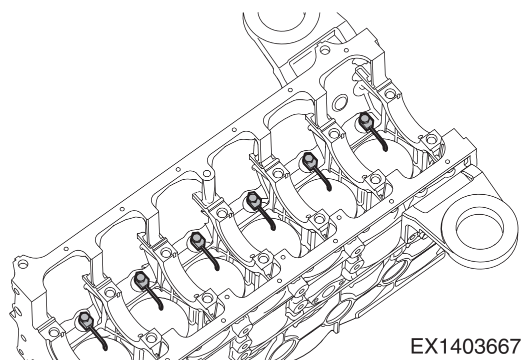


Figure 57

46. Remove the camshaft and tappet.

   A. To prevent damage of the camshaft, pull it out while turning it.

   B. Store the removed camshaft on a safe special shelf so that it is not deformed or damaged.

   C. Remove the tappet.

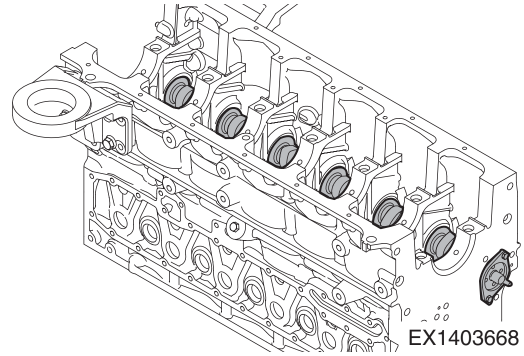


Figure 58

CAUTION

AVOID INJURY

Check for damage, scratch and wear. If any abnormal condition is found, replace it.

47. Remove the cylinder liner.

   A. Be careful not to damage the cylinder block when removing the cylinder liner.

   B. Remove the cylinder liner with its removing tool and hands.

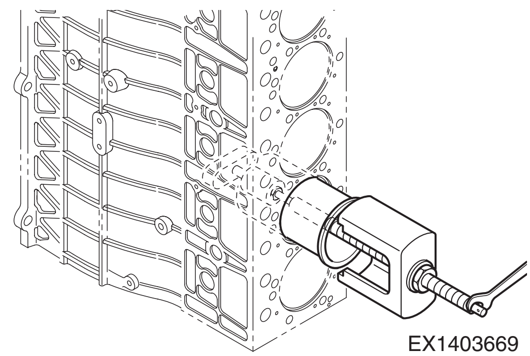


Figure 59

ENGINE ASSEMBLY

Engine Assembly

CAUTION

AVOID INJURY

- **Clean all the removed parts thoroughly. Especially, clean the oil and coolant passages with compressed air thoroughly to eliminate any restriction.**
- **Organize general tools and special service tools for engine assembly.**
- **Prepare clean engine oil to apply onto moving parts.**
- **Prepare service parts, such as sealant and gasket.**
- **Replace any used gasket, seal ring and consumables with new ones.**
- **Each bolt should to tightened to the specified torque according to the tightening order. Never over-tighten it.**
- **After installing the engine components, check their proper operation.**
- **After primary assembly, check if any bolt is loose.**
- **Keep your hands clean at all times during work.**

Assemble the engine according to the following procedure:

1. Install the cylinder block.
   A. Place a wooden block or thick paper on the ground of the working area to prevent damage of the cylinder head mounting surface. Then, set the head mounting surface toward the ground.
2. Install the cylinder liner.
   A. Stand the cylinder block with its flywheel side facing the ground.
   B. Clean the flange mounting surface and inside of the liner with compressed air thoroughly.
   C. After cleaning the cylinder liner, dry it completely and insert it into the cylinder block with hands.
   D. Apply engine oil to the inside of the cylinder liner.

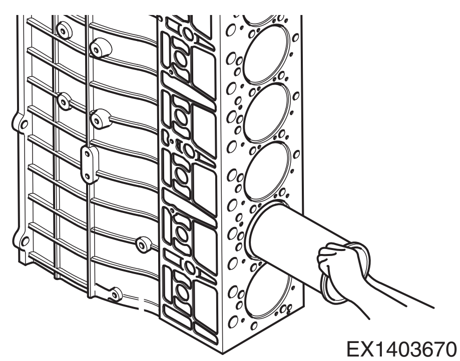


Figure 60

3. Install the oil spray nozzle.

   A. Align the oil spray nozzle with the groove of the cylinder block using the oil spray nozzle installing jig.

   B. Install the relief valve.

   C. Tighten the mounting bolt to 20.6 N.m (2.1 kg.m, 1 ft lb).

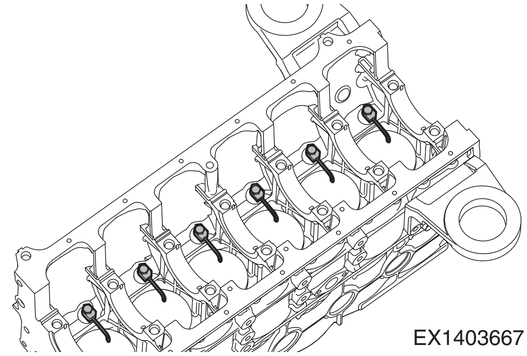


Figure 61

4. Install the crankshaft.

   A. Make sure to align the holes of the main bearing with the machined oil holes (2 ea) on the cylinder block during installation.

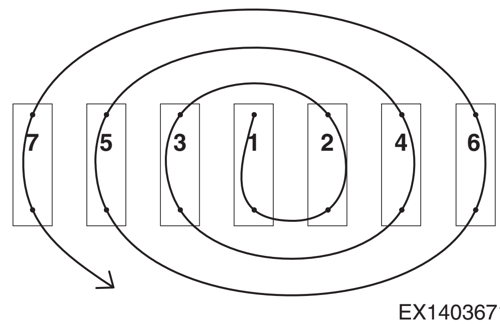


Figure 62

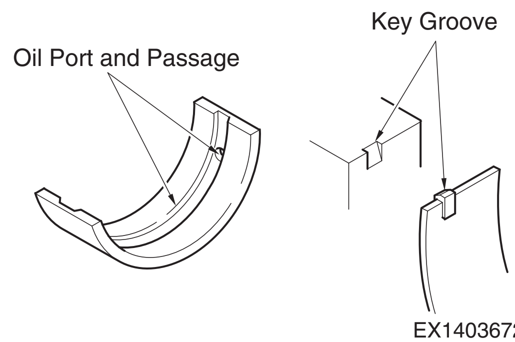


Figure 63

   B. Apply clean engine oil to the bearing surface.

   C. Heat the wear ring at 150°C for 10 minutes with a heater and install this front wear ring using an assembly jig.

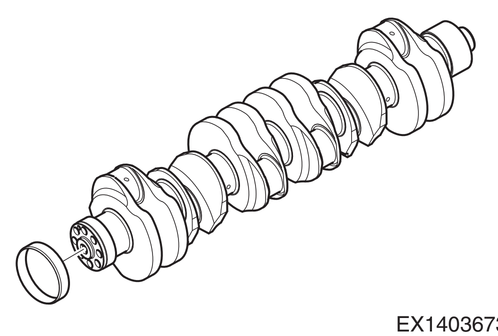


Figure 64

D. Fit the bolts to both sides of the crankshaft temporarily. Then, place the crankshaft on the cylinder block using the mounting bolts.

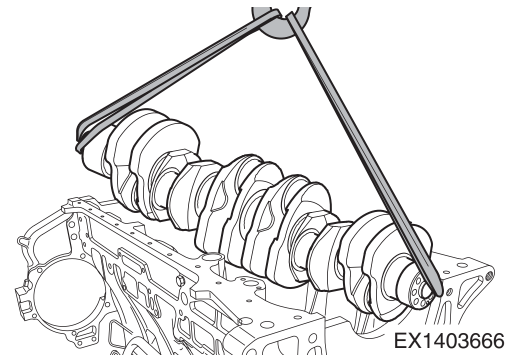


Figure 65

E. Apply engine oil to the pin and journal of the crankshaft.

F. After oil application, install the thrust washer with its oil groove facing the outside.

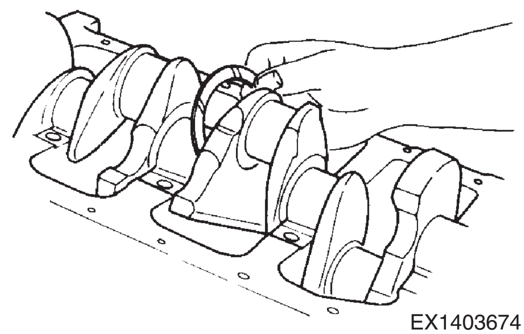


Figure 66

G. Install the bearing and thrust washer to the bearing cap.

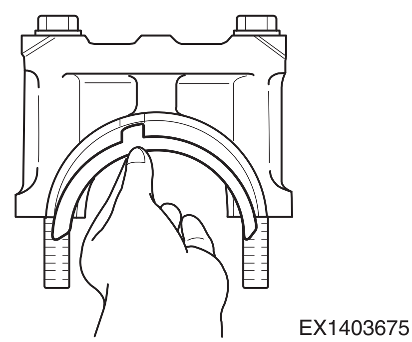


Figure 67

H. Apply oil to the bearing and thrust washer.

I. Install the bearing caps correctly by matching their numbers with the cylinder block numbers.

J. Tighten the bearing cap bolts to the specified tightening torque in the specified order.

K. Tighten both bolts evenly to set the bearing cap tight.

L. Tighten the bolt according the following steps with a torque wrench:

– Step 1: Tighten the bolt to 49 N.m (5 kg.m, 36.2 ft lb) until it is tightly set against the surface.

– Step 2: Tighten it to 147.1 N.m (15 kg.m, 108.5 ft lb) with a torque wrench.

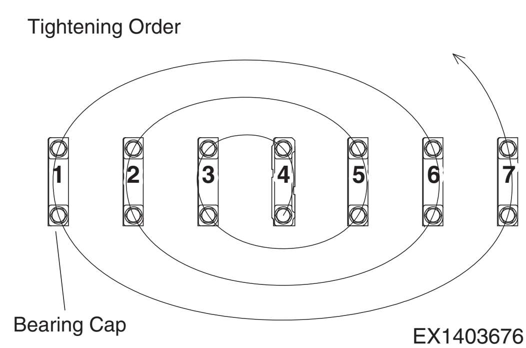


Figure 68

- Step 3: Tighten it to 245.1 N.m (25 kg.m, 180.8 ft lb) with a torque wrench.
- Step 4: Tighten it to 294.1 N.m (30 kg.m, 217 ft lb) with a torque wrench for the final time.

M. Tighten the bearing caps in the following order: 4 - 3 - 5 - 2 - 6 - 1 - 7.

N. Rotate the installed crankshaft for 2 ~ 3 turns to check its free motion.

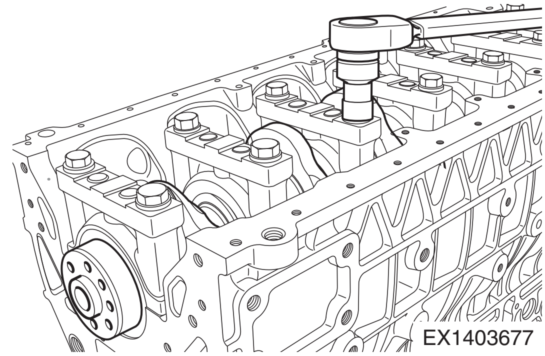


Figure 69

5. Install the tappet and camshaft.

A. Cool a new bushing in dry ice for approximately 2 hours.

B. Press the new bushing into the cam bushing position of the cylinder block using a bench press.

C. After pressing it in, measure the inside diameter of the cam bushing to check for its deformation.

D. Apply engine oil to the face of the tappet and insert the tappet into its hole of the cylinder block.

E. Apply engine oil to the camshaft hole and camshaft journal sections of the cylinder block.

F. Insert the camshaft into its hole of the cylinder block.

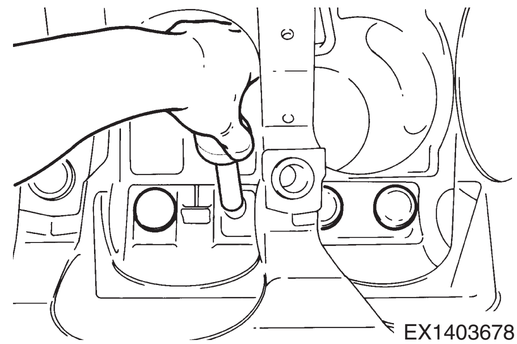


Figure 70

6. Install the timing gear case.

A. Install the gasket to the cylinder block using a reference pin.

B. Align the pin hole of the timing gear case with the reference pin.

C. Install the timing gear case to the cylinder block.

D. Set it tightly against the cylinder block by tapping its left and right with a urethane hammer.

E. Tighten the relief valve to 25.5 N.m (2.6 kg.m, 18.8 ft lb).

F. Tighten the timing gear case mounting bolts to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

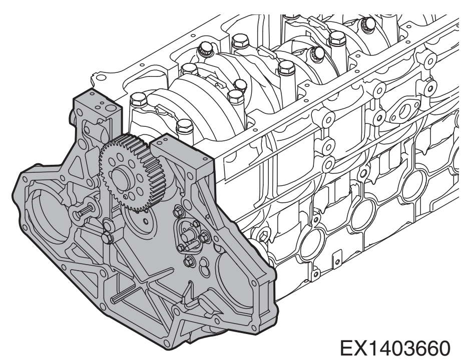


Figure 71

CAUTION

AVOID INJURY

When tightening the bolts, tighten the bolts on both ends first and tighten the remaining bolts.

7. Install the fuel high-pressure pump.

   A. Install the gear of the fuel high-pressure pump using its jig.

   B. Tighten the gear nut to 107.9 N.m (11 kg.m, 79.6 ft lb).

   C. Tighten the mounting bolt to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

   D. Install the fuel high-pressure pump to the timing gear case on the back of the flywheel housing.

   E. Tighten the flow screw to 29.4 N.m (3 kg.m, 21.7 ft lb).

   F. Tighten the nipple to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

   G. Tighten the mounting bolts to the specified torque in the correct order.

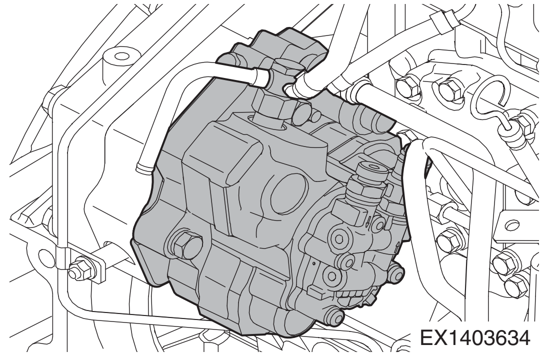


Figure 72

8. Install the gear system.

   A. Install the thrust washer to the camshaft.

   B. Install the cam gear, aligning it with the pin hole of the camshaft.

   C. Tighten the camshaft thrust washer to 9.8 N.m (1 kg.m, 7.2 ft lb).

   D. Tighten the camshaft gear mounting bolt to 30.4 N.m (3.1 kg.m, 22.4 ft lb).

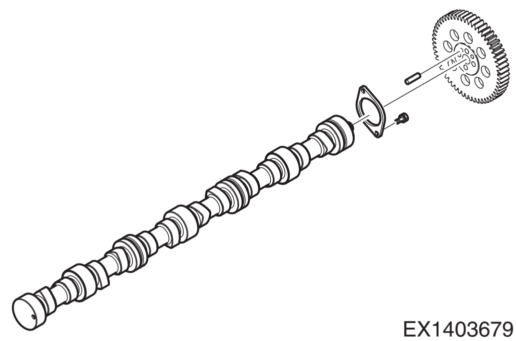


Figure 73

CAUTION

AVOID INJURY

When installing the gears, install the camshaft gear, idle gear, fuel high-pressure pump idle gear and fuel high-pressure pump in this order.

   E. Install the idle gear while aligning the marks on the crankshaft gear, camshaft gear and idle gear.

      – Gear mark

Crankshaft Gear - Idle Gear (A)	"0" and "0"
Camshaft Gear - Idle Gear (B)	"1" and "1"

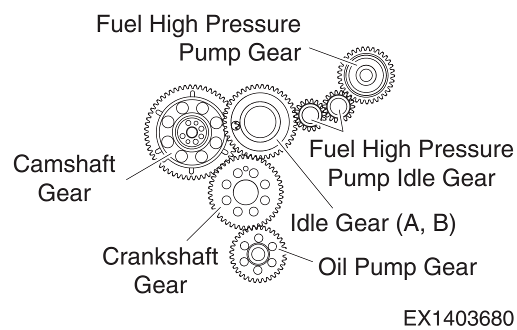


Figure 74

   F. Tighten the step idle gear to 60.8 N.m (6.2 kg.m, 44.8 ft lb).

   G. Tighten the fuel high-pressure pump idle gear to 60.8 N.m (6.2 kg.m, 44.8 ft lb).

   H. Use a feeler gauge to check the backlash and end play of the gear.

      – Backlash

Measuring Position	Standard (mm)
Camshaft Gear and Idle Gear	0.074 ~ 0.163
Fuel High-pressure Pump Gear and Idle Gear	0.103 ~ 0.182
Crankshaft Gear and Oil Pump Drive Gear	0.073 ~ 0.239

– End play

Measuring Position	Standard (mm)
Camshaft Gear	0.280 ~ 0.430
Step Idle Gear	0.107 ~ 0.183
Fuel High-pressure Pump Idle Gear	0.078 ~ 0.140

9. Install the flywheel housing.
   A. Install a guide bar to the cylinder block temporarily.
   B. Install the gasket to the cylinder block.
   C. Use a dowel pin and guide bar to install the flywheel housing.
   D. Tighten the mounting bolts to 109.8 N.m (11.2 kg.m, 81 ft lb) in the specified order.
   E. Remove the guide bar.
   F. Apply a thin film of engine oil to the outer surface of the oil seal and fit this seal into the flywheel housing.

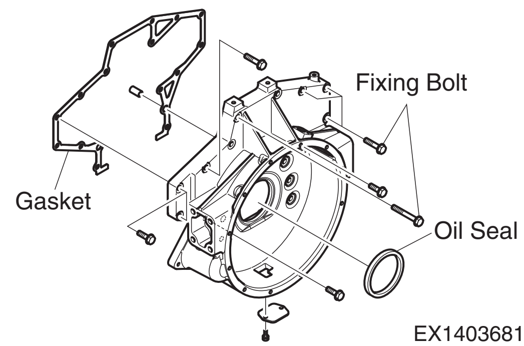


Figure 75

10. Install the rear oil seal.
    A. Align the oil seal with the crankshaft.
    B. Install the oil seal using its jig.

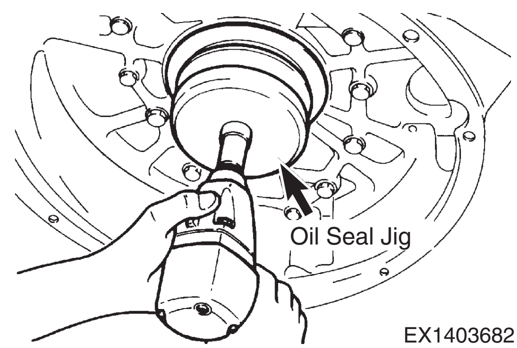


Figure 76

11. Install the flywheel.
    A. Heat the ring gear with a gas burner evenly to expand it. Then, install it with a hammer.

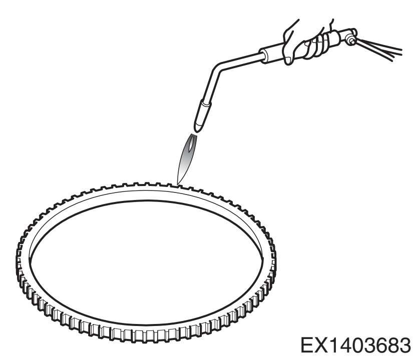


Figure 77

CAUTION

AVOID INJURY

- **Make sure that the temperature of the ring gear does not exceed 200°C.**
- **When installing the ring gear, heat it to 150°C with a heater, and apply loctite #262 to it, and use an assembly jig to install it.**

B. The front of the wear ring can be identified by the mounting surface on the outer skirt.

C. Fit a guide bar into the crankshaft bolt hole.

D. Align the flywheel with the reference pin to install it temporarily.

E. Apply adhesive (loctite #587) to the mounting bolt.

F. Fit the bolts that have no guide pin in their holes. Then, remove the guide pin and fit the remaining bolt.

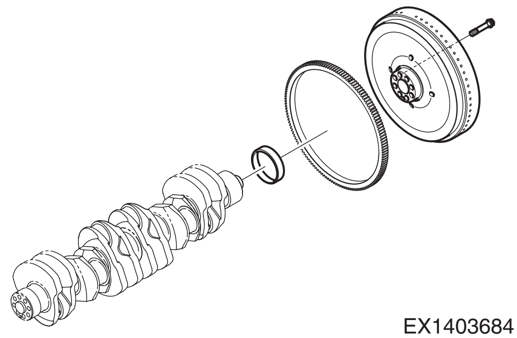


Figure 78

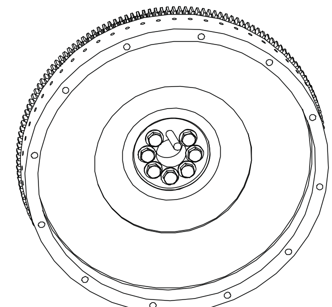


Figure 79

G. Tighten the bolts (M14 x 1.5) to 196.1 N.m (20 kg.m, 144.7 ft lb) in the specified order.

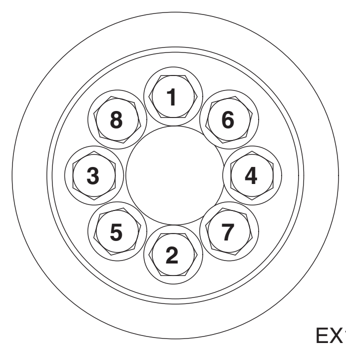


Figure 80

12. Install the piston and connecting rod.

A. Heat the piston to approximately 100°C with a heater for 5 minutes.

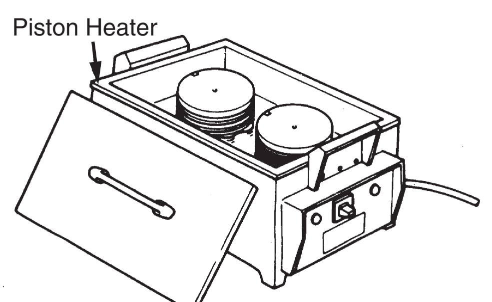
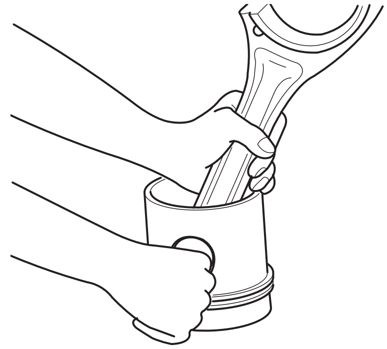


Figure 81

B. When installing the piston and connecting rod, the weight controlling section at the small end of the connecting rod and the oil gallery inlet (big hole side) of the piston should face the opposite direction.

C. Apply oil to the pin hole of the piston and align this hole with the small end of the connecting rod. Then, tap the piston pin with a rubber hammer gently to install the connecting rod and piston.



EX1403663

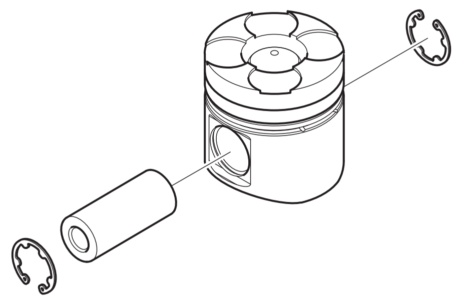
Figure 82

D. The openings of the snap rings should be set in the opposite direction (upwards and downwards).

CAUTION

AVOID INJURY

Direction of snap ring is assembling to be positioned the opposite side.



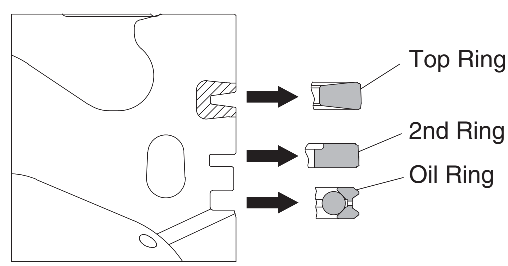
EX1403688

Figure 83

E. Install the snap ring. Check its mounting condition.

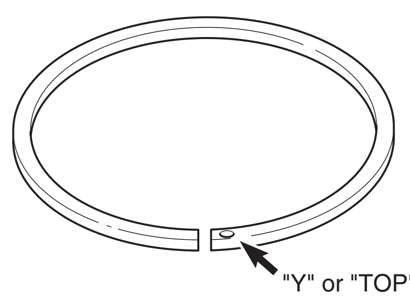
F. Use piston ring pliers to install the piston ring to the piston.

G. Make sure to install the piston ring in the correct direction. The mark "Y" or "TOP" on the ring connection should face up.



EX1403689

Figure 84



EX1403690

Figure 85

H. Adjust each piston ring connection angle to 120° and fit a piston inserting jig into the piston.

CAUTION

AVOID INJURY

The connection of the piston ring should not be in the same direction with the pin.

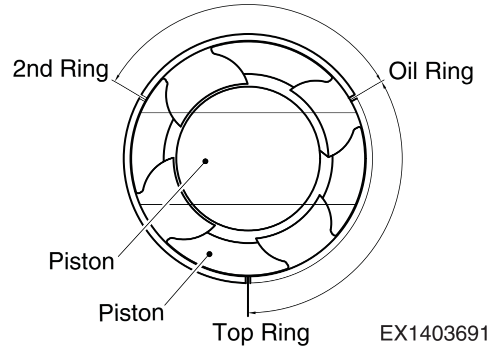


Figure 86

I. Install the connecting rod bearing while aligning it with the key groove. Then, apply oil to the bearing and piston.

J. Fit the piston so that the oil gallery inlet of the piston is in the same direction with the spray nozzle.

K. Use a piston inserting tool to insert it into the cylinder liner. Be careful not to damage the ring by the tip of the liner.

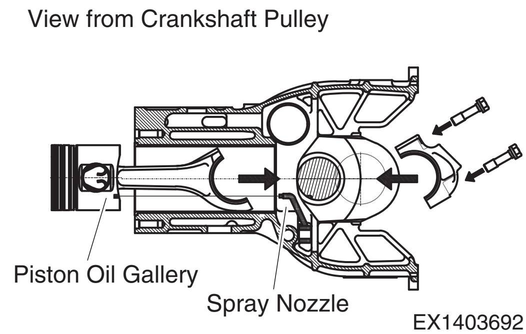


Figure 87

CAUTION

AVOID INJURY

Make sure that the cylinder liner and piston are not damaged.

L. Fit the bearing to the connecting rod cap and apply oil on it.

M. Check that the manufacturing serial numbers stamped on the connecting rod cap and connecting rod big end are the same.

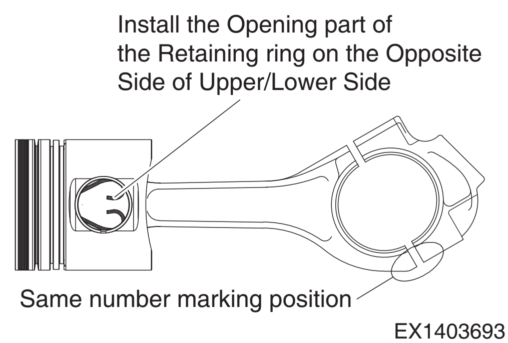


Figure 88

N. Install the connecting rod cap while aligning it with the reference pin.

O. Apply oil to the mounting bolt and install the bolt loosely.

P. Tighten the bolts to the specified tightening torque in the specified order using a torque wrench.

– Step 1: When tightening the connecting rod bolt, tighten it with a hand until its head touches the bolt seat of the connecting rod.

– Step 2: Tighten it to 39.2 ~ 58.8 N.m (4 ~ 6 kg.m, 28.9 ~ 43.4 ft lb) with a torque wrench.

– Step 3: Tighten it to 95.6 N.m (9.75 kg.m, 70.5 ft lb) with a torque wrench for the final time.

Q. Shake the bearing cap with a hand. If it does not move, loosen and tighten it again.

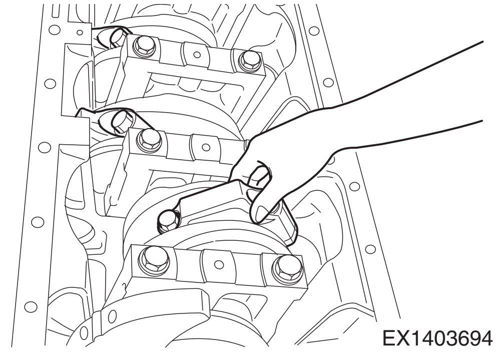


Figure 89

13. Install the oil pump and oil pipe.

A. Install the reference pin to the bearing cap No. 7.

B. Tap the oil pump with a urethane hammer gently to install it.

C. Fit the washer and tighten the mounting bolt (M8) to 21.6 N.m (2.2 kg.m, 15.9 ft lb). Tighten the bolt (M10) to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

D. Connect the oil feed pipe to the oil pump with the bolt.

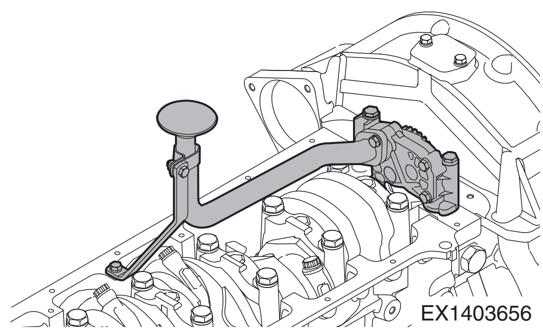


Figure 90

14. Install the front oil seal.

A. Apply engine oil to the inside of the oil seal before installing the oil seal to the cover.

B. Align a new oil seal with the center of the hole on the oil seal cover.

C. Use an installing jig to install the oil seal.

D. Tighten it to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

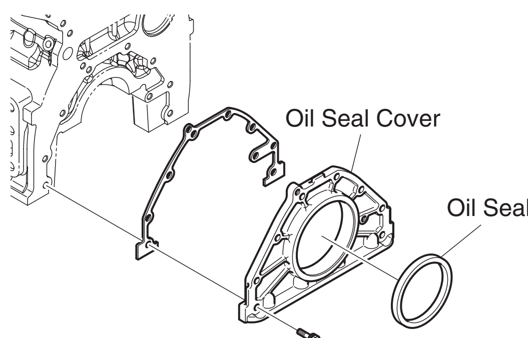


Figure 91

15. Install the oil pan.

    A. Remove any protruded gasket on the timing gear case, cover, cylinder block and flywheel housing contact surface with a scraper thoroughly.

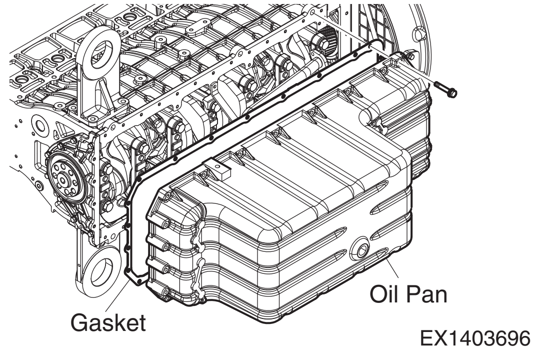


Figure 92

CAUTION

AVOID INJURY

Make sure any gasket does not enter the engine during work.

    B. Apply silicon on the surfaces where the used gasket was removed. Then, attach a new oil pan gasket.

    C. Install the oil pan.

    D. Tighten the bolts (4 ea) on both ends of the oil pan first and tighten the remaining bolts.

    E. Tighten the oil pan mounting bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

CAUTION

AVOID INJURY

Align the bolt holes with the gasket holes before tightening the bolts.

    F. Tighten the drain plug to 98.1 N.m (10 kg.m, 72.3 ft lb).

16. Install the crankshaft pulley and vibration damper.

    A. Install the vibration damper to the crankshaft pulley.

    B. Tighten the bolts in the correct order.

    C. Tighten the vibration damper to 60.8 N.m (6.2 kg.m, 44.8 ft lb).

    D. Tighten the crankshaft pulley to 196.1 N.m (20 kg.m, 144.7 ft lb).

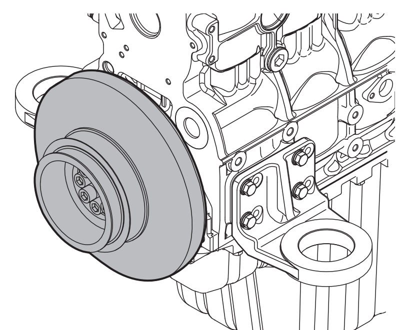


Figure 93

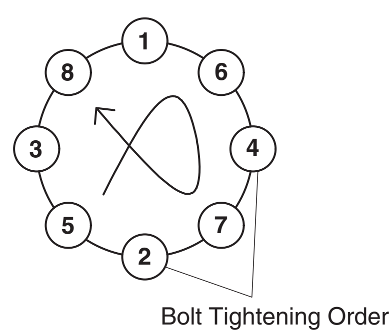


Figure 94

17. Install the intake and exhaust valves.

    A. Before installing the valve to the cylinder head, check the marks "I" and "E" on the valve head surface.

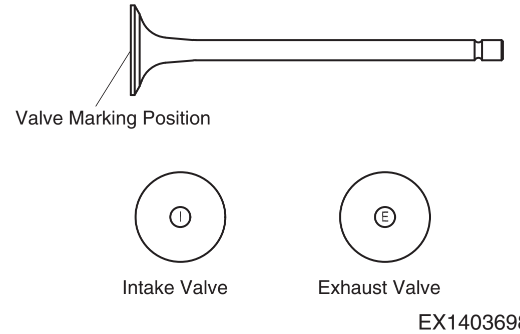


Figure 95

    B. Use a valve stem seal installing jig to install the valve stem seal to the valve guide.

    C. Install the valve cotter by pressing the retainer with a valve spring compressing tool after installing the valve spring and retainer.

    D. Tap the valve stem with a rubber hammer gently to check if the valve is corrected installed.

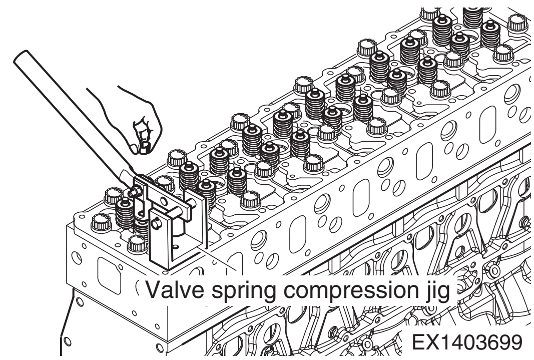


Figure 96

18. Install the cylinder head.

    A. Blow compressed air through the bolt hole of the cylinder head to remove any foreign materials.

    B. Clean the gasket mating surface of the cylinder head thoroughly.

CAUTION

AVOID INJURY

Ensure that no foreign material enters the combustion chamber.

    C. Align the new gasket bolt hole with the reference pin on the cylinder block.

    D. When installing the gasket, its mark on the right should be upwards.

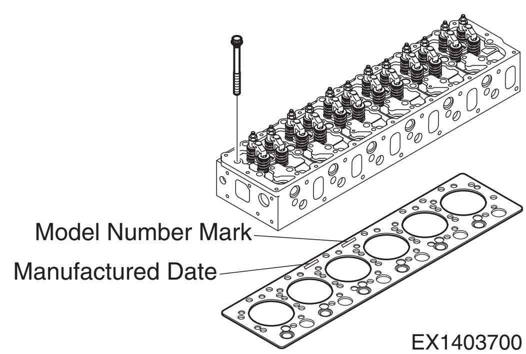


Figure 97

CAUTION

AVOID INJURY

Replace the gasket with a new one.

E. Check if there is any foreign material in the combustion chamber.

F. Install the cylinder head by aligning it with the retaining pin.

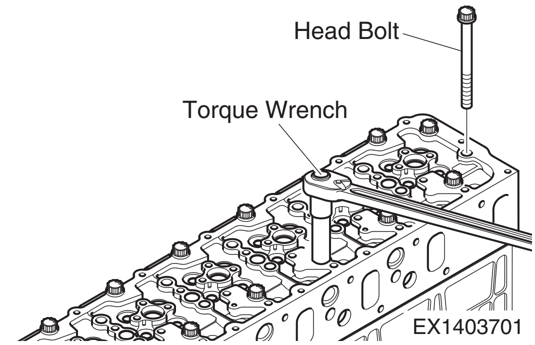


Figure 98

CAUTION

AVOID INJURY

- **Be careful not to damage the gasket.**
- **If the pin hole cannot be aligned, lift the head and then try to seat it again.**

G. Install the cylinder head bolt.

H. Tighten the cylinder head bolts to the specified tightening torque in the specified order.

– Step 1: Tighten it for 1 to 2 threads with a hand, and then tighten it to 39.2 N.m (4 kg.m, 28.9 ft lb) temporarily.

– Step 2: Tighten it to 6 kg.m with a torque wrench.

– Step 3: Tighten it for 90° with a torque wrench.

– Step 4: Tighten it for 90° with a torque wrench.

– Step 5: Tighten it for 90° with a torque wrench for the final time.

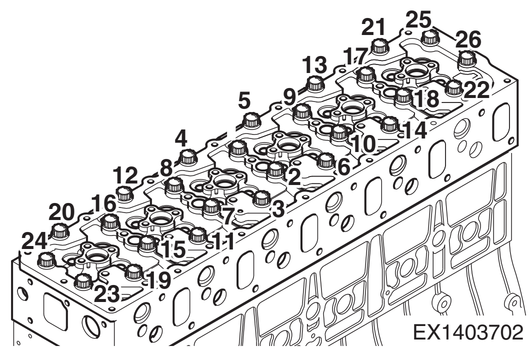


Figure 99

CAUTION

AVOID INJURY

All the bolts should be tightened according to the above steps.

19. Install the push rod.

A. Apply engine oil to the push rod.

B. Insert the push rod into the push rod hole of the cylinder head.

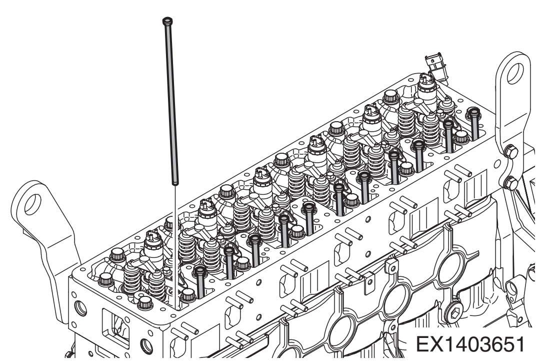


Figure 100

20. Install the injector.

⚠ CAUTION

AVOID INJURY

- **Clean all parts thoroughly and make sure that no foreign material enters any part.**
- **Especially, the fuel line between the common rail and injector is not equipped with a filtering function. Therefore, this section should be kept clean with care.**
- **Clean the drilling of the head for the fuel high-pressure connector and the hole for the injector thoroughly to remove any foreign materials from them.**
- **If the injector is removed, the fuel high-pressure connector should be replaced with a new one.**
- **If fuel collected in the fuel return line enters the combustion chamber during injector disassembly process, remove fuel by sucking it out with a hand pump or by cranking the engine with fuel flow blocked.**

A. Install the injector correctly according to the following steps.

B. Fit the O-ring to the injector and apply engine oil to the outer circumference surface.

⚠ CAUTION

AVOID INJURY

Make sure that oil or foreign material is not on the fuel high-pressure connector hole on the side of the injector.

C. Align the seal ring with the injector hole on the cylinder head. Then, insert the injector gently.

D. Align the injector mounting bolt with the thread of the head. Then, tighten the bolt for 2 ~ 3 threads with a hand.

E. Set the injectors to the mounting positions of the injector mounting brackets (1 and 2) with the mounting bolts. Then, tighten them temporarily.

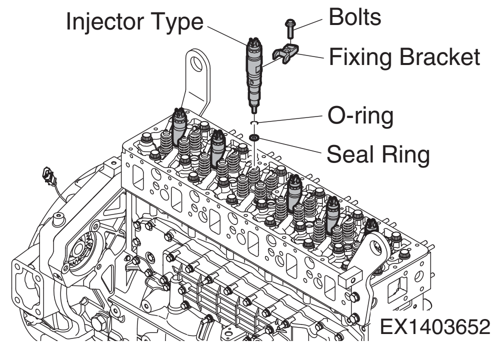


Figure 101

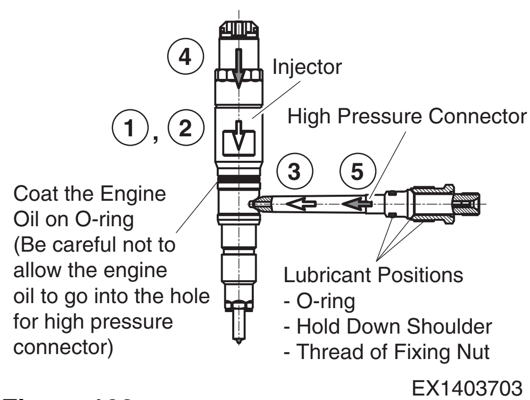


Figure 102

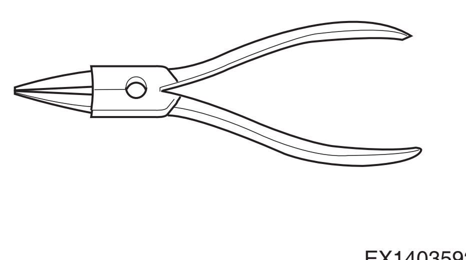


Figure 103

F. After tightening the injectors temporarily, unscrew the bolts of the mounting brackets enough to move the injectors freely without load.

G. Set the fuel high-pressure connector (3) with its balls set vertically.

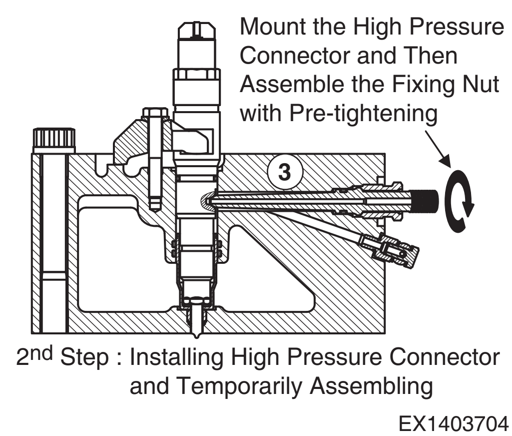


Figure 104

H. Ensure that it is aligned with the groove in the hole on the side of the head on the intake manifold side.

I. Align the fuel high-pressure connector through the hole on the side of the head, and push in the fuel high-pressure connector enough.

J. Tighten the mounting nut (M22 x 15) of the fuel high-pressure connector for 2 ~ 3 threads with a hand.

K. Tighten the injector mounting bracket bolt to 2.9 N.m (0.3 kg.m, 2.2 ft lb) with a torque wrench.

L. Tighten the injector mounting bracket bolt to 14.7 + 4.9 N.m (1.5 + 0.5 kg.m, 10.8 + 3.6 ft lb) using a torque wrench.

M. Tighten the injector mounting bracket mounting bolt (4) to 30.4 ~ 34.3 N.m (3.1 ~ 3.5 kg.m, 22.4 ~ 25.3 ft lb)

N. Tighten the fuel high-pressure connector mounting nut (5) to 49 ~ 53.9 N.m (5 ~ 5.5 kg.m, 36.2 ~ 39.8 ft lb).

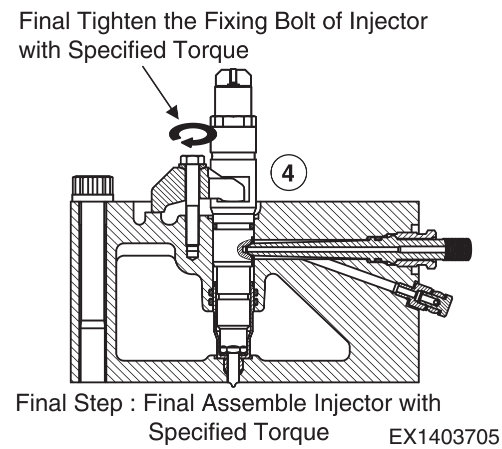


Figure 105

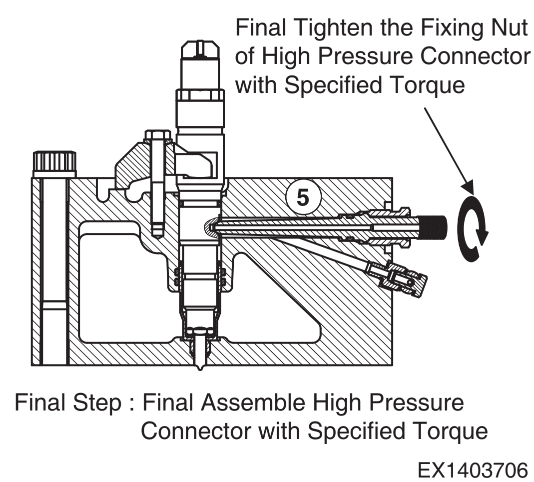


Figure 106

21. Install the rocker arm.

    A. For rocker arm assembly, install the spring, rocker arm, bracket, rocker arm, spring, washer and snap ring in order.

⚠ CAUTION

AVOID INJURY

Install the rocker arm and bracket in the same direction.

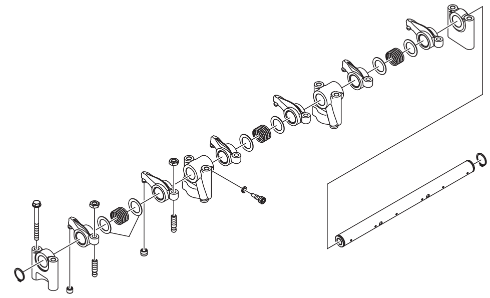


Figure 107

    B. Apply oil to the rocker arm bushing and shaft.

    C. Use the mounting bolts to install the rocker arm and bracket onto the cylinder head.

    D. Tighten the bolts to 36.8 N.m (3.75 kg.m, 27.1 ft lb) diagonally.

    E. Install the valve clearance adjusting screw to the rocker arm temporarily.

    F. Adjust the valve clearance.

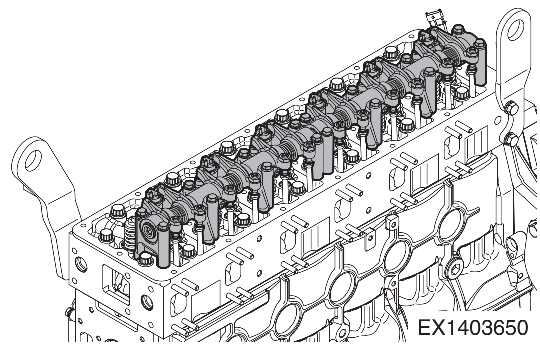


Figure 108

22. Install the intermediate cover.

    A. Install a new gasket to the intermediate cover.

    B. Tighten the mounting bolt to 30.4 N.m (3.1 kg.m, 22.4 ft lb).

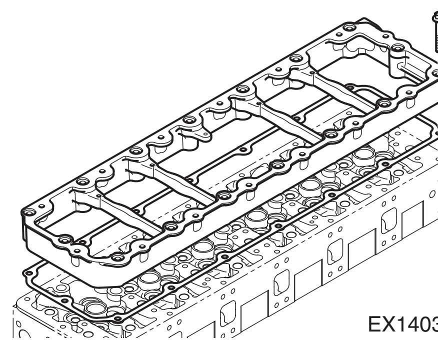


Figure 109

23. Install the cylinder head cover.

    A. Install a new rubber gasket to the cylinder head cover.

    B. Install the cylinder head cover to the cylinder head.

    C. Tighten the mounting bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

    D. Install the oil filler cap to the cylinder head cover.

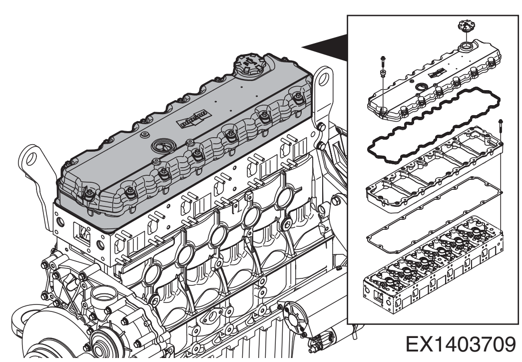


Figure 110

24. Install the oil cooler.

    A. Install the oil cooler and gasket to the cylinder block.

CAUTION

AVOID INJURY

Make sure to install the gasket in the correct direction.

    B. Tighten the bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

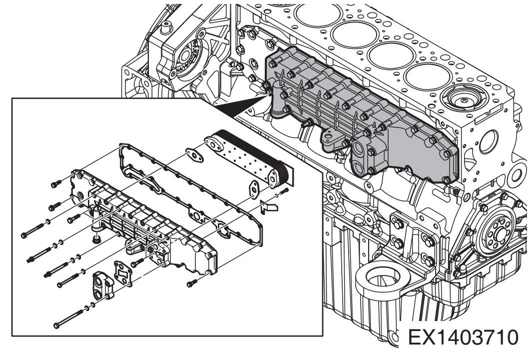


Figure 111

25. Install the oil filter.

    A. Install the oil filter cartridge using a special service tool.

CAUTION

AVOID INJURY

The oil filter should be installed to the engine without oil in it. Never fill the new oil filter with oil drained from the used oil filter.

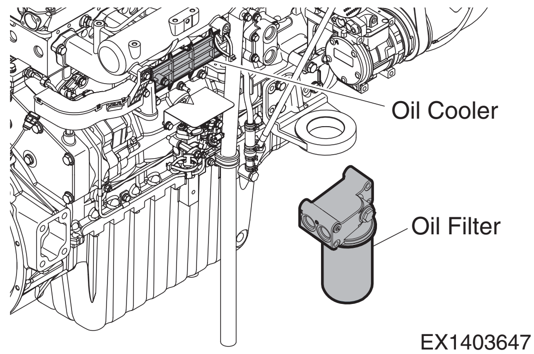


Figure 112

26. Install the coolant pump.

    A. Install the coolant pump cover and coolant pump gasket.

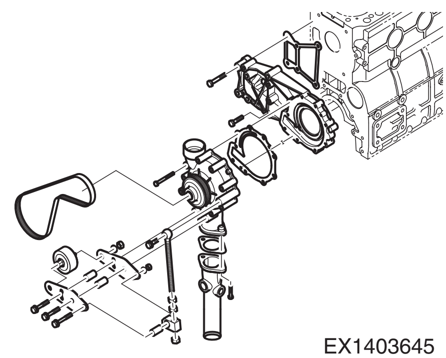


Figure 113

    B. Install the coolant pump to the cylinder block.

    C. Tighten the mounting bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

    D. Install the idle pulley bracket.

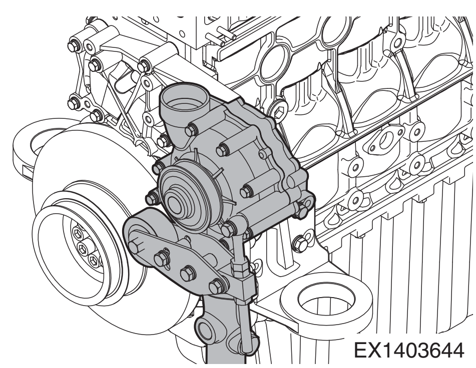


Figure 114

27. Install the start motor.

    A. Install the start motor to the stud bolt of the flywheel housing.

    B. Tighten the mounting nut to 78.5 N.m (8 kg.m, 57.9 ft lb).

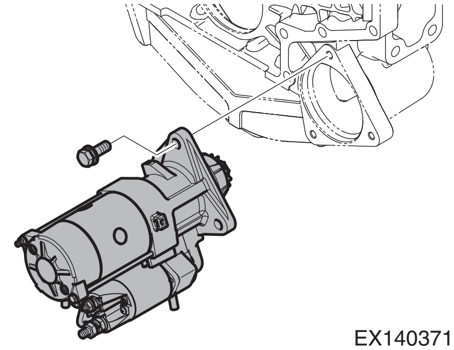


Figure 115

28. Install the common rail and high-pressure pipe.

    A. Install the common rail to the cylinder block.

    B. Connect the fuel feed pipe between the common rail and fuel high-pressure connector.

    C. Tighten the fuel high-pressure pipe on the common rail side to 24.5 N.m (2.5 kg.m, 18.1 ft lb).

    D. Tighten the fuel high-pressure pipe on the fuel high-pressure connector side to 27.5 N.m (2.8 kg.m, 20.3 ft lb).

    E. Tighten the common rail fuel high-pressure pipe from the fuel high-pressure pump to 20.6 N.m (2.1 kg.m, 15.2 ft lb).

    F. Tighten the common rail mounting bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

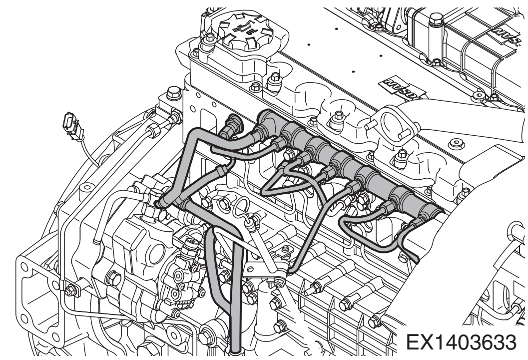


Figure 116

CAUTION

AVOID INJURY

- **Never reuse the fuel high-pressure pipe.**
- **Tighten the fuel high-pressure pipe to the specified torque for a cylinder by cylinder.**

29. Install the intake manifold.

    A. Install a new gasket between the cylinder head and intake manifold.

    B. Tighten the mounting bolt to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

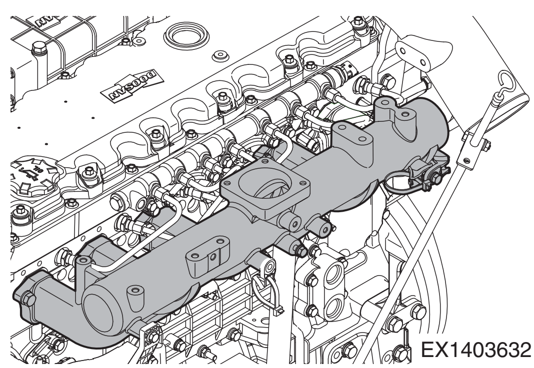


Figure 117

30. Install the exhaust manifold.

    A. Install the exhaust manifold gasket to the stud bolt of the cylinder head.

    B. \Align the gas outlet of the cylinder head with the gasket hole.

    C. Install the exhaust manifold.

    D. Tighten the mounting bolt to 49 N.m (5 kg.m, 36.2 ft lb).

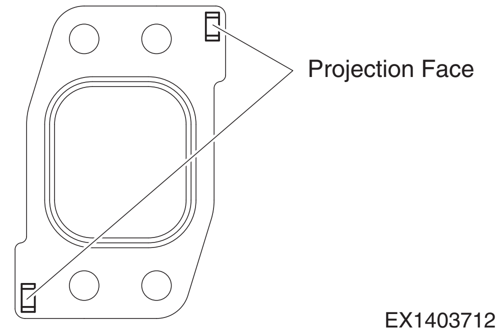


Figure 118

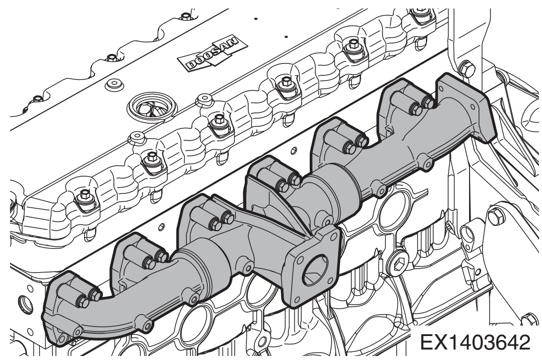


Figure 119

31. Install the turbocharger.

    A. Install a new gasket to the stud bolt of the exhaust manifold.

    B. Install the turbocharger.

    C. Connect the oil feed pipe and drain pipe.

    D. Tighten the clamp for the rubber hose to connect the air pipe and turbocharger.

    E. Tighten the mounting bolt to 78.5 N.m (8 kg.m, 57.9 ft lb).

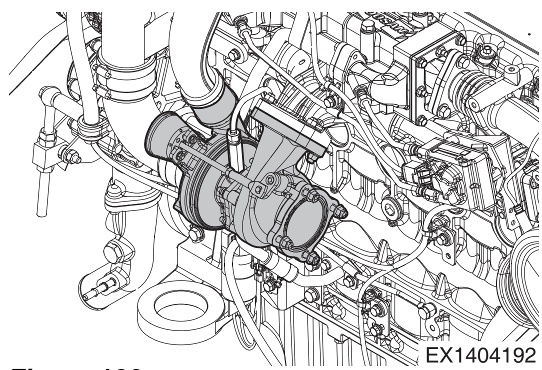


Figure 120

32. Install the coolant pipe and thermostat.

    A. Install the gasket to the cylinder head.

    B. Install the housing to the thermostat.

    C. Install the O-ring to the thermostat.

    D. Connect the coolant pipe.

    E. Tighten the bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

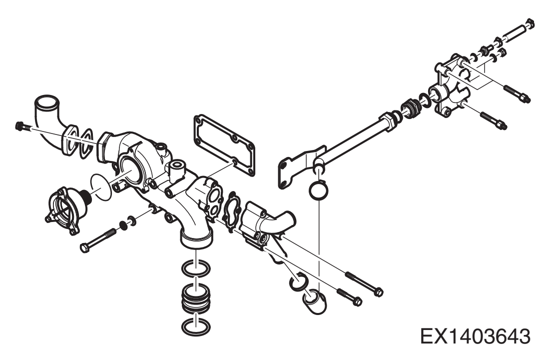


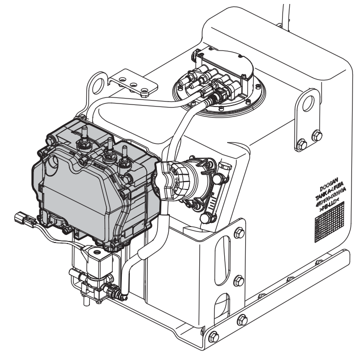
Figure 121

33. Install dosing module.

   A. Install the dosing module to the UREA tank with the mounting bolts.

   B. Install the cover for the dosing module with the mounting bolts.

   C. Connect the dosing pipe.



EX1404191

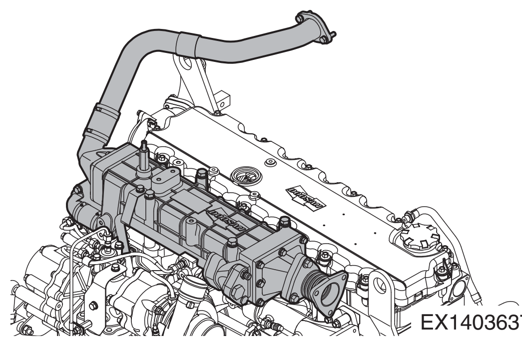
Figure 122

34. Install the EGR cooler.

   A. Install the EGR cooler mounting bracket to the cylinder head with the mounting bolts.

   B. Install the EGR cooler to the bracket with the mounting bolts.

   C. Connect the pipe and hose to the EGR cooler.



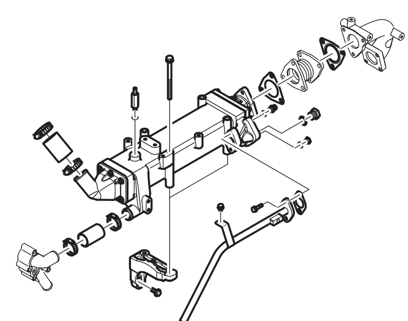
EX1403637

Figure 123

CAUTION

AVOID INJURY

Do not reuse the gasket.



EX1403713

Figure 124

35. Install the EGR valve.

    A. Install the exhaust pipe to the EGR cooler with the gasket and secure it with the mounting bolt.

    B. Install the EGR valve to the exhaust pipe with the gasket and secure it with the mounting bolt.

CAUTION

AVOID INJURY

Do not reuse the gasket.

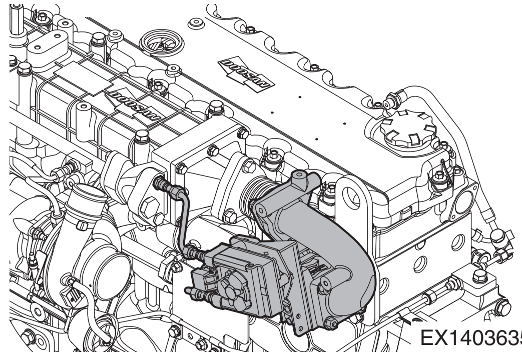


Figure 125

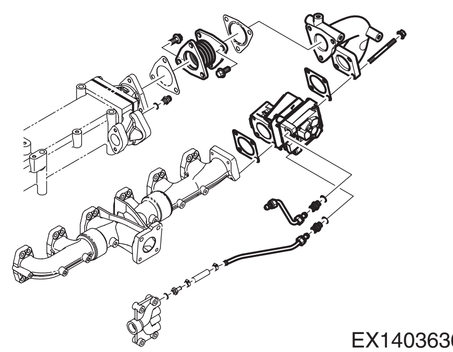


Figure 126

36. Install the ECU (Electrical Control Unit).

    A. Fix the ECU mounting plate.

    B. Install the ECU.

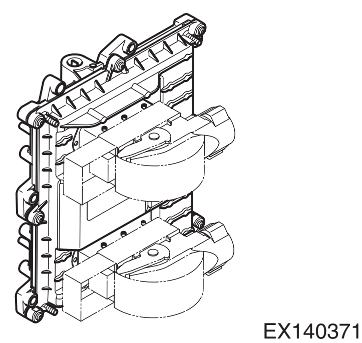


Figure 127

37. Install the crankshaft speed sensor and camshaft speed sensor.

    A. Measure the clearance between the mounting section of the crankshaft speed sensor and flywheel. Use shims to adjust this clearance to 1.0 mm.

    B. Tighten the crankshaft speed sensor to 9.8 N.m (1 kg.m, 7.2 ft lb).

    C. Measure the clearance between the mounting section of the camshaft speed sensor and timing gear. Use shims to adjust this clearance to 1.0 mm.

    D. Tighten the camshaft speed sensor to 9.8 N.m (1 kg.m, 7.2 ft lb).

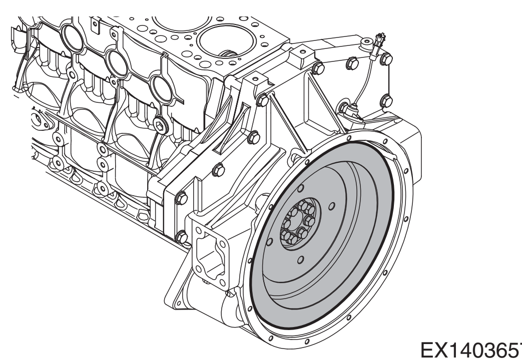


Figure 128

38. Install the fuel filter.

    A. Fuel needs to flow through the following components in this order: fuel feed pump, fuel filter, fuel high-pressure pump and common rail. Connect the fuel feed pipe correctly according to the arrow direction mark on the head of the fuel filter to ensure correct fuel flow.

    B. Tighten the fuel pipe to 29.4 N.m (3 kg.m, 21.7 ft lb).

    C. Tighten the fuel temperature sensor to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

    D. Tighten the mounting bracket to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

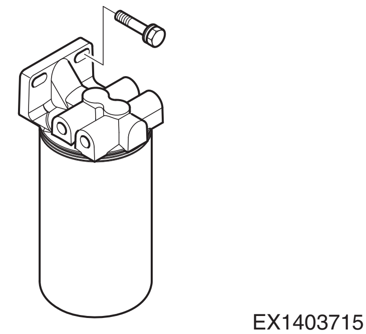


Figure 129

CAUTION

AVOID INJURY

A new fuel filter should be installed without fuel in it. Never add fuel in the used fuel filter or fuel tank to a new fuel filter.

39. Install the alternator and belt.

    A. Install the alternator and A/C bracket. Then, secure them with the mounting bolts.

    B. Install the alternator, A/C compressor and idle pulley.

    C. Tighten the alternator mounting bolt to 75.5 N.m (7.7 kg.m, 55.7 ft lb).

    D. Tighten the alternator support mounting bolt to 49 N.m (5 kg.m, 36.2 ft lb).

    E. Install the belt and adjust its tension with its adjusting bolt.

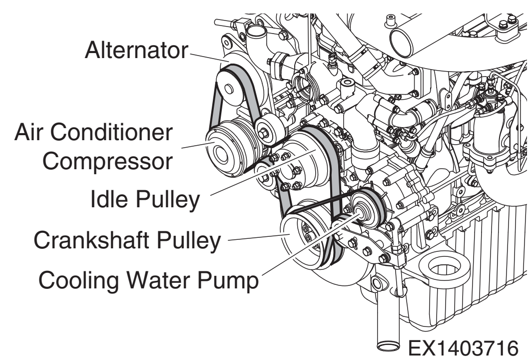


Figure 130

40. Connect the air pipe and install the air heater block.

    A. Install the air pipe, air heater block and throttle valve.

    B. Tighten the mounting bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

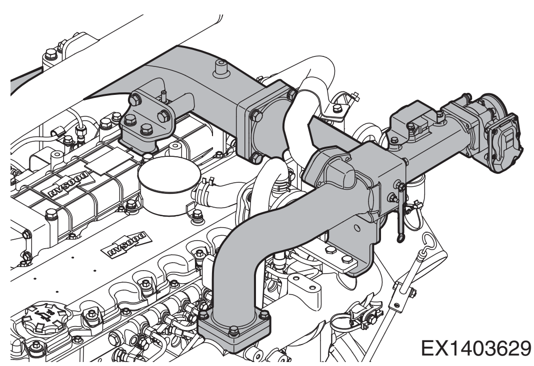


Figure 131

CAUTION

AVOID INJURY

Never let foreign materials enter the turbocharger.

41. Install the cooling fan.

    A. Install the fan flange to the coolant pump pulley.

    B. Install the cooling fan.

    C. Tighten the cooling fan bolt to 21.6 N.m (2.2 kg.m, 15.9 ft lb).

    D. Tighten the fan drive to 43.1 N.m (4.4 kg.m, 31.8 ft lb).

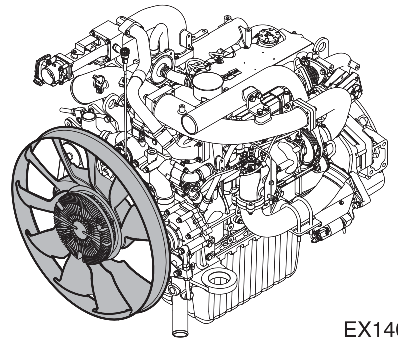


Figure 132

42. Fit the dipstick.

    A. Apply adhesive (loctite #262) to the guide tube.

    B. Install the guide tube and dipstick to the oil pan.

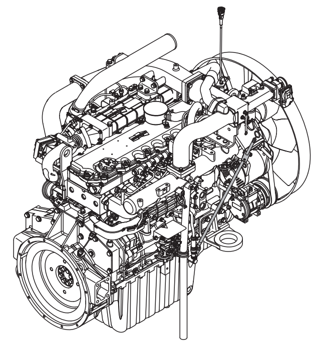


Figure 133

43. Connect the cables and harnesses of the engine to each sensor.

44. Mount the engine to the machine.

45. Add engine oil.

    A. Open the oil filler cap on top of the cylinder head cover and add engine oil to it.

CAUTION

AVOID INJURY

Make sure to use the recommended genuine oil.

46. Add coolant.

    A. Open the radiator cap and add coolant.

CAUTION

AVOID INJURY

Make sure to use the recommended coolant.

CYLINDER

General Information

Doosan's diesel engine is an air-cooled electronic control diesel engine that uses cooling fans, overhead valve, and turbocharger.

The high-pressure fuel generated from the fuel high-pressure pump is stored in the common rail. When a driver operates the vehicle, fuel injection timing and optimum fuel amount are decided based on the data set in the electronic control unit (ECU) and the solenoid valve of the injector installed in each engine cylinder is operated to inject fuel into the cylinder.

The cylinder block is made out of cast iron alloy and an anti-vibration and anti-noise crank case is mounted. In addition, the cylinder block and the timing gear case are designed as an integral structure to reduce the engine length and improve tightness. The cylinder head is an integral structure, too.

The forged crankshaft is an integral structure. The oil seals of the crankshaft and the flywheel prevents oil from permeating into the flywheel housing. The connecting rod is forged and its big end part vertically separated. Like a piston, the connecting rod can be disassembled through the upper side of the cylinder. The alloy-type prefabricated bearing is used for the moving part of the crankshaft and the connecting rod.

Cylinder Head

General Description

The cylinder head is a cover mounted on top of the cylinder, and it is bolted to the cylinder block with the head gasket in between, forming the combustion chamber with other components, including the pistons and cylinders. It has a oil passage for the glow plug and lubrication and a coolant passage for reduction of frictional heat. This cylinder head is integrated to each cylinder and cannot be removed.

Parts List

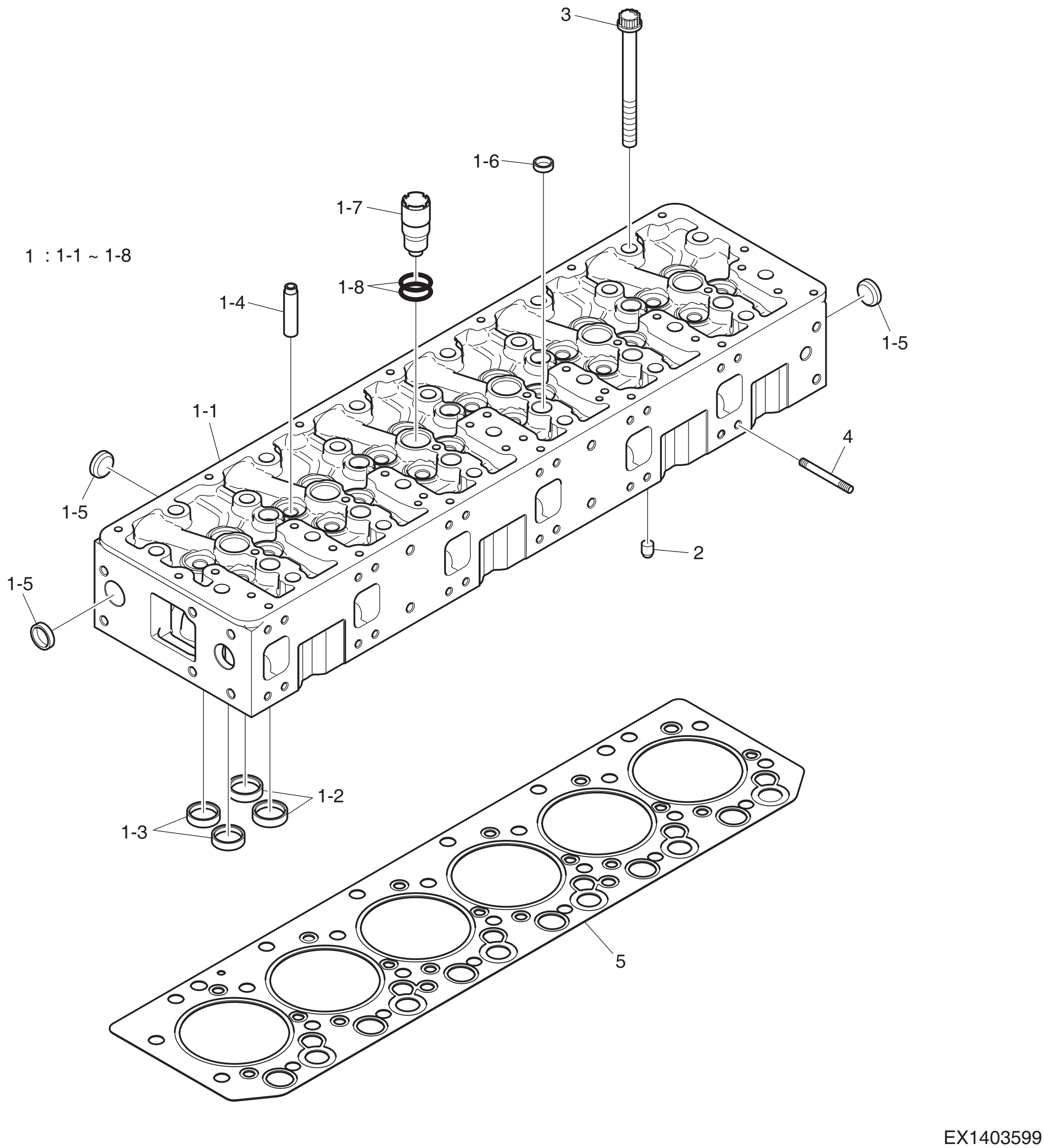


Figure 134

Reference Number	Description
1	Head Assembly, Cylinder
1-1	Head, Cylinder
1-2	Seat; Valve IN.
1-3	Seat; Valve EX.
1-4	Guide; Valve
1-5	Core; Plug
1-6	Plug; Core

Reference Number	Description
1-7	Bush; INJ. Nozzle
1-8	O-ring
2	Pin
3	Bolt; Head
4	Bolt; Stud
5	Gasket; Cylinder Head

Disassembly

1. After disassembling the cylinder head, keep it on a shelf in an organized way for later assembly.
2. Be careful not to damage the contact surface of the cylinder head gasket.
3. Remove the valve cotter, spring and spring seat using a valve spring compression tool.
4. Pull out the intake and exhaust valves.
5. Keep the removed parts in order.
6. Remove the valve stem seal.

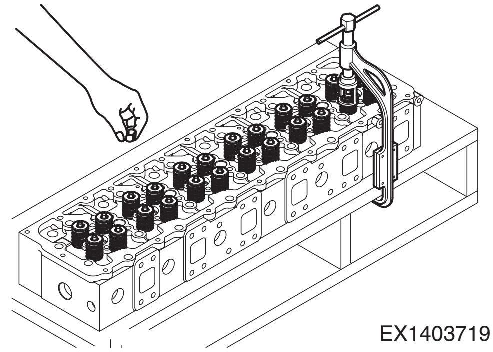


Figure 135

Assembly

1. Clean the cylinder head thoroughly.
2. Replace the valve stem seal with a new one.
3. Use a special service tool to install the stem seal to the valve guide of the cylinder head.
4. Apply engine oil to the valve stem and valve guide, and install the valve.

CAUTION

AVOID INJURY

Be careful not to damage the valve stem seal.

5. Install the valve spring seat to the valve guide on the cylinder head.
6. Install the inner and outer valve springs and place the spring seat on the top.
7. While pressing the valve spring with the valve spring compression tool, insert the valve cotter to install the valve.
8. After installing the valve, tap the valve gently with a urethane hammer to check if it is firmly installed.

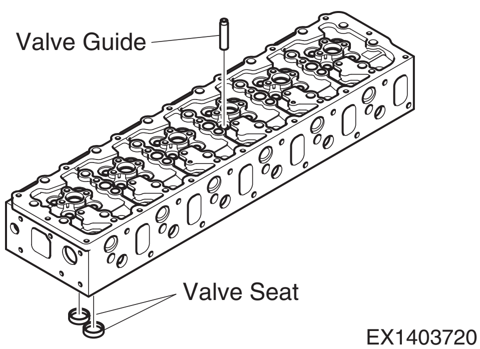


Figure 136

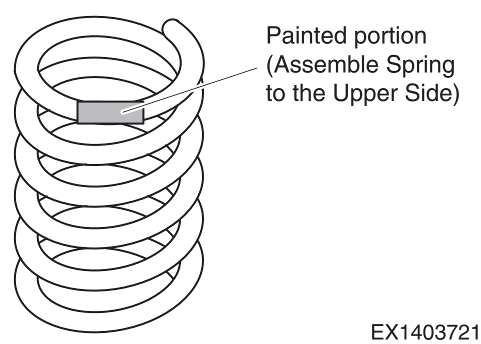


Figure 137

Inspection

Cylinder Head Inspection

1. Remove carbon from the bottom of the cylinder head.

CAUTION

AVOID INJURY

Be careful not to scratch the valve seat surface.

2. Visually check if the cylinder head is damaged.
3. A minute scratch or damage that cannot be found with with the naked eyes can be found through the hydraulic pressure test or magnetic particle test.

Bottom Distortion

1. Use a straightedge and feeler gauge to measure the distortion of the cylinder head in 6 directions.
2. If any measured value is over the allowable service limit, correct it with a fine sandpaper or grinder.
3. If it is under the allowable limit, replace the cylinder head.
   - Distortion and height of cylinder head

	Standard	Allowable Limit
Cylinder Head Bottom Flatness	0.08 mm or below	0.15 mm
Head Height: t	104.9 - 105.1 mm	104.4 mm

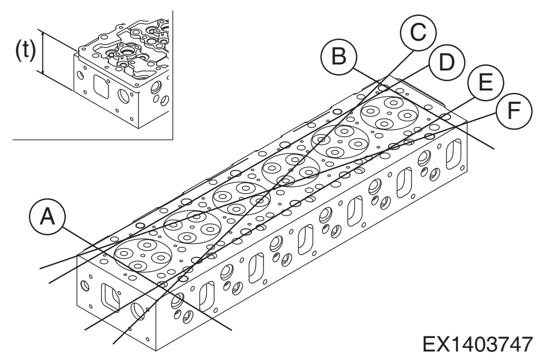


Figure 138

Flatness

1. Use a straightedge and feeler gauge to measure the flatness of the intake/exhaust manifold mounting surface of the cylinder head.

Standard	Allowable Limit
0.15 mm	0.3 mm

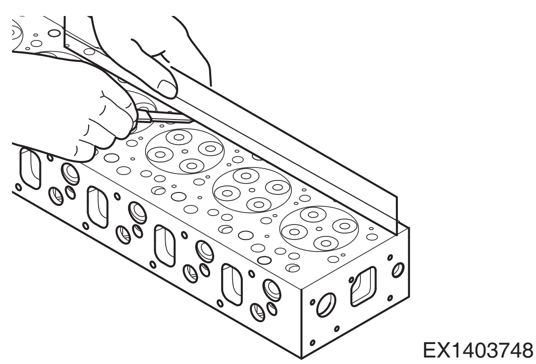


Figure 139

Cylinder Block

General Description

This forms a base for the engine body, and component shapes, including the crankshaft's and head's, and bolt holes are machined on it for their installation. It also has coolant and oil passage.

The cylinder block is cast in one piece, in compact graphite iron (CGI) and has all-in-one cylinder head. The cylinder bores have dry liners.

Parts List

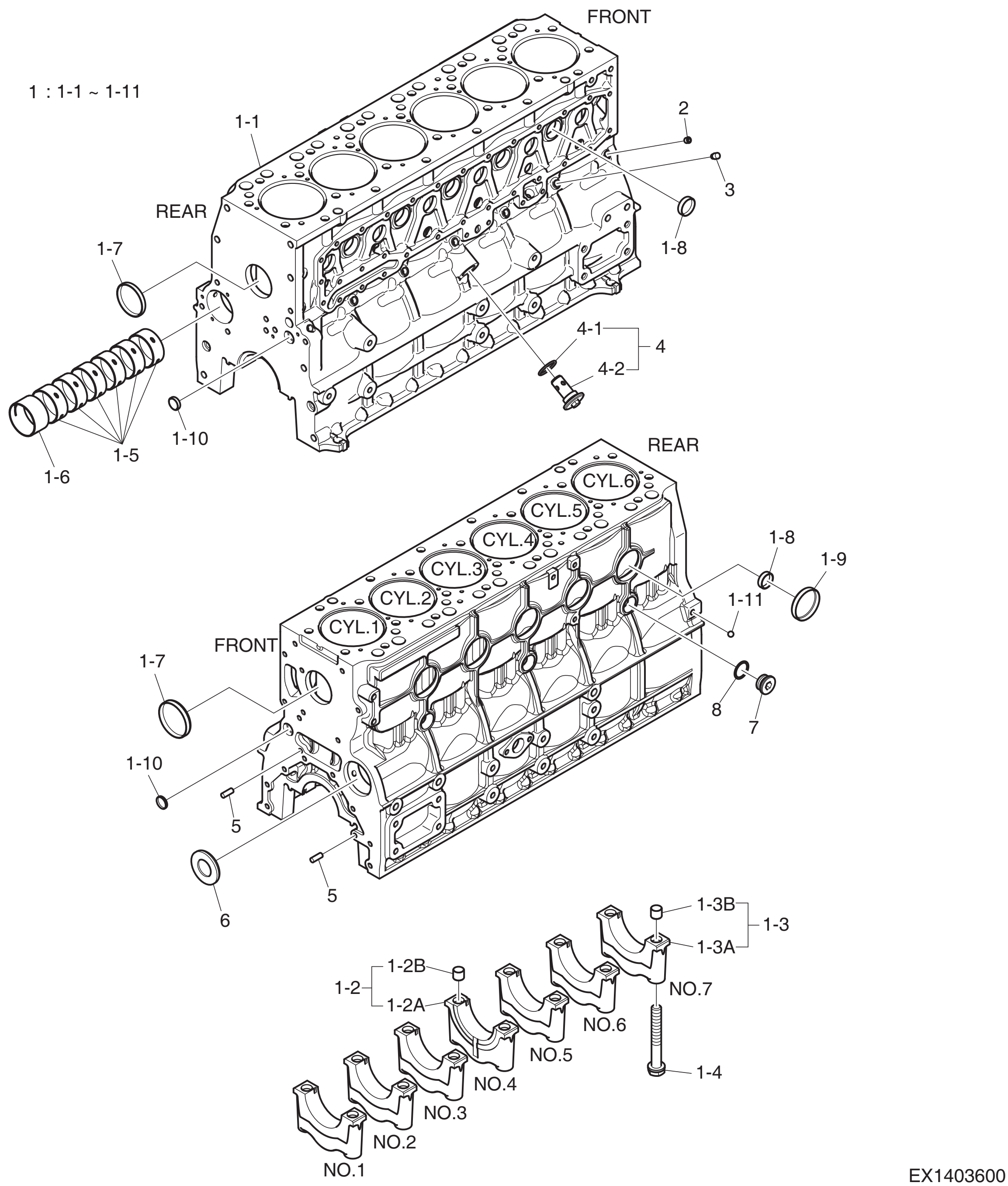


Figure 140

Reference Number	Description
1	Block Assembly, Cylinder
1-1	Block, Cylinder
1-2	Thrust Bearing Cap Assembly
1-2A	Bearing Cap; Thrust
1-2B	Ring; Stopper
1-3	Bearing Cap Assembly
1-3A	Bearing Cap
1-3B	Ring; Stopper
1-4	Bolt
1-5	Bush; Camshaft
1-6	Bush; Camshaft
1-7	Plug; Core
1-8	Plug; Core

Reference Number	Description
1-9	Plug; Core
1-10	Plug; Core
1-11	Ball; Steel
2	Plug Screw PT1/8
3	Pin; Core
4	Relief Valve Assembly
4-1	O-ring
4-2	Relief Valve
5	Pin
6	Cover; Core Hole
7	Screw; Plug
8	Seal; Ring

Inspection

1. Cleanse the cylinder block and check if there is any cracked or damaged part with naked eye.
2. Replace the cylinder block if it is seriously cracked or damaged. Repair tiny cracks if existing.
3. Check if the oil path or coolant path is clogged or corroded.
4. Perform the hydrostatic test to check whether there is a crack or an air leakage.
5. Block the discharging outlets of the cooling water path and the oil path of the cylinder block and put pressure of 4 kg/cm^2 (3.9 bar, 56.9 psi) on the inlet. Then sink the cylinder block in the 70°C water for 1 minute and check if air leaks.

Valve Mechanism

General Description

The valve mechanism consists of one or two camshafts, roller tappets, pushrods, rocker arms and valve tappets.

Straight engines have one camshaft and V engines have two camshafts, one for each cylinder line. In both cases the camshaft is driven by the timing gears and rotates at half the speed of the crankshaft.

The camshaft has two cams per cylinder, one for the intake valves and one for the outlet valves.

One end of the push rod rests on the roller tappet, and the other end acts on the rocker arm. At one end of the rocker arm there is an adjusting screw. The lower ball-shaped end of the screw rests in the pushrod, making the tappet adjust to the camshaft movement.

The valve seat inserts are firmly pressed to a tight fit in the cylinder head. The material in the seat inserts is very strong, so the valve seats have a long service life. If required the valve seat rings can be replaced.

With four valves per cylinder the valve area is greater, which makes it easier to fill the cylinder with air. At the same time, less energy is consumed in forcing out the exhaust fumes.

The effort required for gas flow is reduced and engine efficiency is improved. This in turn leads to a reduction in fuel consumption.

WARNING

AVOID DEATH OR SERIOUS INJURY

Wear protective goggles to prevent injury to eyes.

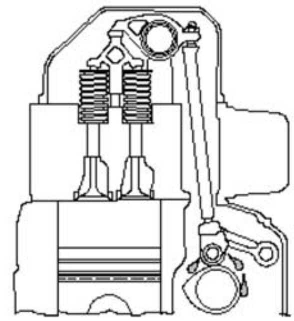

EX1302148

Figure 141

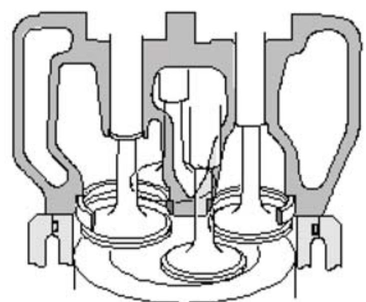
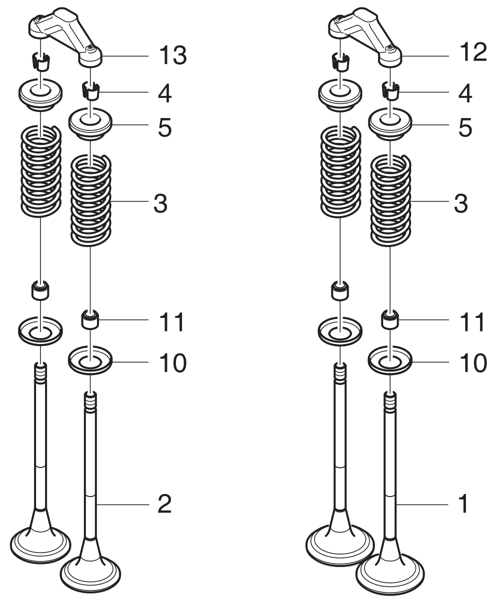

EX1302149

Figure 142

Parts List

Valve



EXHAUST INTAKE

EX1403601

Figure 143

Reference Number	Description
1	Valve; Intake
2	Valve; Exhaust
3	Spring; Valve
4	Plate; Valve Spring
5	Cotter; Valve

Reference Number	Description
10	Washer
11	Seal; Valve Stem
12	Caliper; Intake
13	Caliper; Exhaust

Rocker Arm

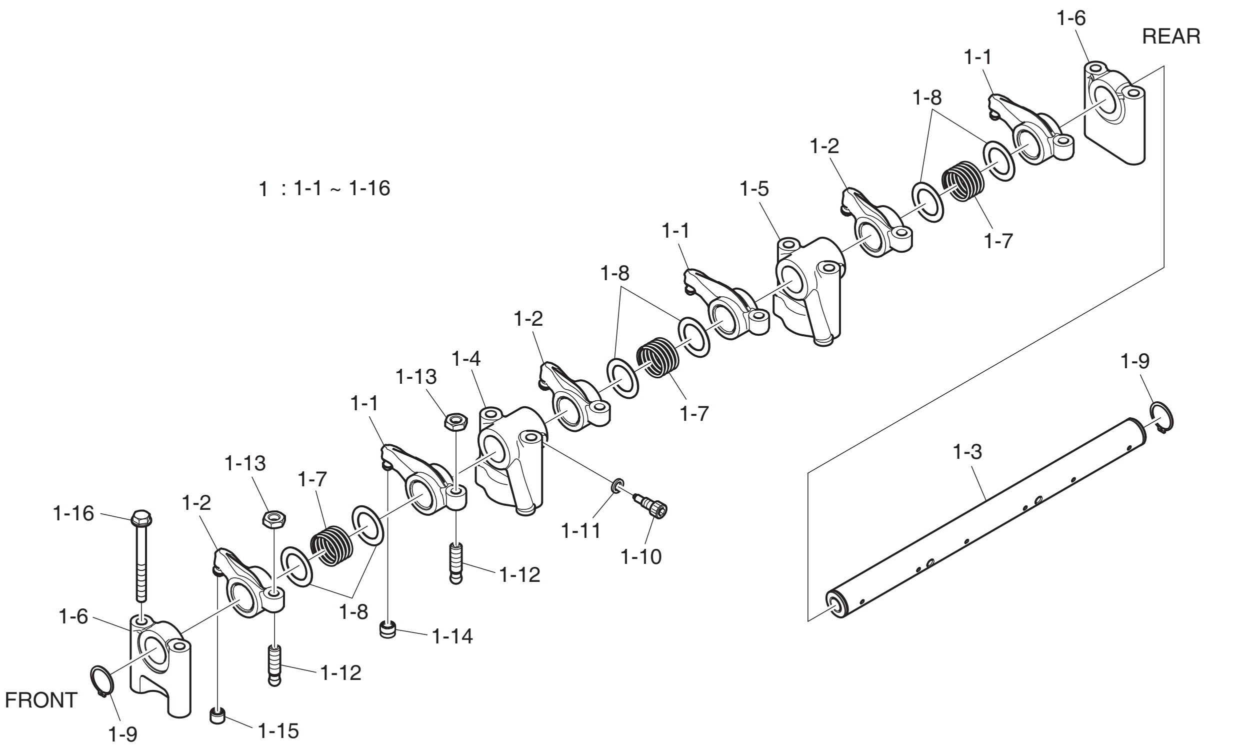


Figure 144

Reference Number	Description
1	Rocker Arm Shaft Assembly
1-1	Rocker Arm; Intake
1-2	Rocker Arm; Exhaust
1-3	Shaft; Rocker Arm
1-4	Bracket; Rocker Arm
1-5	Bracket; Rocker Arm
1-6	Bracket; Rocker Arm
1-7	Spring; Compession
1-8	Washer

Reference Number	Description
1-9	Ring; Snap
1-10	Bolt; Socket
1-11	Washer
1-12	Screw; Adjust
1-13	Nut
1-14	Cap; Intake
1-15	Cap; Exhaust
1-16	Bolt; Collared Hex.

Valve Tappet and Push Rod

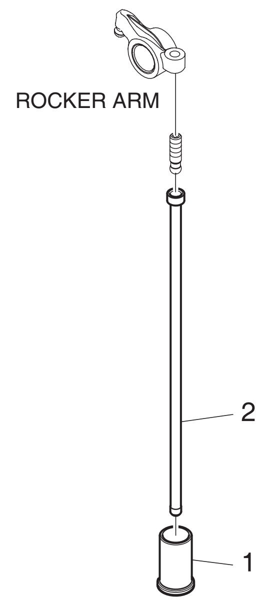


Figure 145

Reference Number	Description
1	Tappet; Valve

Reference Number	Description
2	Rod; Push

Valve Inspection

Wash the valve with clean engine oil and inspect it as follows:

Valve Stem O.D.

1. Measure the outside diameter of the valve stem at three location (upper, middle and lower points).
2. If the wear amount is over the allowable limit, replace the valve.

	Standard	Allowable Limit
Intake Valve Stem	ø6.963 ~ ø6.977 mm	ø6.93 mm
Exhaust Valve Stem	ø6.950 ~ ø6.964 mm	ø6.91 mm

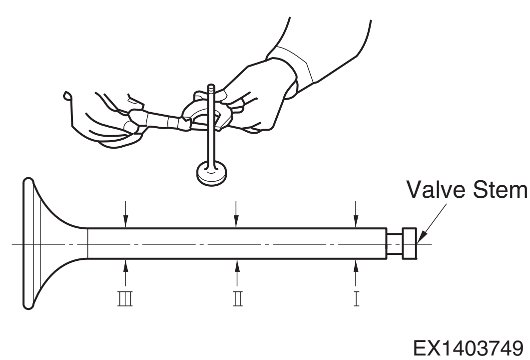


Figure 146

Valve Seat Contact Surface

1. Check if the valve seat contact surface is scratched or damaged.
2. If necessary, correct the surface with sandpaper. If damage is severe, replace the seat.

Valve Head Thickness

1. Measure the thickness of the valve head.
2. If the measurement is below the allowable limit, replace the valve.

	Standard	Allowable Limit
Intake Valve (A)	3.3 ~ 3.7 mm	2.8 mm or below
Exhaust Valve (A)	3.3 ~ 3.7 mm	2.8 mm or below

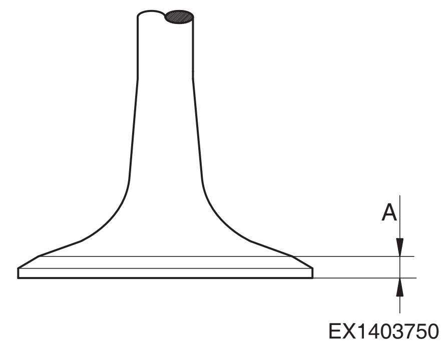


Figure 147

Valve Guide Inspection

1. Install the valve to the cylinder head.
2. Measure the clearance between the valve guide and valve with motion of the valve.
3. If the clearance is excessive, measure the size of the valve and replace either the valve or valve guide which is worn more.
   - Valve stem play

	Standard	Allowable Limit
Intake Valve	0.023 ~ 0.052 mm	0.1 mm
Exhaust Valve	0.036 ~ 0.065 mm	0.15 mm

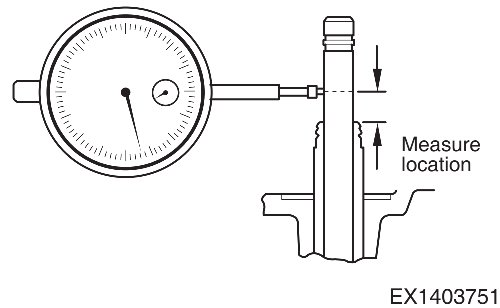


Figure 148

Valve Seat Inspection

Contact area on contact surface.

1. To check the wear level of the valve seat, measure the height of the contact surface from the intake/exhaust valves.
2. If the measurement is over the allowable limit, replace the seat.
3. Install the valve to the valve seat of the cylinder head.
4. Use a dial gauge to measure the amount of insertion of the value from the bottom of the cylinder head.

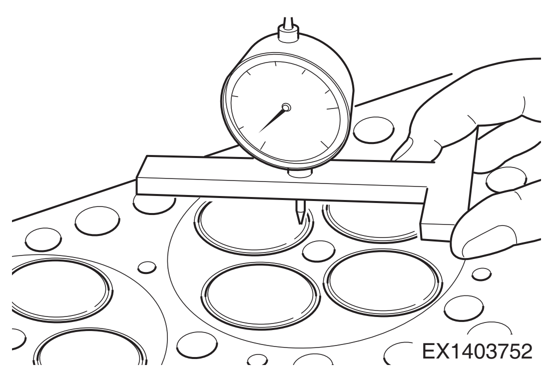


Figure 149

– Valve step portion

	Standard	Allowable Limit
Intake Valve (A)	0.35 ~ 0.65 mm	0.85 mm
Exhaust Valve (A)	0.35 ~ 0.65 mm	0.85 mm

– Valve angle

Intake valve (B)	Exhaust valve (B)
60°	45°

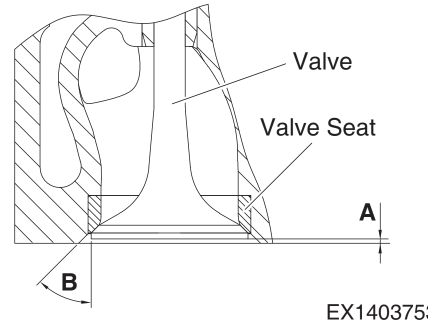


Figure 150

A. If the amount of valve insertion is over the allowable limit, replace the valve seat.

B. When removing the valve seat, arc weld two positions of the valve seat and use a special service tool to pull out the valve seat.

NOTE: *When replacing the valve seat, it should be bored.*

C. When installing the valve seat, put it in dry ice for approximately two hours to cool it down.

D. Use a bench press to press the valve seat into the cylinder head.

E. Apply abrasive to the valve head contact surface of the valve seat.

F. Rotate the valve to grind the valve seat until the valve is seated. Then, remove the abrasive thoroughly.

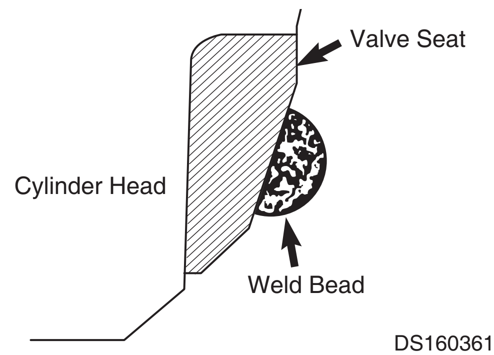


Figure 151

Valve Spring Inspection

1. Visually check the outside of the valve spring.

   A. Visually check if the valve spring is damaged. Replace it if necessary.

2. Check the free length of the valve spring.

   A. Use vernier calipers to measure the free length of the valve spring.

   B. If the measurement is below the standard value, replace the valve spring.

Free Length of Spring	Standard
Intake Valve	53.5
Exhaust Valve	53.5

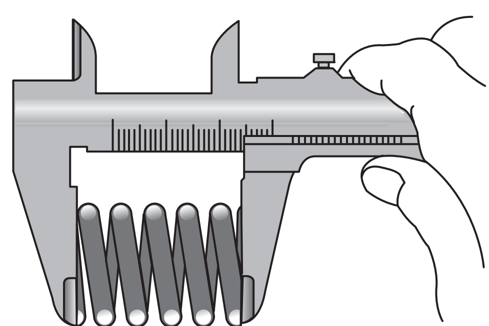


Figure 152

3. Check the squareness of the valve spring.

Reference Number	Description
A	Free Length
B	Squareness
C	Straightedge

   A. Use a surface plate and straightedge to measure the squareness of the valve spring.

   B. If the measurement is over the allowable limit, replace the valve spring.

	Specification	Allowable Limit
Valve Spring Squareness	1.4 mm or below	2.0 mm

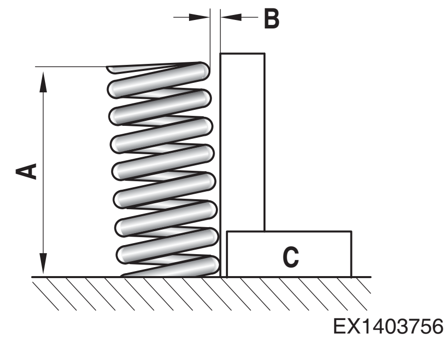


Figure 153

4. Check the tension of the valve spring.

   A. Use a spring tester (A) to measure the tension of the valve spring.

   B. If the measurement is below the allowable limit, replace the valve spring.

Item	Setting Length	Spring Tension	Allowable Limit
Intake/ Exhaust Valves	39.4 mm	28.8 kg	±2 kg
	29.67 mm	50 kg	±2 kg

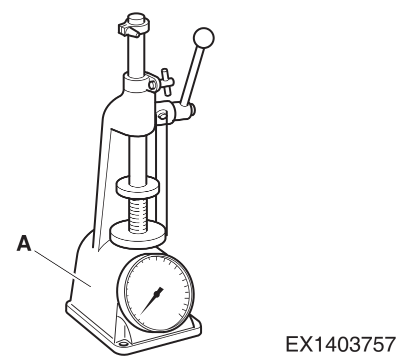


Figure 154

Rocker Arm Removal

1. Use pliers to remove the snap rings from both ends of the rocker arm shaft.
2. Remove the washer, rocker arm bracket, rocker arm spring and rocker arm in order.

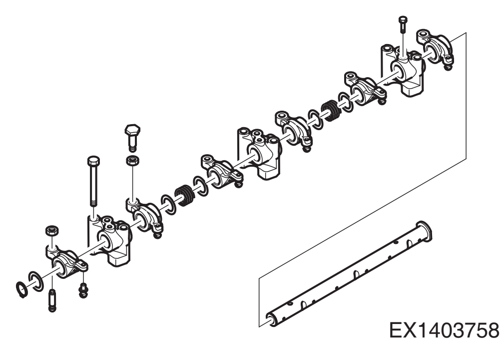


Figure 155

Rocker Arm Installation

1. Install the rocker arm in the reverse order of its removal.

CAUTION

AVOID INJURY

- **Check if there is any foreign material in the oil feed hole of the rocker arm shaft. Wash it cleanly.**
- **Make sure to install the rocker arm in the correct position in the correct order.**

Rocker Arm Inspection

Visual Inspection

1. Visually check the surface of the adjusting screw cap assembly which moves in contact with the valve stem. Check if the surface is scratched or has worn layers.
2. If the wear level is small, grind the surface with an oily whetstone or fine sandpaper. If the surface has severely worn layers, replace the rocker arm.

Rocker Arm Bushing I.D.

1. Use a micrometer or vernier calipers to measure the inside diameter of the rocker arm bushing.
2. Compare the measurement with the outside diameter of the rocker arm shaft. If the clearance is over the allowable limit, replace either the bushing or shaft which is worn more.

Standard	Allowable Limit
ø24.991 ~ ø25.012 mm	ø25.04 mm

	Standard	Allowable Limit
Clearance between Rocker Arm and Shaft	0.031 ~ 0.073 mm	0.14 mm or below

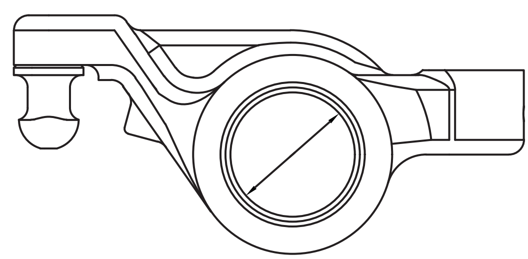


Figure 156

Rocker Arm Shaft Inspection

Deflection of Rocker Arm Shaft

1. Place the rocker arm shaft on two V-blocks and use a dial gauge to measure the deflection of the shaft.
2. If its deflection is minute, use a press to straighten it. If its deflection is over the allowable limit, replace it.

Allowable Limit	0.1 mm

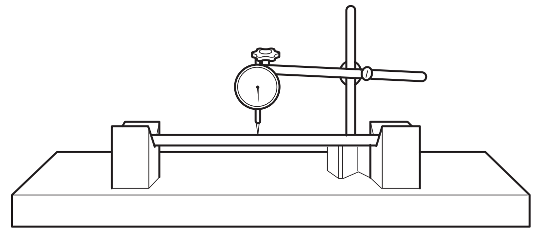


Figure 157

Rocker Arm Shaft O.D.

1. Use a O.D. micrometer to measure the outside diameter of the rocker arm shaft at the location where the rocker arm was installed.
2. If the measurement is over the allowable limit, replace the rocker arm shaft.

Standard	Allowable Limit
ø24.939 ~ ø24.960 mm	ø25.90 mm

Valve Tappet Inspection

Tappet Clearance

1. Measure the outside diameter of the tappet and the inside diameter of the tappet hole of the cylinder block.
2. If the measurement is over the allowable limit, replace the tappet.

Standard	Allowable Limit
0.028 ~ 0.069 mm	0.13 mm

Visual Inspection of Tappet

1. Visually check the surface of the tappet which moves in contact with the camshaft. Check if the surface is cracked, scratched or damaged.
2. If such damage is minute, grind the surface with an oily whetstone or fine sandpaper. If its surface has severely damaged, replace it.

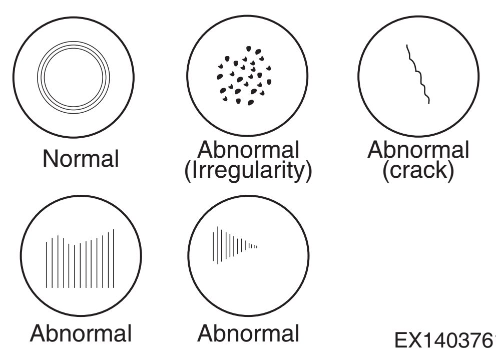


Figure 158

Tappet O.D.

1. Use a O.D. micrometer to measure the outside diameter of the tappet.
2. If the measurement is over the allowable limit, replace the tappet.

Standard	ø27.962 ~ ø27.982 mm

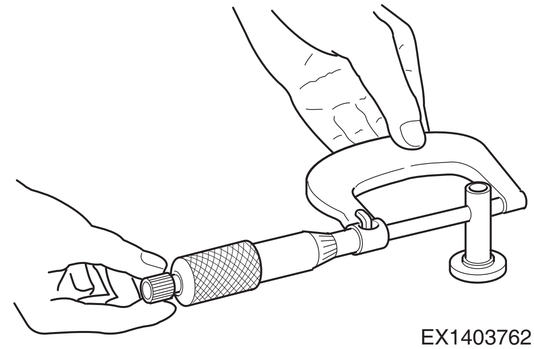


Figure 159

Push Rod Deflection Inspection

1. Place the push rod on the surface plate.
2. Measure its deflection with a feeler gauge while rolling it.
3. If the measurement is over the allowable limit, replace it.

Allowable Limit	0.25 mm or below

Push Rod Length	344 mm

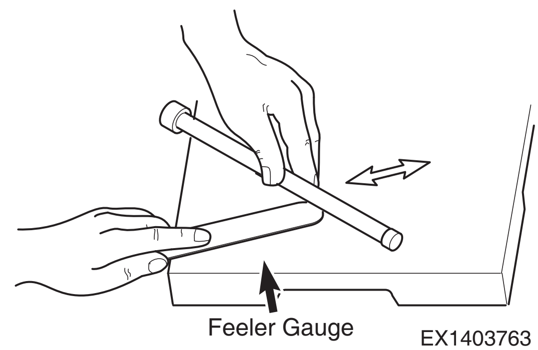


Figure 160

Valve Clearance

Adjust the valve clearance under the following conditions:

- When disassembling the engine or cylinder head,
- When loud noise is heard from the valve connection,
- When the fuel injection system is intact but the engine operates abnormally.

Valve Clearance Adjustment Procedure

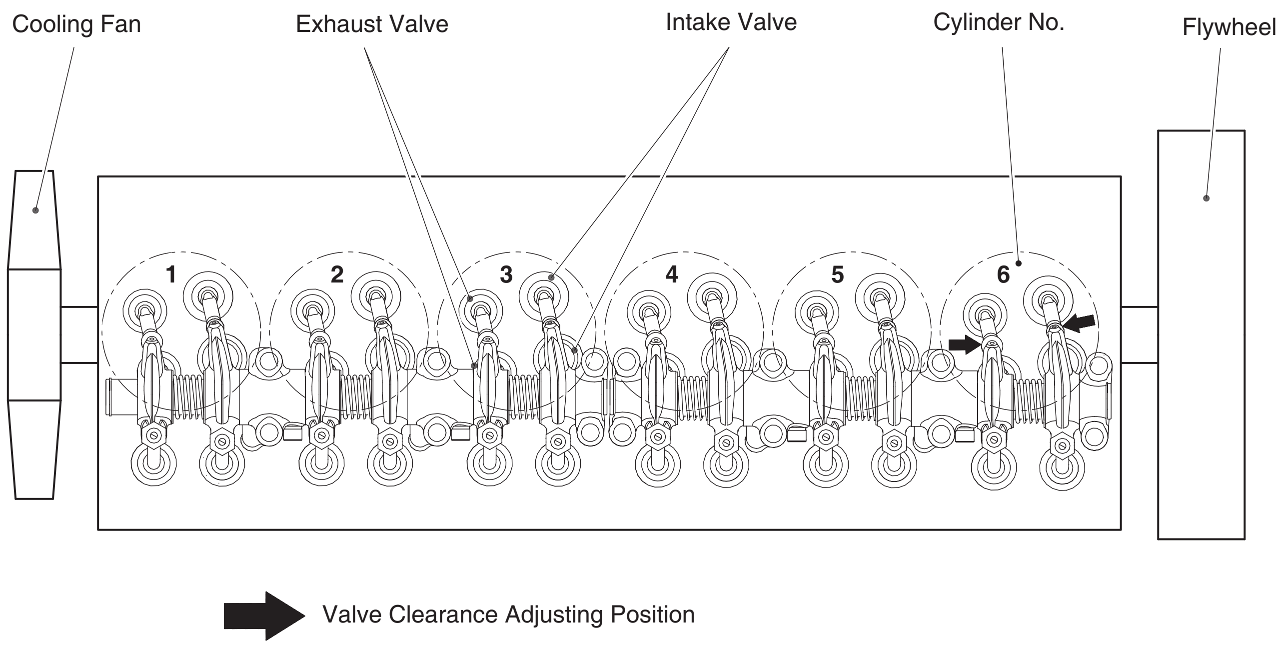


Figure 161

EX1403764

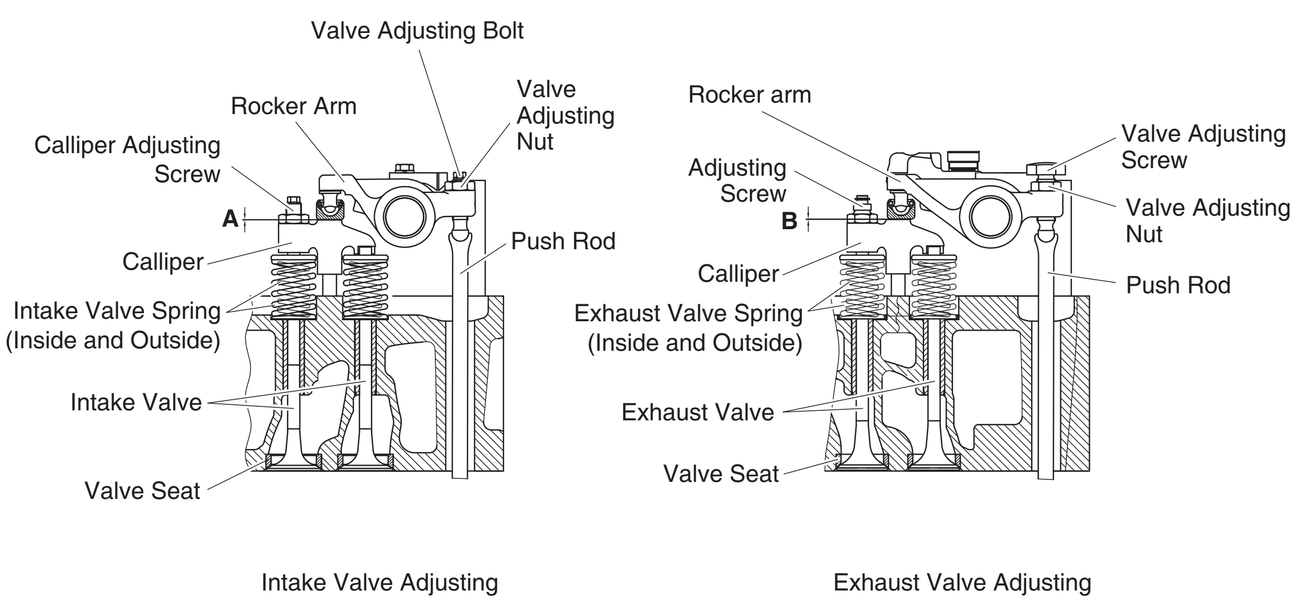


Figure 162

EX1403765

Method 1

1. Turn the crankshaft to set the piston of the cylinder No. 1 to the TDC on the compression stroke.

   NOTE: *The cylinder No. 1 can be identified by the cooling fan.*

   NOTE: *When the cylinder No. 1 is at the TDC on the compression stroke, valve overlap is occurred at the cylinder No. 6.*

2. Unscrew the rocker arm mounting nut at the cylinder No. 1.
3. Adjust the cylinder clearance with its adjusting nut. Then, tighten the mounting nut.

Intake Valve (mm)	Exhaust Valve (mm)
0.3	0.4

4. Turn the crankshaft to adjust the valve clearance for each cylinder at the TDC on the compression stroke.
5. According to the cylinder in the valve overlap period, adjust the valve clearance for the corresponding cylinder at the TDC on the compression stroke as follows:

Cylinder No. in Valve Overlap Period					
1	5	3	6	2	4
6	2	4	1	5	3
Cylinder No. for Valve Adjustment					

Method 2

1. Turn the crankshaft to set the valves of the cylinder No. 6 overlapped.

   NOTE: *When the cylinder No. 1 is at the TDC on the compression stroke, valve overlap is occurred at the cylinder No. 6.*

   NOTE: *The cylinder No. 1 can be identified by the cooling fan.*

2. Adjust the valve clearance marked with ' o ' in the table.
3. Rotate the engine for 1 turn (360°) in the engine rotating direction to set the valves for the cylinder No. 1 overlapped.

   NOTE: *When the cylinder No. 6 is at the TDC on the compression stroke, valve overlap is occurred at the cylinder No. 1.*

4. Adjust the valve clearance marked with ' x ' in the table.
5. Check the valve clearance again, and adjust it as necessary.

Cylinder No.	1		2		3		4		5		6	
Valve	E	I	E	I	E	I	E	I	E	I	E	I
No. 1 TDC	o	o			o			o	o	o		
Turn 360°			x	x		x	x				x	x

ACTUATING SYSTEM

Camshaft

General Description

The task of the camshaft is to control the opening and closing of the intake and exhaust valves. On engines equipped with the injection system, the camshaft also provides the movement required to build up pressure in the injectors.

Camshaft Design

The camshaft has two or three cams per cylinder. There is always one for intake valves and one for exhaust valves. In some cases, there is also one for the injectors.

A cam can be described with the following terms; see picture:

Reference Number	Description
1	Cam Profile
2	Base Circle Diameter
3	The Largest Lift of the Cam Profile, Equivalent to the Maximum Movement of the Roller Tappet.

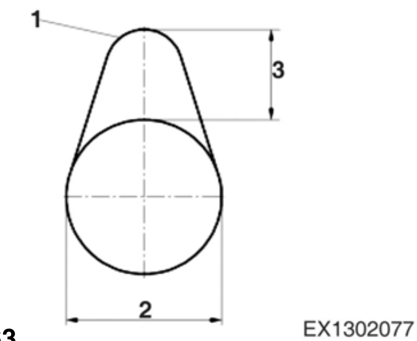


Figure 163

Function

The camshaft rotates at half the speed of the crankshaft so each group of cams can actuate the valves of their cylinder every other engine revolution during the exhaust stroke and intake stroke. Where applicable, the injectors are actuated in relation to injection timing.

Valve transition occurs at the arrow. This is when the exhaust valves are closing and the intake valves are starting to open. The time point when both the exhaust valves and the intake valves are open simultaneously is called valve overlap.

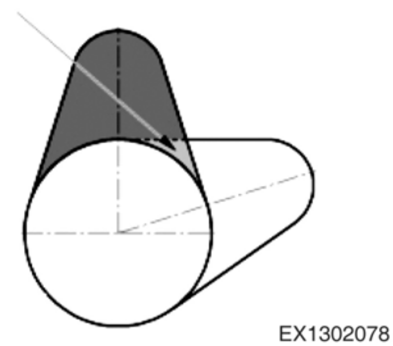


Figure 164

Camshaft Play

1. Move the camshaft gear to the opposite side of the cylinder block.
2. Use a feeler gauge to measure the clearance between the thrust plate and camshaft gear.
3. If the play is excessive, replace the thrust plate.

Standard	Allowable Limit
0.280 ~ 0.430 mm	0.5 mm

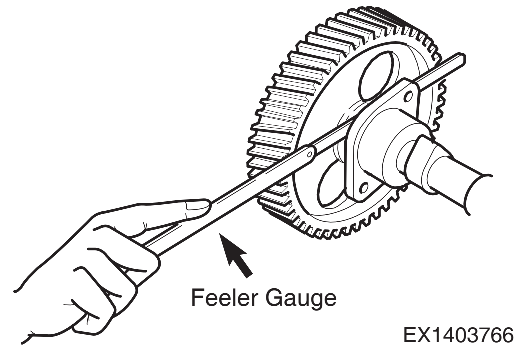


Figure 165

Inspection

Measure the height of the cam lobe.

1. Use a micrometer to measure the cam lobe height and journal diameter.
2. If the measurement is below the allowable limit, replace the camshaft.

		Standard	Allowable Limit
Cam Lobe Height (C)	Intake	46.025 mm	45.73 mm
	Exhaust	47.782 mm	47.48 mm
Cam Journal Diameter (A and B)		ø55.92 ~ ø55.95 mm	ø57.65 mm

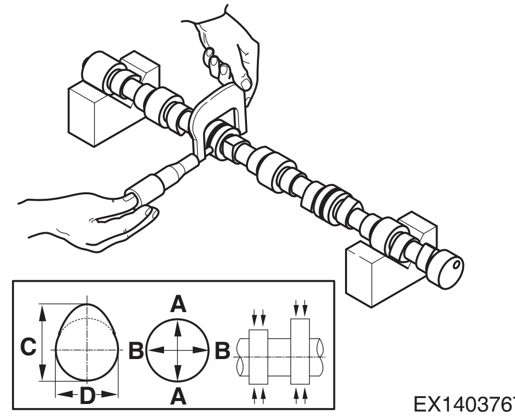


Figure 166

Check the cam surface.

1. Check if the cam surface is scratched or damaged.
2. Minutely worn layers or small damage can be corrected with an oily whetstone or fine oily sandpaper. If damage is severe, replace it.

Clearance between camshaft and bearing.

1. Use an O.D. micrometer to measure the outside diameter of the camshaft bearing section.
2. Use a cylinder I.D. gauge to measure the inside diameter of the camshaft bearing, and compare the measurement result with the outside diameter of the camshaft to calculate the clearance.
3. If the measurement is over the allowable limit, replace the camshaft bearing.

Standard	Allowable Limit
0.03 ~ 0.09 mm	0.18 mm

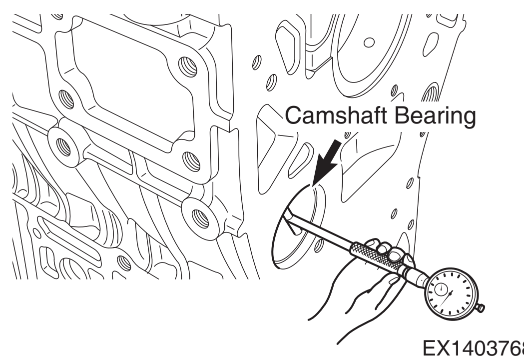


Figure 167

Camshaft deflection

1. Place the camshaft on two V-blocks.
2. Use a dial gauge to check the deflection of the camshaft. Correct it as necessary.
3. If its deflection is excessive and cannot be corrected, replace it.

Standard	Allowable Limit
0.05 mm	0.15 mm

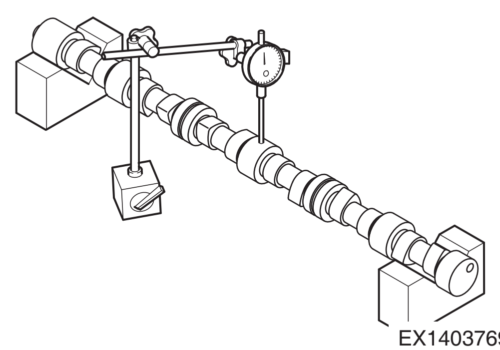


Figure 168

Piston

General Description

The piston moves in a reciprocating motion in the cylinder block to receive high-pressure high-temperature gas in the combustion stroke and produce rotating power for the crankshaft through the connecting rod. Its head is designed to withstand hot combustion gas and high pressure, and three to four piston rings are fitting around its top to ensure its sealing and to prevent oil entrance into the combustion chamber.

As it needs to move up and down in the cylinder at a high speed repeatedly, it needs to be light and robust and have low thermal expansion characteristic.

- The piston is an important component that receives higher combustion pressure, So it is necessary to scrap it if the head or pin hole part involves even a tiny scratch.
- Sometimes, the assembly can be done upside down since the shapes of the top and bottom side are similar. So, the assembly work requires attention.
- If the assembly is complete upside down, the piston may run abnormally, which leads to higher consumption of oil, increase of bypass gas, damage to the ring, and sometimes even stand burn of the engine. Therefore, the whole assembly process needs to take great care.

Parts List

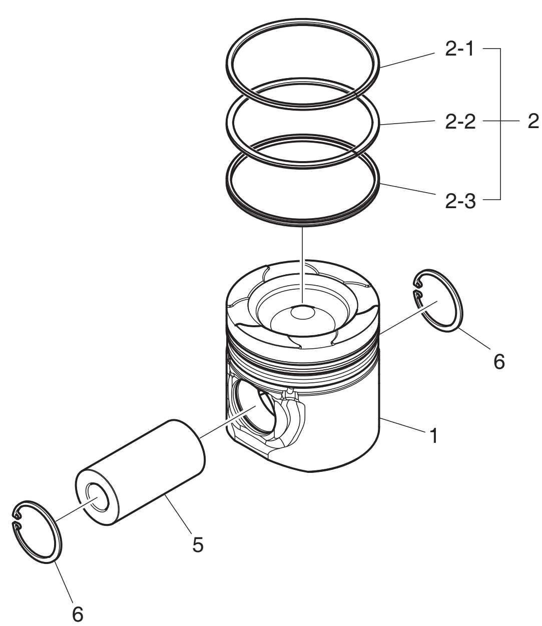


Figure 169

Reference Number	Description
1	Piston
2	Piston Ring Kit
2-1	Ring; Top
2-2	Ring; Second
2-3	Ring; Piston
5	Pin; Piston
6	Ring; Lock

Disassembly

Disassemble the piston according to the specified disassembly steps.

Assembly

Assemble the piston according to the specified assembly steps.

Piston Inspection

Visual inspection

1. Visually inspect the piston for a crack, scratch and wear.
2. Especially, check if the ring groove is worn.

Clearance between piston and cylinder liner

1. Use an O.D. micrometer to measure the outside diameter of the piston at the position 12 mm up from the bottom of the piston in the orthogonal direction of the piston pin hole.

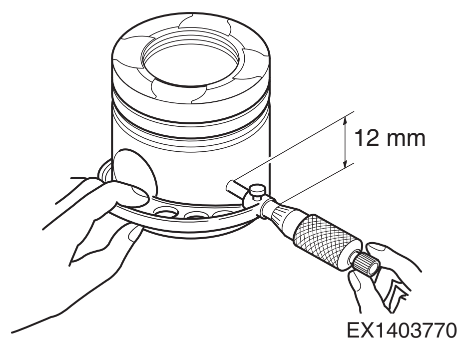


Figure 170

2. Use a cylinder I.D. gauge to measure the inside diameter of the cylinder liner.
3. Perform the measurement at 3 locations of the cylinder liner: the top ring contact section, middle section, and oil ring contact section around the B.D.C. in the 45° direction.
4. Calculate the average value from the measurement results and exclude the maximum and minimum values.
5. The clearance can be calculated by subtracting the outside diameter of the piston from the inside diameter of the cylinder liner.

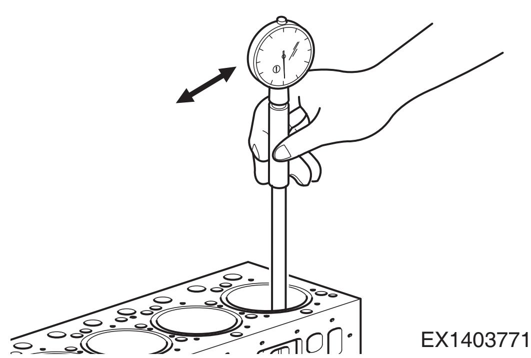


Figure 171

6. If this value is over the allowable limit, replace either the piston or cylinder liner which is worn more.

Clearance between Piston and Liner	
Standard	0.079 ~ 0.101 mm

Piston Ring Inspection

Visual Inspection

If any worn or damaged piston ring is found during disassembling the engine, replace it with a new one.

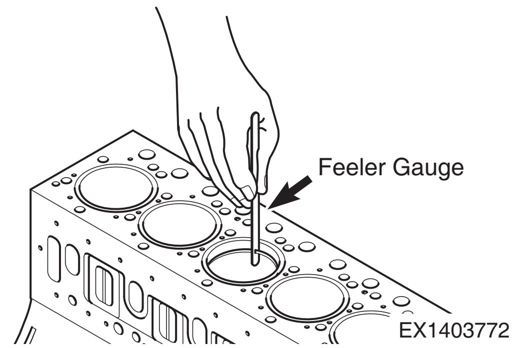


Figure 172

Piston Ring Gap

1. Insert the piston into the top of the cylinder at a right angle to the cylinder liner wall.
2. Use a feeler gauge to measure the piston ring gap.

	Specification	Allowable Limit
Ring No. 1	0.30 ~ 0.45 mm	1.5 mm
Ring No. 2	0.60 ~ 0.80 mm	1.5 mm
Oil Ring	0.25 ~ 0.45 mm	1.5 mm

3. If the piston ring gap is over the allowable limit, replace the piston ring with a new one.

Piston Ring Side Clearance

1. Install the compression ring and oil ring to the piston's ring groove.
2. Use a feeler gauge to measure the side clearance of the ring.

	Standard	Allowable Limit
Ring No. 1	-	-
Ring No. 2	0.05 ~ 0.09 mm	0.15 mm
Oil Ring	0.03 ~ 0.07 mm	0.15 mm

3. If the measurement is over the allowable limit, replace the ring or piston.

Piston Ring Tension

1. Use a tension gauge to measure the tension of the piston ring.
2. If the measurement is over the allowable limit, replace the piston ring.

	Standard
Ring No. 1	1.47 ~ 2.21 kg
Ring No. 2	1.49 ~ 2.23 kg
Oil Ring	4.08 ~ 5.52 kg

Piston and Piston Pin Inspection

1. Measure the wear amount of the piston pin.
2. If the measurement is over the allowable limit, replace the pin.

Standard Value for Piston Pin	Allowable Limit
ø39.994 ~ ø40.000 mm	ø39.94 mm

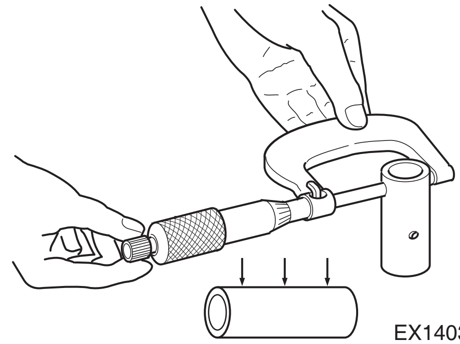

EX1403773

Figure 173

3. Measure the clearance between the piston pin and connecting rod bushing.
4. If the measurement is over the allowable limit, replace either one of them which is worn more.

Standard	Allowable Limit
0.008 ~ 0.020 mm	0.08 mm

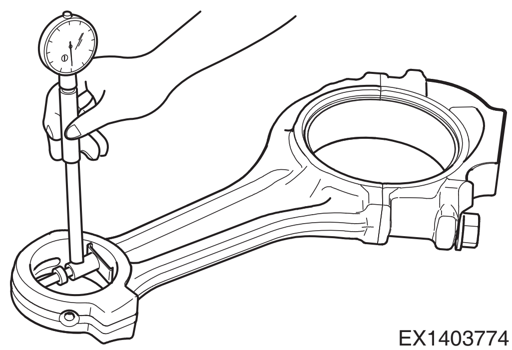

EX1403774

Figure 174

5. Check the mounting status of the piston and piston pin.

IMPORTANT

If the piston needs to be replaced, replace the piston pin as well.

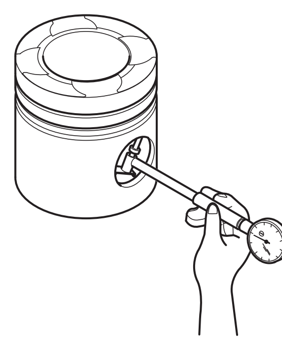

EX1403775

Figure 175

Connecting Rod

General Description

The connecting rod is designed to convert the vertical reciprocating motion of the piston into the rotating motion of the crankshaft. As it is subject to powerful explosive force, it needs to be rigid.

Its one end matched with the piston is called "small end" while its the other end matched with the crankshaft is called "big end." The big end is split in two parts which are put together with a bolt. As the big end is connected to the rotating crankshaft, its inner side is fitted with a replaceable metal bearing.

Parts List

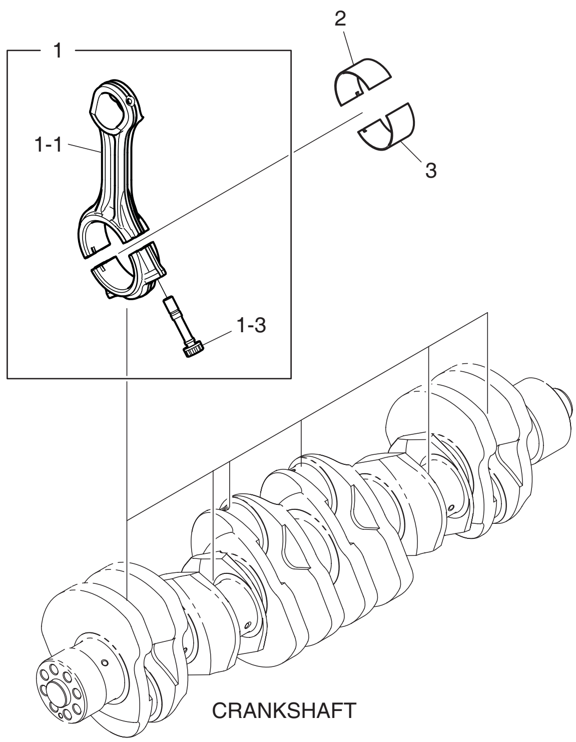


Figure 176

EX1403605

Reference Number	Description
1	Connecting Rod Assembly
1-1	Rod; Connecting
1-3	Bolt; Connecting Rod

Reference Number	Description
2	Metal; Con-rod
3	Metal; Con-rod

Inspection

Distortion

1. Check the distortion of the connecting rod.
2. Fit the connecting rod to its measuring device and use a feeler gauge to check its distortion.
3. If the connecting rod is distorted, do not reuse it, but replace it with a new one.

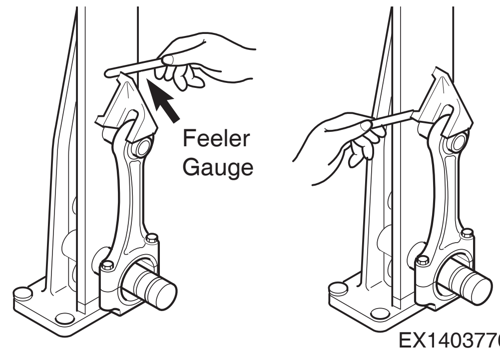


Figure 177

Hole Parallelization

1. Measure the parallelization of the small end bushing hole and big end bearing hole of the connecting rod.

   NOTE: *Use the connecting rod measuring device and feeler gauge for this measurement.*

Standard	Allowable Limit
0.02 mm	0.1 mm or below

Wear

1. Install the connecting rod to the crankshaft.
2. Use a feeler gauge to measure the side clearance at the big end of the connecting rod.
3. Install the connecting rod to the piston.
4. Measure the side clearance at the small end of the connecting rod.
5. If the measurement is over the allowable limit, replace the connecting rod.

Standard	Allowable Limit
0.17 ~ 0.30 mm	0.50 mm

Crankshaft

General Description

The crankshaft is used to convert power from the piston to rotating torque through the connecting rod and transfer this torque through the flywheel. Other than in the explosion stroke, it transfers movement back to the piston, and it transfers rotating torque to it to drive the oil pump, water pump and high-pressure fuel pump.

Parts List

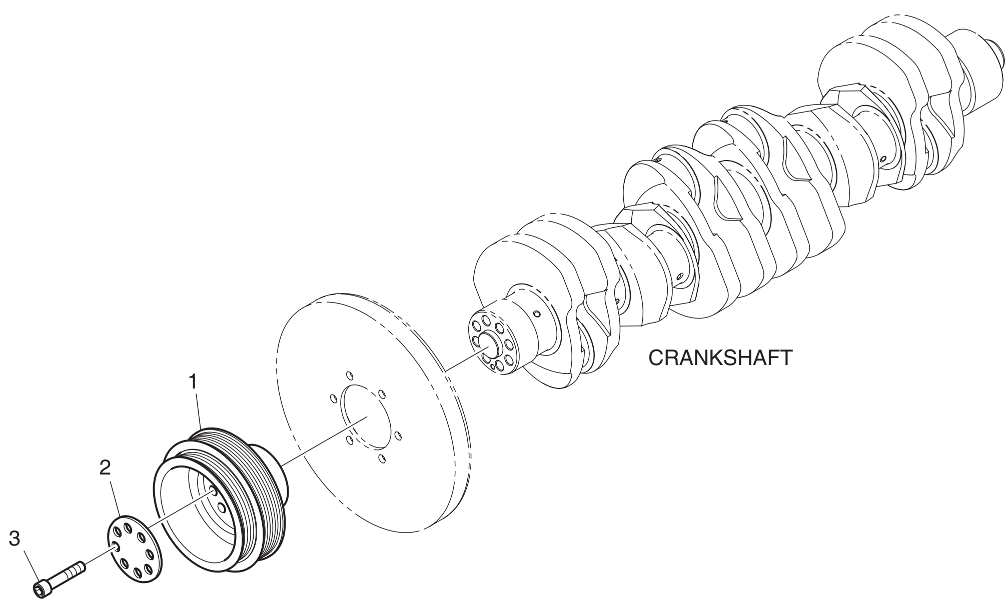


Figure 178

EX1403606

Reference Number	Description
1	Pulley; Crankshaft
2	Washer; Plain
3	Bolt; Socket

Inspection

Inspection for Defect

1. Visually check the crankshaft journal and crank pin for a scratch or crack.
2. Perform the magnetic particle test or dye penetrant test (color check) to check the crankshaft for a crack. If the crankshaft is cracked, replace it.

Wear Measurement

1. Use a O.D. micrometer to measure the journal and pin of the crankshaft in the specified direction as illustrated to check its wear amount.
2. If the wear amount is over the allowable limit, grind the crankshaft to install an undersized bearing.
3. However, if the wear amount is within the allowable limit, correct it with an oily whetstone or fine oily sandpaper.

NOTE: *Use a sandpaper soaked in oil.*

	Standard	Allowable Limit
Journal O.D.	ø79.905 ~ ø79.925 mm	ø78.905 mm
Pin O.D.	ø68.924 ~ ø68.944 mm	ø67.924 mm

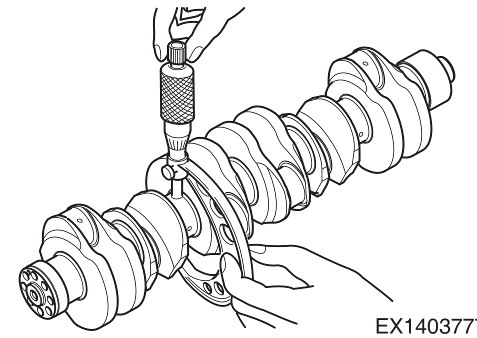


Figure 179

4. If the pin wear amount is over the allowable limit, grind the crank journal and crank pin and use an undersized bearing.

NOTE: *Use a sandpaper soaked in oil to grind the crankshaft.*

5. There are four types of undersized bearings. The crankshaft can be reused by grinding it according to the undersized bearing to be used.
   - Standard
     - 0.25 (I.D.: 0.25 mm smaller than standard)
     - 0.50 (I.D.: 0.50 mm smaller than standard)
     - 0.75 (I.D.: 0.75 mm smaller than standard)
     - 1.00 (I.D.: 1.00 mm smaller than standard)
6. Standard for section "R"
   - Crank pin section "R": 3.5 ~ 4.0
   - Crank journal section "R": 3.5 ~ 4.0

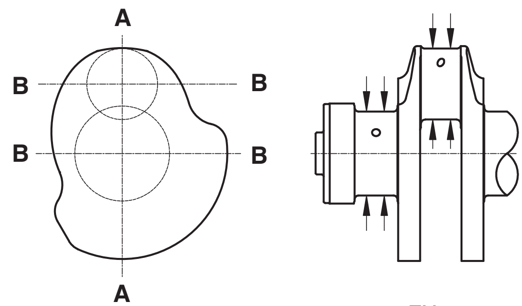


Figure 180

IMPORTANT

When grinding the crankshaft, the section "R" at the end of the bearing should be precisely ground. There should be no step or rough surface.

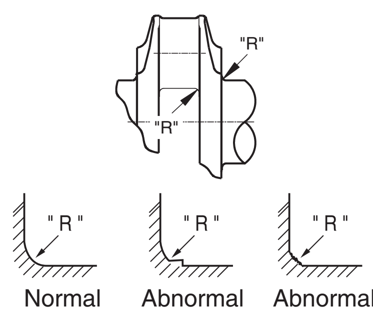


Figure 181

Crankshaft Deflection

1. Place the crankshaft on two V-blocks.
2. Place a dial gauge on the surface plate. While turning the crankshaft, measure the deflection of the crankshaft.

Standard	Allowable Limit
0.06 mm	0.15 mm or below

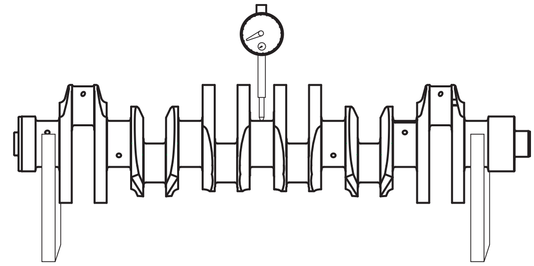


Figure 182

Crankshaft Bearing and Connecting Rod Inspection

Visual Inspection

Visually check the crankshaft bearing and connecting rod bearing for a scratch, abnormal wear or damage.

Oil clearance between crankshaft and bearing (method 1: using dial gauge):

1. Main bearing clearance
   A. Install the main bearing to the cylinder block, tighten the bearing cap to the specified torque, and measure the inside diameter.

Torque	294.1 N.m (30 kg.m, 216.9 ft lb)

   B. Compare the inside diameter of the main bearing with the outside diameter of the crankshaft journal to calculate the oil clearance.

Main Bearing Oil Clearance	
Standard	**Allowable Limit**
0.052 ~ 0.122 mm	0.15 mm

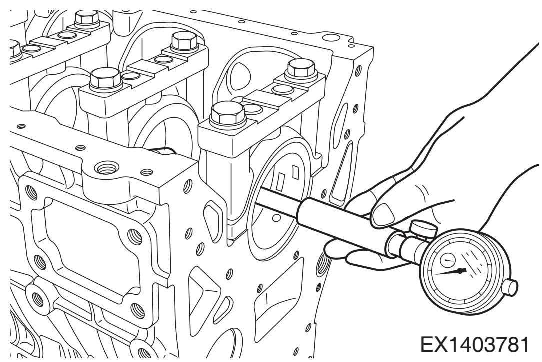


Figure 183

2. Connecting rod bearing clearance
   A. Install the connecting rod bearing to the connecting rod bearing cap, tighten the bolt to the specified torque, and measure the inside diameter.

Torque	95.6 N.m (9.75 kg.m, 70.5 ft lb)

IMPORTANT

When tightening the connecting rod bolt, tighten it with a hand until its head touches the bolt seat of the connecting rod. Then, tighten it finally with a torque wrench.

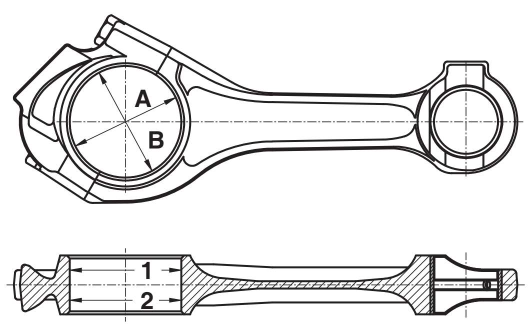


Figure 184

B. Compare the two values obtained from measurement of the inside diameter of the connecting rod bearing with the outside diameter of the crankshaft pin to calculate the oil clearance.

Standard	Allowable Limit
0.030 ~ 0.081 mm	0.15 mm

C. If the clearance is over the allowable limit, grind the crankshaft journal and pin sections to install an undersized bearing.

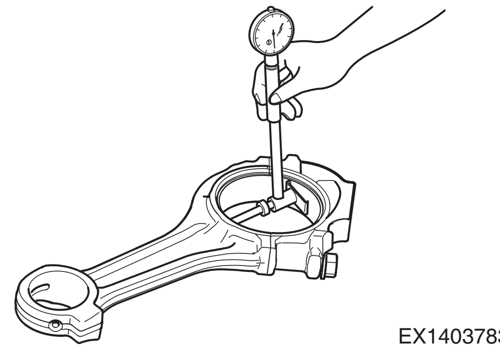


Figure 185

Oil Clearance between Crankshaft and Bearing (Method 2: Using Plastigauge):

1. Install the crankshaft onto the cylinder block.
2. Place a plastigauge onto the journal and pin sections of the crankshaft.
3. Install the bearing cap and tighten the bolt to the specified torque.
4. Unscrew the bolt to remove the bearing cap.
5. Measure the thickness of the flat section of the plastigauge with a plastigauge measuring ruler.
6. This is the oil clearance.

Bearing Spread and Crush

1. Inspection
   A. When installing the bearing, check if a large crush is felt.

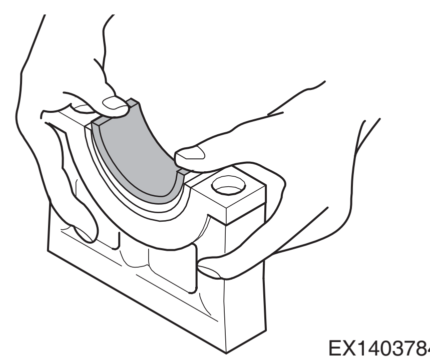


Figure 186

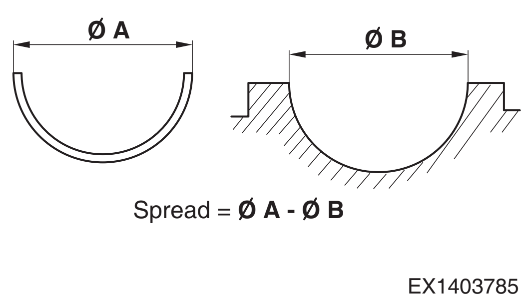


Figure 187

2. Bearing cap crush

   A. Install the bearing and cap to the cylinder block.

   B. Tighten the bolt to the specified tightening torque.

   C. Unscrew one bolt completely and use a feeler gauge to measure the clearance between the bearing cap and cylinder block.

Standard	0.065 ~ 0.105 mm

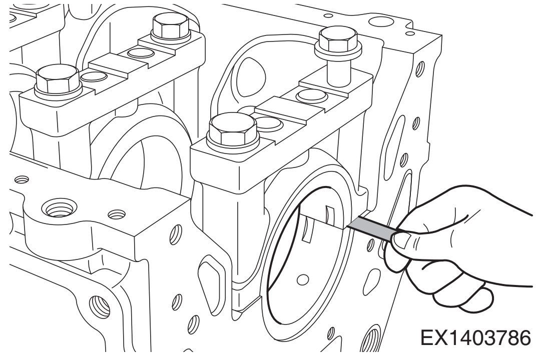


Figure 188

3. Connecting rod bearing crush

   A. Install the bearing and cap to the big end of the connecting rod.

   B. Tighten the bolt to the specified tightening torque.

   C. Unscrew one bolt completely and use a feeler gauge to measure the clearance between the bearing cap and connecting rod big end.

Standard	0.085 ~ 0.125 mm

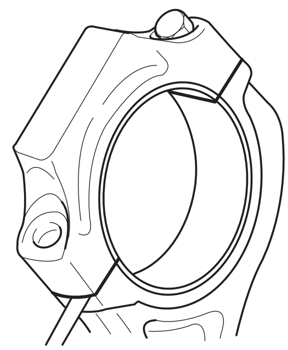


Figure 189

4. Axial play of crankshaft

   A. Install the crankshaft onto the cylinder block.

   B. Use a dial gauge to measure the axial play of the crankshaft.

Standard	Allowable Limit
0.14 ~ 0.33 mm	0.4 mm

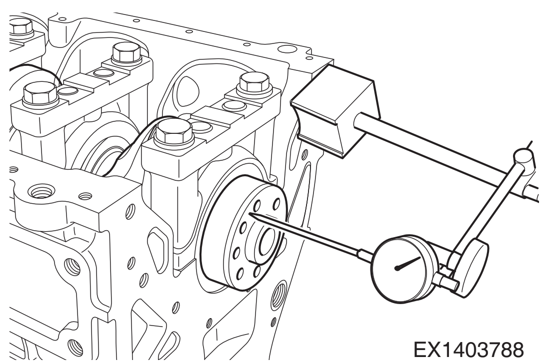


Figure 190

Timing Gear

Overview

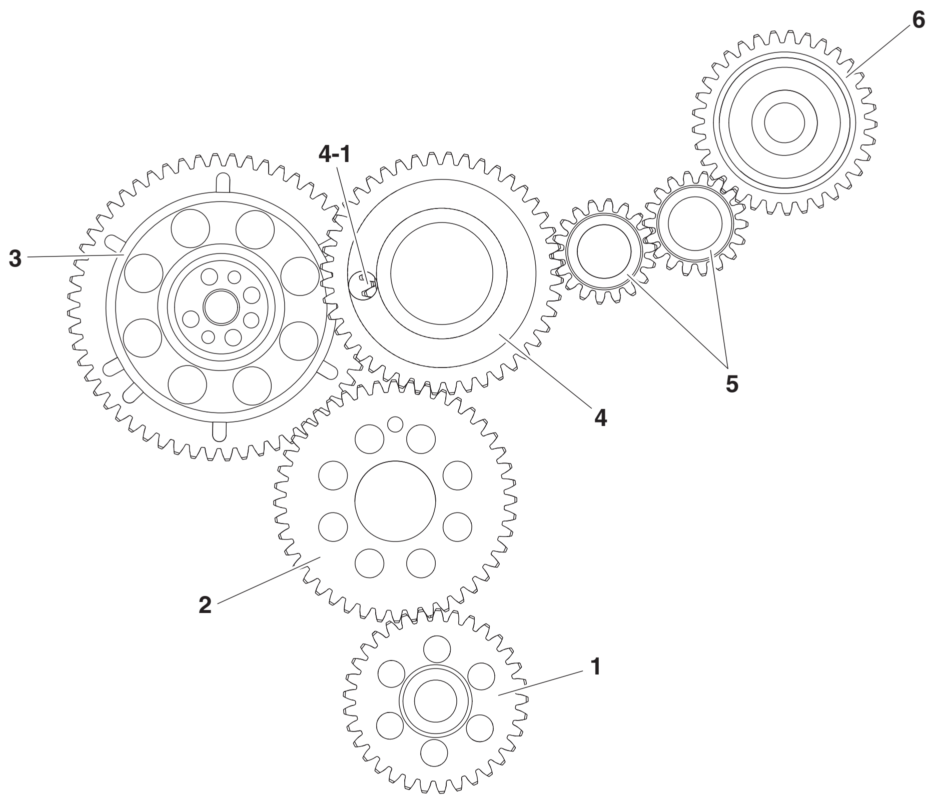


Figure 191

EX1403789

Reference Number	Description	Number of Tooth
1	Oil Pump Gear	33
2	Crankshaft Gear	44
3	Camshaft Driving Gear	56
4	Intermediate Gear (A)	44
4-1	Intermediate Gear (B)	25

Reference Number	Description	Number of Tooth
5	High-pressure Pump Idle Gear	18
6	High-pressure Pump driving Gear	33

Function

The timing gears are located at the rear end of the engine. Important components such as the unit injector and valve mechanism require precise control. They are attached to the rear end of the crankshaft, close to the flywheel, where the crankshaft rotation is the smoothest.

The crankshaft gear drives intermediate gear. The intermediate gear drives camshaft gear and high-pressure pump idle gear.

LUBRICATION SYSTEM

General Information

General Description

This engine is a forced lubrication type. Oil pressure is generated and supplied by rotation of the oil pump gear which is engaged with the crankshaft gear on the back of the cylinder block. The oil pump receives oil from the oil pan through the suction pipe to send it to the main passage of the cylinder block through the oil filter and oil cooler. Then, it is distributed to the crankshaft bearing, camshaft bearing and rocker arm for lubrication. Also, as the turbocharger is connected to the engine lubrication circuit, it receives oil for engine brake operation. Lubricant is sprayed around the cylinder block and timing gear. Each cylinder is equipped with its own oil spray nozzle to cool down the internal section of the piston. Engine oil is filtered by the oil filter.

Overview

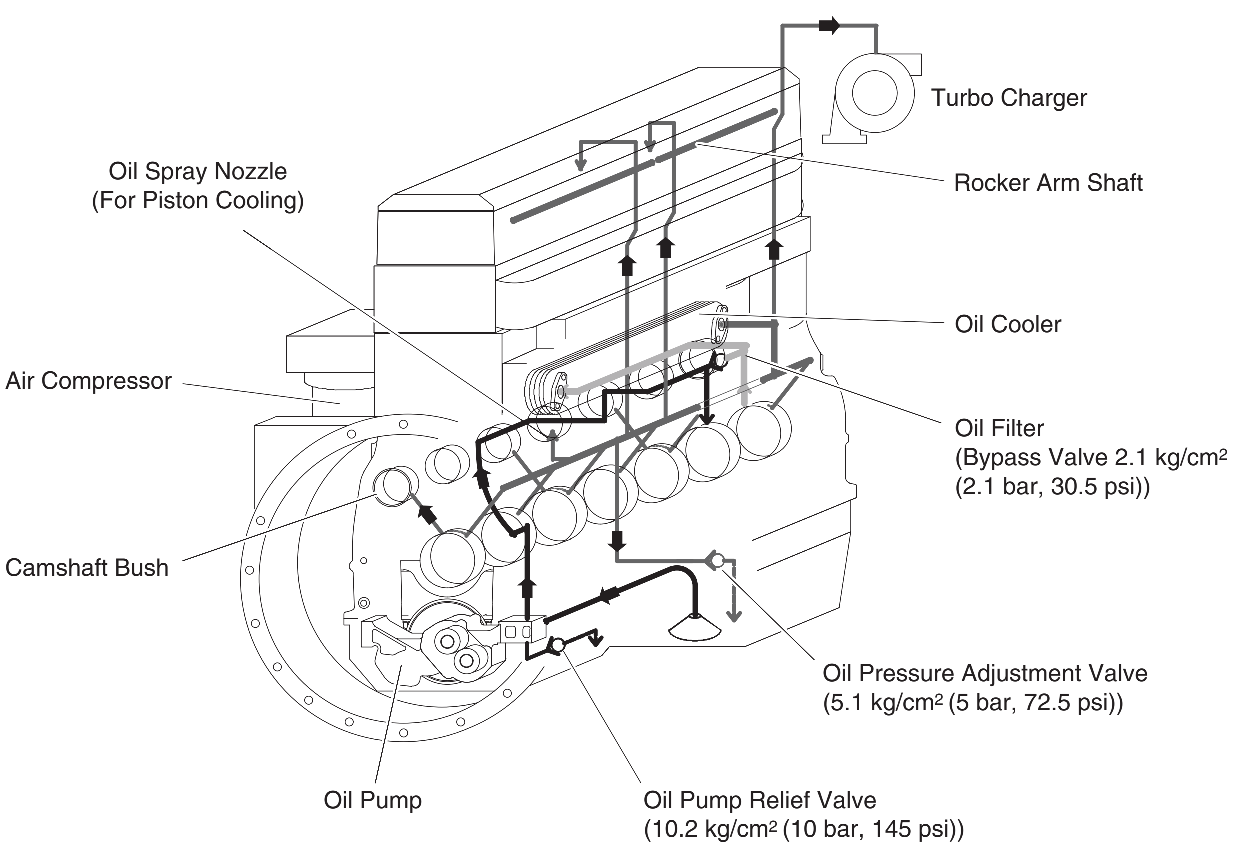


Figure 192

Purpose of Lubrication by Oil

1. Reduction of friction (Prevention of abrasion)

   Lubrication maintains the least possible level of friction, and forms a stronger oil film in a critical state to prevent the surface friction on the perturbed section and subsequent defacement.

2. Sealing function

   Prevents the leak of gas under a high-pressure in concurrence with the piston ring, just as in the cylinder lubrication.

3. Cooling function

   Regionally absorbs the heat from parts located on higher spots, and discharge the heat again in a proper temperature through the oil cooler and other units

4. Stress dispersing function

   Provides momentarily and regionally a great pressure to lubricated parts to destroy the oil film and raise adherence. At this point, the lubricant disperses the local pressure across the entire oil

5. Anti-rust function

   Forms a lubricant film to keep any moisture from infiltrating into the lubricated surface to produce rust.

6. Oil purifying function

   This absorbs alien materials such as carbon or metals produced at lubricated parts and store them in the oil filter

Applicable Oil

Use only specified engine oil according to the environment and condition of the area.

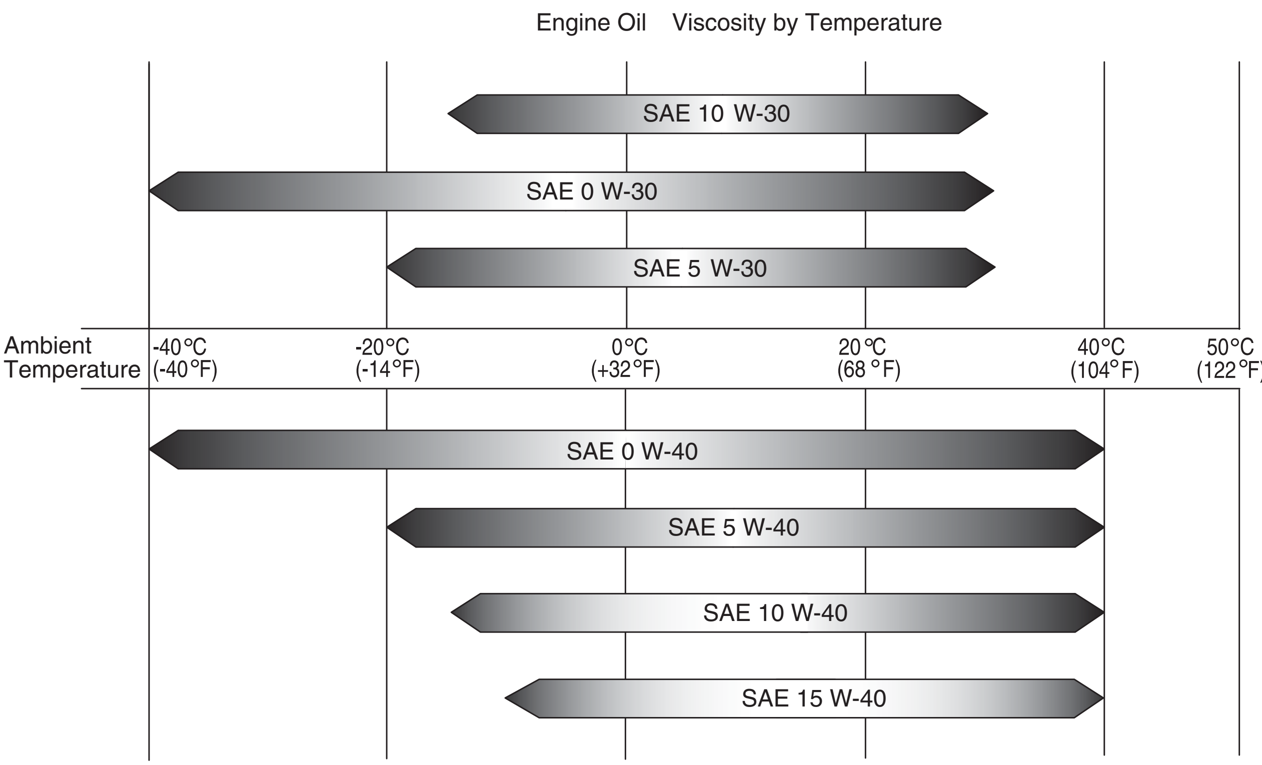


Figure 193

EX1403791

Make sure to use proper engine oil according to the following recommendation.

Oil Classification	Oil Grade	Capacity (L/U.S.gal.)		
		Maximum	Minimum	Total
SAE 15W40	API CJ-4 or Higher	27/7	17/4.5	29/7.6

NOTE: *Make sure to use the recommended genuine oil.*
Total capacity of engine oil includes 2.0 liter in engine.

Oil Lubricant Circuit

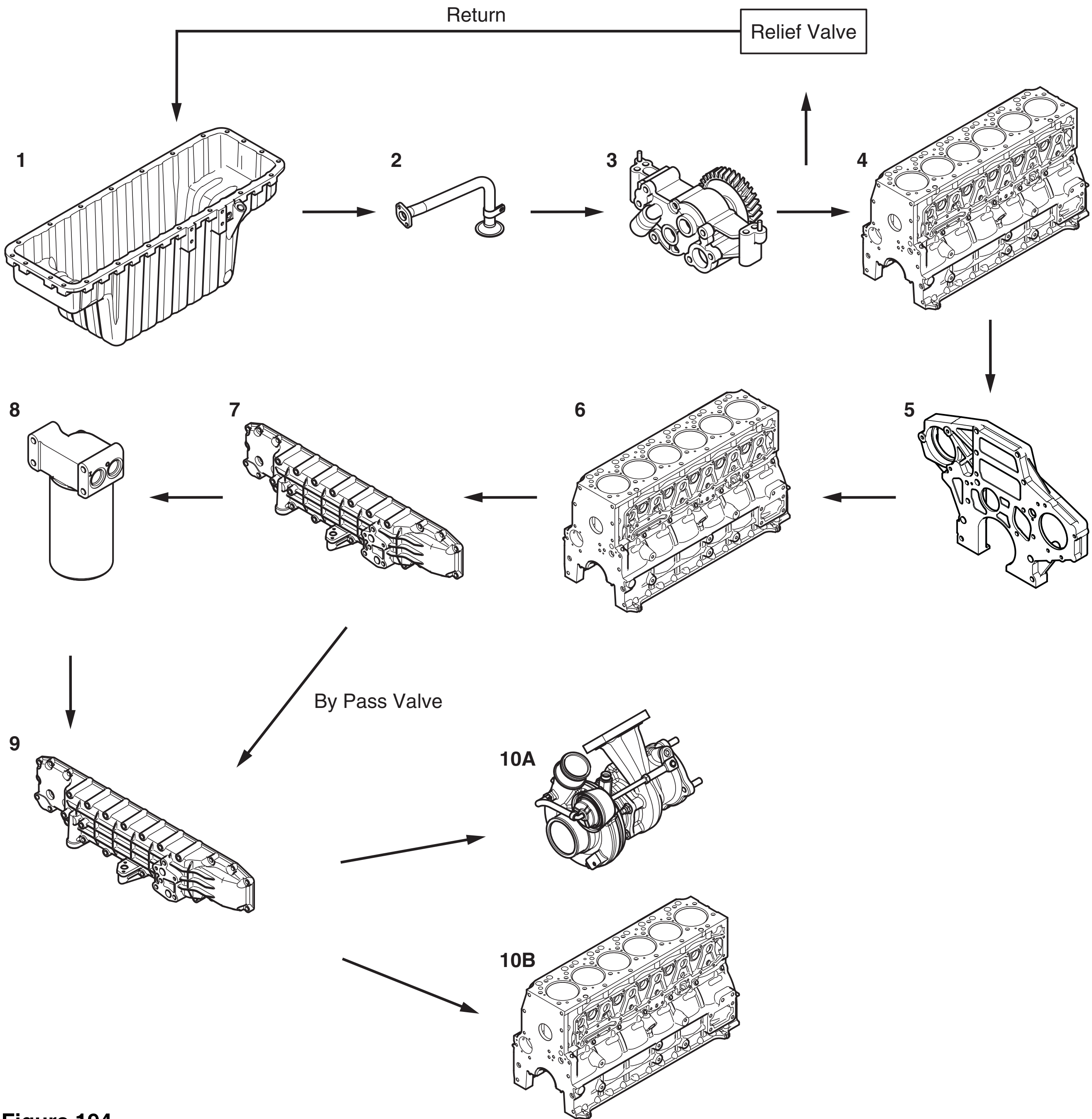


Figure 194

EX1403792

Reference Number	Description
1	Oil Pan
2	Strainer
3	Oil Pump
4	Cylinder Block
5	Timing Gear Case
6	Cyliner Block

Reference Number	Description
7	Oil Cooler
8	Oil Filter
9	Oil Cooler
10A	Turbo Charger
10B	Cylinder Block

Oil Pan

Parts List

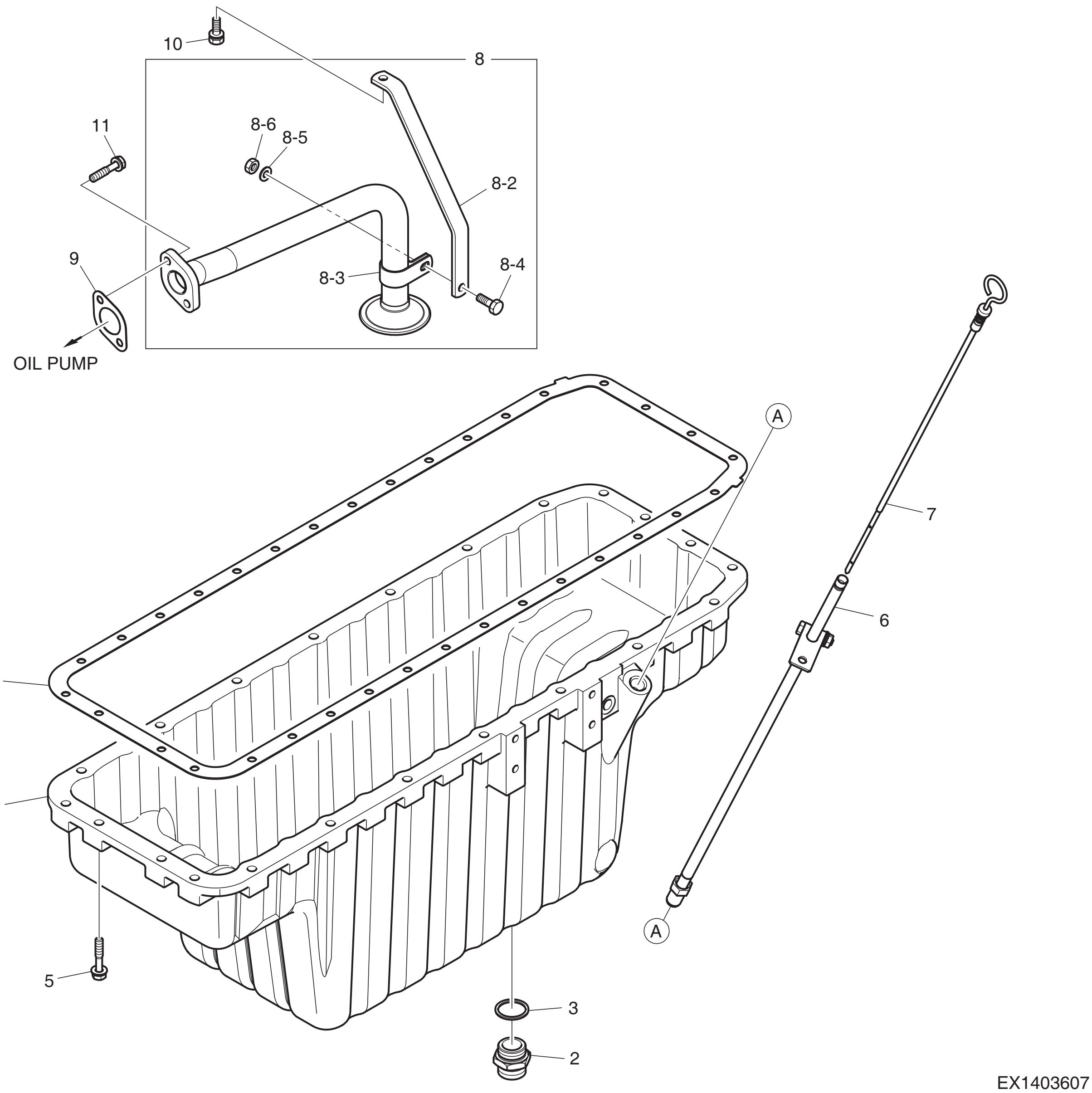


Figure 195

Reference Number	Description
1	Pan, Oil
2	Joint; Drain
3	Seal; Ring
4	Gasket, Oil Pan
5	Bolt Assembly M8 x 45
6	Tube; Oil Level Gauge
7	Gauge; Oil Level
8	Oil Pipe Assembly

Reference Number	Description
8-2	Bracket; Oil Suct. Pipe
8-3	Clip; Pipe
8-4	Bolt M8 x 25
8-5	Washer
8-6	Nut
9	Gasket
10	Bolt Assembly M8 x 25
11	Bolt Assembly M8 x 40

Tightening Sequence

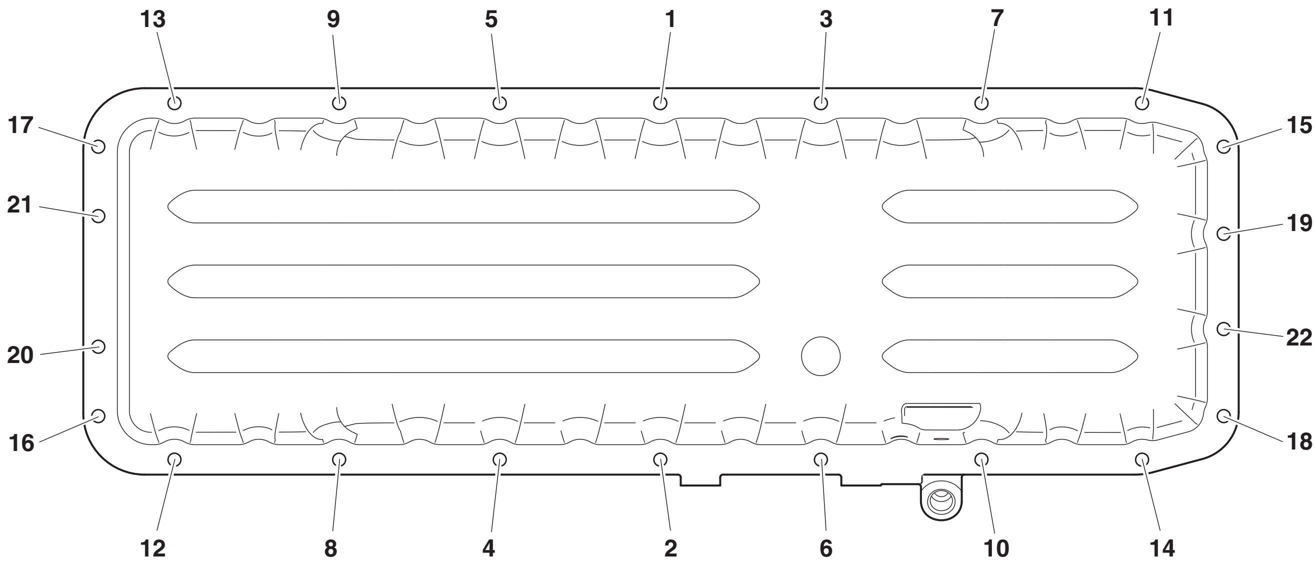


Figure 196

EX1403793

Oil Pump

General Description

Engine oil is sucked from the oil pan by the gear type oil pump and then all of the oil is forcibly delivered to the oil cooler and filter for filtering. The filtered oil passes through the main oil path of the cylinder block and lubricates bearing parts and the turbocharger of the engine in order to maintain normal engine performance.

Parts List

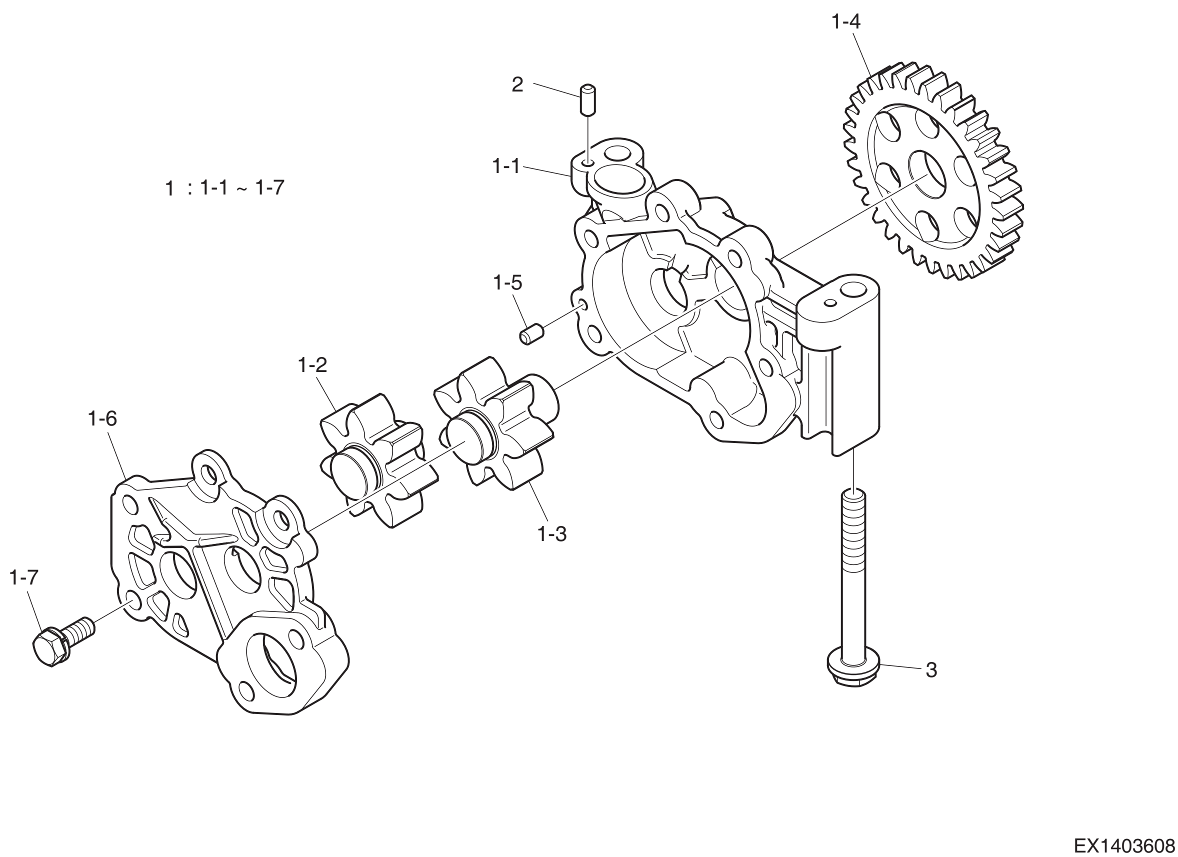


Figure 197

Reference Number	Description
1	Oil Pump Assembly
1-1	Housing; Oil Pump
1-2	Gear; Oil Pump
1-3	Gear; Oil Pump
1-4	Gear; Drive; Oil Pump

Reference Number	Description
1-5	Pin; Dowel 6M6 x 10
1-6	Cover; Oil Pump
1-7	Bolt Assembly M8 x 22
2	Pin; Dowel 6M6 x 12
3	Bolt; Collared Hex.

Disassembly

1. Remove the oil pump drive gear.
   A. Loosen the screw to remove the oil relief valve.
   B. Unfold the lock washer of the oil pump drive gear to remove the mounting nut and washer.
   C. Remove the drive gear.
2. Unscrew the mounting nut of the oil pump cover to remove the oil pump cover.

   NOTE: *The oil pump cover is fixed to the body with 2 retaining pins.*
3. Remove the drive gear and driven gear.

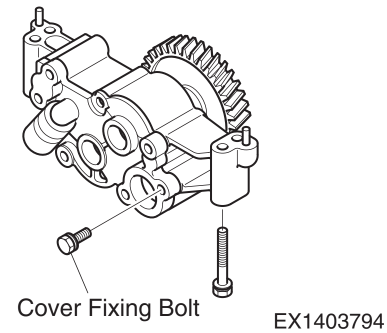


Figure 198

Assembly

Assemble in the reverse order of disassembly.

Inspection

1. Use a steel ruler and feeler gauge to measure the axial play of the oil pump gear. If the measurement is over the allowable limit, replace it.

Allowable Limit	0.03 ~ 0.136 mm

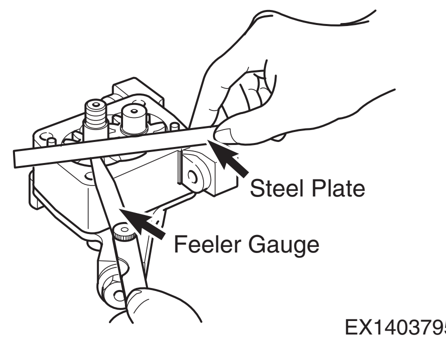


Figure 199

2. Use a feeler gauge to measure the backlash between the drive gear and driven gear of the oil pump. If the measurement is over the allowable limit, replace it.

Standard	0.312 - 0.476 mm
Allowable Limit	0.64 mm

3. Measurement of clearance between drive shaft and bushing
   A. Measure the outside diameter of the drive shaft. If any measurement is below the allowable limit, replace the corresponding part.

Standard	ø21.936 ~ ø21.95 mm
Allowable Limit	ø21.90 mm

   B. Measure the inside diameter of the pump body bushing and the outside diameter of the shaft. Compare this measurement with the standard oil clearance value to determine the necessity of replacement.

Allowable Limit	0.05 ~ 0.085 mm

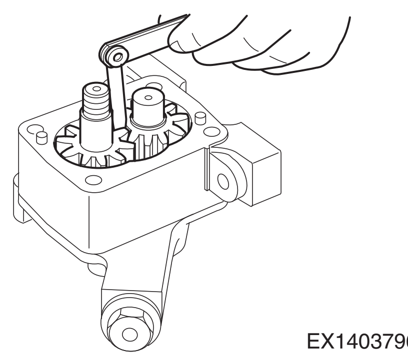


Figure 200

Oil Filter

General Description

As engine oil is sent from the oil pump to each part, it circulates in the engine for lubrication, rust prevention, cooling, cleaning, sealing and stress dispersion. After it circulates in the engine, it may contain foreign materials. Therefore, an oil filter is installed between the oil pan and cylinder or in the middle of the flow passage to remove foreign materials from it.

Parts List

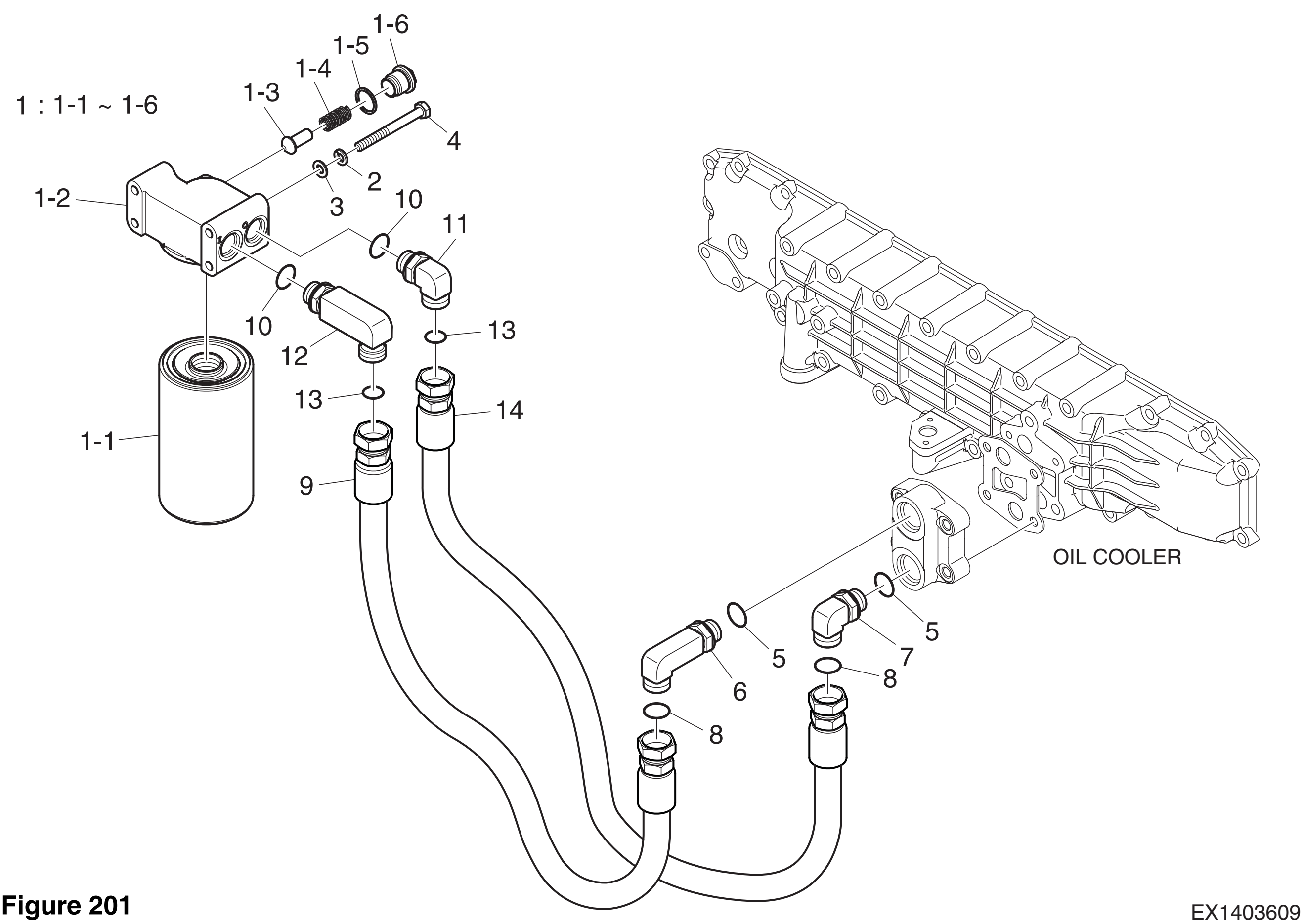


Figure 201

Reference Number	Description
1	Oil Filter Assembly
1-1	Filter; Oil
1-2	Head; Oil Filter
1-3	Valve
1-4	Spring
1-5	Seal; Ring
1-6	Screw; Plug
2	Washer; Spring
3	Washer; Plain
4	Bolt; Hex

Reference Number	Description
5	O-ring
6	Adapter
7	Adapter
8	O-ring
9	Hose; Oil Cooler
10	O-ring
11	Adapter
12	Adapter
13	O-ring
14	Hose; Oil Cooler

Replacing Oil Filter

1. Remove the oil filter using its service wrench.
2. Wipe the head and cartridge contact area of the oil filter clean.
3. Seat the cartridge of the oil filter properly.
4. Apply a small amount of oil to the O-ring section of the cartridge.
5. Fit a new oil filter loosely by screwing it with a hand.
6. Remove the oil filter using its service wrench.

IMPORTANT

- **When replacing the cartridge of the oil filter, make sure to use the specified genuine one.**
- **The oil filter should be installed to the engine without oil in it. Never fill the new oil filter with oil drained from the used oil filter.**

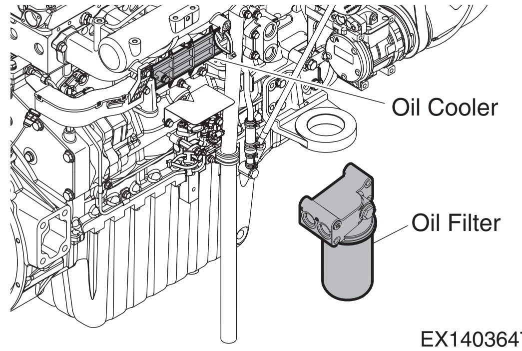


Figure 202

Troubleshooting

Phenomenon	Causes	Troubleshooting
Too much Oil Consumption	Bad oil	Replace oil with specified oil.
	Oil leakage from the oil seal ring and packing part	Replace it
	Worn or damaged piston and piston ring	Replace it
	Worn cylinder liner	Replace it
	Burnt piston ring	Replace it
	Worn valve guide oil seal, valve guide, or valve stem	Replace it
Low Oil Pressure	Bad oil	Replace oil with specified oil.
	Burnt oil pump relief valve	Replace it
	Clogged oil pump strainer	Cleanse the strainer
	Worn oil pump gear	Replace it
	Cracked oil delivery pipe of the oil pump	Replace it
	Defect oil pump	Repair or replace it
	Oil pressure gauge fault	Repair or replace it
	Worn bearings	Replace it
Contaminated Oil	Clogged oil filter	Replace the oil filter with a new one
	Gas leakage	Replace piston ring with a new one
	Bad oil	Replace oil with specified oil.

EXHAUST SYSTEM

Turbocharger

General Description

The turbocharger uses heat energy of exhaust gas in the engine to draw in high density air into the cylinders to increase the engine power.

Power of the engine is determined by the amount of fuel supply and the engine's efficiency.

A sufficient amount of air should be supplied to the cylinders to burn fuel completely and convert this energy to effective work.

Power of the engine is actually determined by the size of the cylinders. The larger the cylinders are, the more the air is delivered to burn more fuel, resulting in increase of engine power.

Supercharging is a process to compress and supply air into the engine's cylinders. The turbocharger is a device to supply extra air for combustion with energy of exhaust gas in the combustion chamber which is usually released and disappeared into the air.

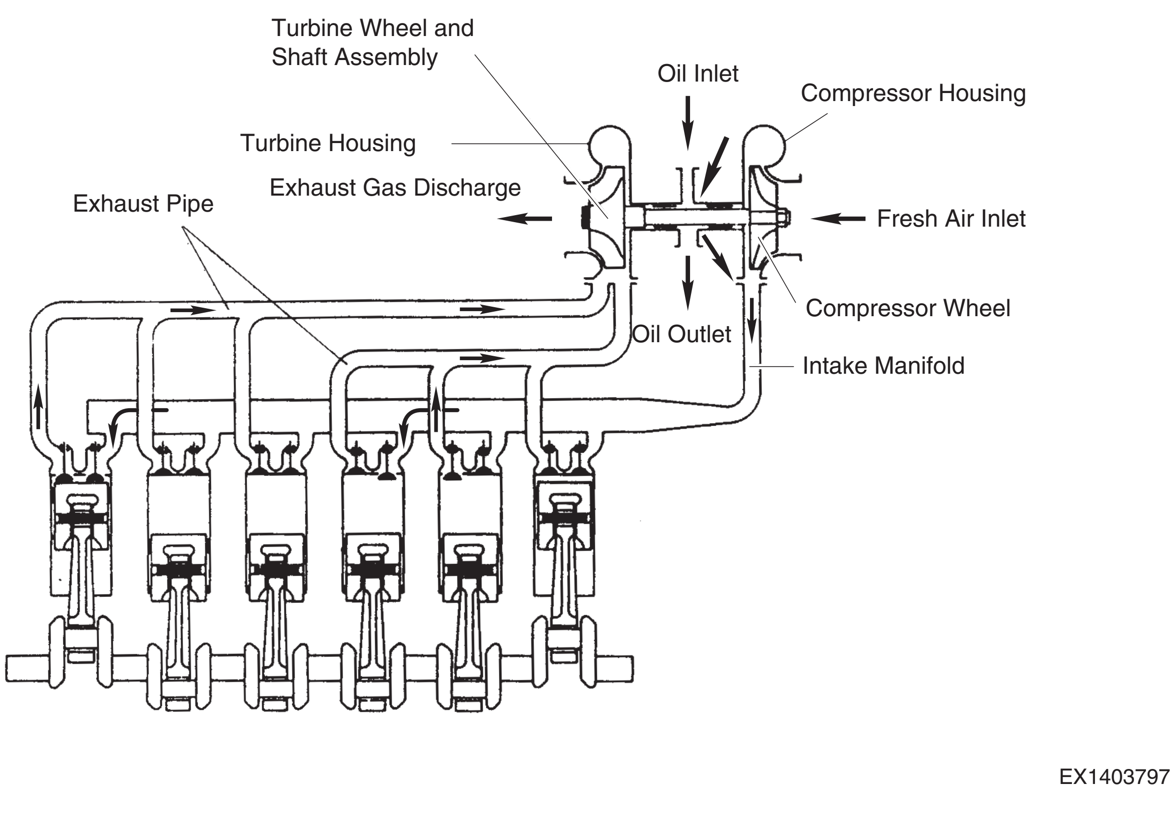


Figure 203

Function

1. Turbine:
   As exhaust gas discharged from the combustion chamber passes through the turbine housing, its energy is transferred to the turbine blades to deliver the rotating force to the turbine shaft. These series of motions are occurred in a component called turbine. The turbine is equipped with the seal ring and heat shield to prevent exhaust gas from affecting its bearing.

2. Compressor:
   As it is connected to the same shaft with the turbine, it rotates together to receive rotating force from the turbine shaft in order to receive, compress and send air to the intake manifold. This is the basic principle of a compressor.

3. Bearings:
   Thrust bearing: The turbine wheel is applied with axial force. This axial force keeps the shaft from moving.

   Journal bearing:
   This bearing is a floating type and has double oil film on its inside and outside so that it can rotate independently. As its double oil film acts as a cushion, the sliding speed on the bearing surface becomes lower than the rotating speed of the shaft, ensuring dynamic stability.

4. Seal ring of compressor shaft:
   The shaft is equipped with the seal plate and seal ring in a dual structure to prevent leakage of compressed intake air and lubricant.

Parts List

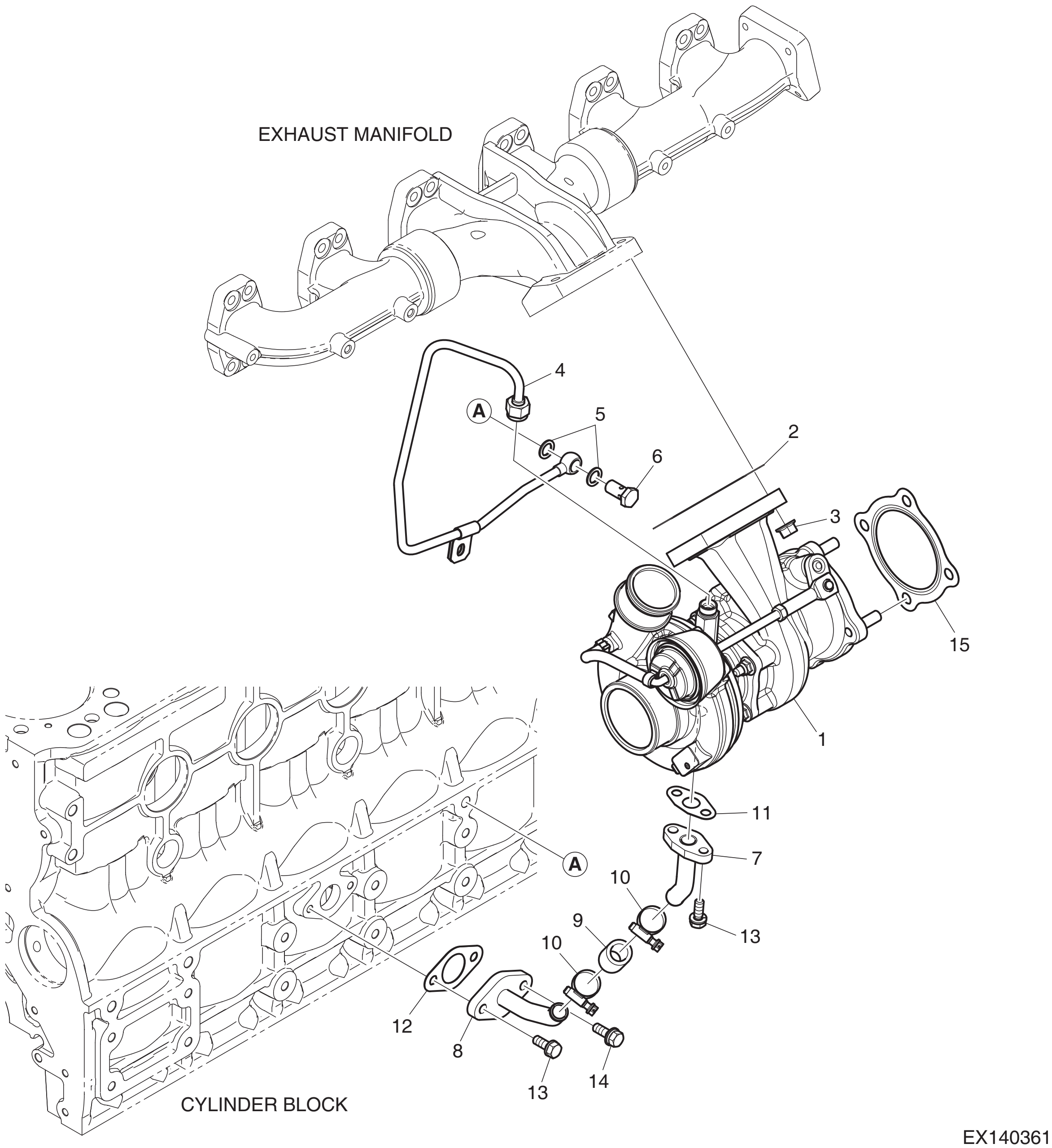


Figure 204

Reference Number	Description
1	Charger Assembly, Turbo
2	Gasket
3	Nut
4	Pipe; Oil Delivery
5	Ring; Seal
6	Hollow Screw M12 x 1.5
7	Pipe; Oil Return
8	Pipe; Oil Return

Reference Number	Description
9	Hose; Rubber
10	Clamp
11	Gasket; Flange
12	Gasket; Pipe-block
13	Bolt Assembly M8 x 22
14	Bolt Assembly M8 x 25
15	Gasket; Exhaust Pipe

Structure

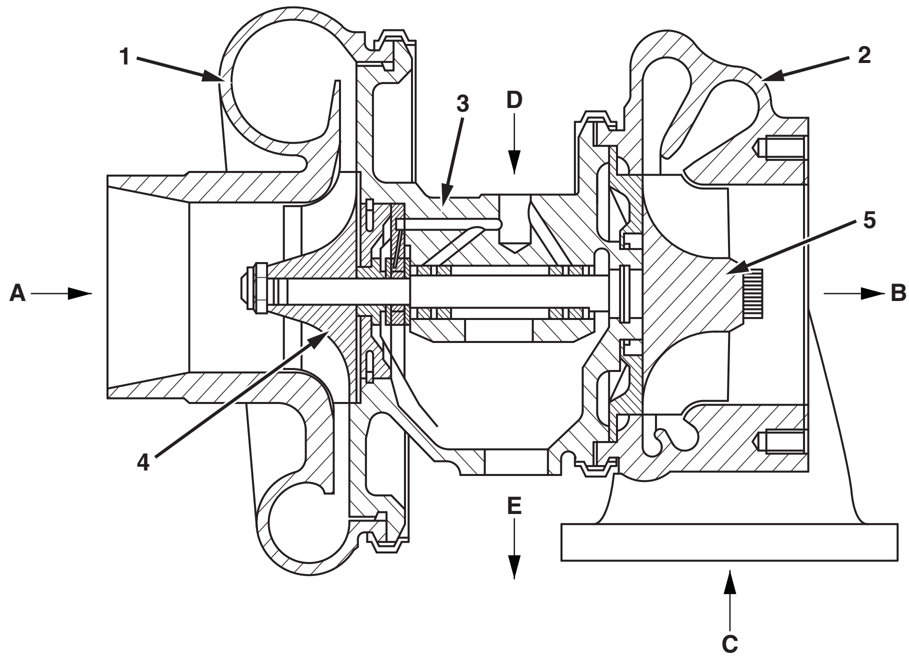


Figure 205

Reference Number	Description
1	Impeller Casing
2	Turbine Casing
3	Bearing Casing
4	Impeller
5	Turbine

Reference Number	Description
A	Intake Air Inlet
B	Gas Outlet
C	Gas Inlet
D	Oil Supply
E	Oil Discharge

Troubleshooting

Phenomenon	Causes	Troubleshooting
Noise or Vibration	Rotating part is contacted	Repair or replace it
	Unbalanced rotation of a rotor	Repair or replace it
	Burn	Repair or replace it
	Loose joint	Check or repair it
	Deformed or damaged intake unit hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Leakage of gas from the exhaust manifold	Replace the gasket or tighten the fixing nut
	Poor turbo actuator operation	Replace the turbocharger
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake and outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance

Phenomenon	Causes	Troubleshooting
Lowered Output	Leakage of gas from each part of the exhaust system	Check or repair it
	Clogged air filter element	Replace or clean it
	Contaminated or damaged turbocharger	Repair or replace it
	Leakage of air from the discharging part of the compressor shaft	Check or repair it
	Deformed or damaged intake unit hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Poor turbo actuator operation	Replace the turbocharger
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance
Oil Leakage	Deformed or damaged intake unit hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Poor turbo actuator operation	Replace the turbocharger
Oil Leakage	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance

Phenomenon	Causes	Troubleshooting
Oil Consumption	Poor clamping state	Adjust and tighten the clamp
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance
Black and White Emissions	Deformed or damaged intake unit hose	Replace it
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Poor turbo actuator operation	Replace the turbocharger
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake and outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance
Blue Emissions	Leakage from the engine block and the exhaust manifold	Check the engine
Too much Fog	Oil leakage to the turbine or compressor	Repair or replace it
	Worn or damaged seal ring due to worn bearing	Repair or replace it
Too much Exhaust Emissions	Clogged air filter element	Replace or clean it
	Clogged air duct	Check or repair it
	Air leakage from the intake system	Check or repair it
	The turbocharger cannot rotate because of burning	Repair or replace it
	A turbine blade or compression wing contacts with the other one or is damaged	Repair or replace it
	Deformed or clogged exhaust system pipe	Check or repair it

How to Maintain Turbocharger

Cautions for Engine Operation

Observe the followings when starting, operating, and stopping an engine.

Item	Cautions	Reasons
Starting an Engine	Check the oil amount	
	Therefore, start the engine with the starter motor to check the rise of oil pressure (until the gradation of the oil pressure gauge moves or the pressure indicator lamp is turned on).	Overhasty start of engine leads to engine rotation without lubricating turbocharger and other engine parts, causing abnormal wear or burning of bearings.
	If you replace oil, oil filter cartridge, or lubrication system parts or use an engine in cold areas, or the engine has stopped for a long period, loosen the oil pipe joint at the inlet of the turbocharger and run the starter motor until oil flows out. After completing the work, tighten the oil pipe joint again and start the engine.	When an engine has stopped or kept cold for a long period, circulation of oil in the pipe gets poor.
After Starting an Engine	Operate the engine at idle for five minutes from starting it.	When the engine is suddenly loaded while the engine and the turbocharger have not been smoothly rotated after starting the engine, parts with insufficient oil may be burnt.
	Check if oil, gas, or air is leaked from each part. If so, take proper action.	Leakage of oil, gas, or air (especially oil) reduces oil pressure and loss of oil cause burning of bearings.
During Operation	check the following.	
	Oil pressure At idle: 1.5 ~ 3.0 kg/cm^2 (1.5 ~ 3.0 bar, 21.3 ~ 42.7 psi) Fully loaded: 3.0 ~ 5.5 kg/cm^2 (3.0 ~ 5.5 bar, 42.7 ~ 78.2 psi)	Too low oil pressure causes abnormal wearing or burning of bearings. Too high oil pressure causes oil leakage.
	When abnormal noise or vibration occurs, slowly reduce the rotate count until the engine stops and then figure out the causes.	Operating an engine with noise or vibration may cause irreversible damage of the engine.
Stopping an Engine	Operate the engine at idle for five minutes before stopping it.	Sudden engine stop after operating the engine under high load allows the heat from the red-heated turbine blade to be delivered to the bearing system. Then oil burns and the bearing metal and rotation shaft are burnt.

Cautions for Maintenance

1. When the rpm is rapidly increased after starting the engine, the journal bearings in the crankshaft is excessively rotated, the crankshaft is rotated at excessive speed before the journal bearing of the crankshaft is lubricated fully. If the turbocharger rotates in this situation, bearings are not smoothly cooled and lubricated, causing bearing burn and damage of the related parts.
2. Please operate the engine for two minutes or more in order to lubricate the turbocharger fully after replacing the engine oil or oil filter.
3. If an engine has been operated at high speed for a long period, fully operate the engine at idle and then stop the engine. Otherwise, the turbine wheel continuously runs without oil pressure in the turbocharger. Therefore, no oil film is created on the center bearings and the journal bearings of the turbocharger, causing bearing, wearing out and shortening of the turbocharger lifetime.
4. If an engine is not operated for a long period during cold weather or in areas with cold climate, operate the engine at idle after starting the engine until the engine oil pressure is normal.
5. The turbocharger turbine spins at high speed of 50,000 ~ 200,000 rpm. Therefore, lubrication of bearings may determine the turbocharger lifetime. Please use only recommended genuine engine oil and check and replace the engine oil periodically.
6. Prolonged usage of contaminated air cleaner may cause a critical damage of the turbocharger. Regularly check and replace the air cleaner.
7. A turbocharger is a very complex and precise part. Only certified and skilled technicians should work on it.
8. If a turbocharger is operated without intake and exhaust pipe, serious human injury may occur and critical faults of the engine performance may occur. Please operate a turbocharger only when all of parts are exactly mounted on the specified position.
9. Do not lift up a turbocharger by grabbing the actuator. The actuator may be damaged because of the weight of the turbocharger.
10. The weight of a turbocharger is about 4.0 kg or more. To lift up a turbocharger for installing or removing it, the worker should lower the center of gravity or press his body close to the turbocharger. Otherwise, worker may drop the turbocharger, causing damage of the part and injury.

Inspection Items during Disassembly/Assembly of Turbocharger

No.	Inspection Items	Possible Problem						Action
		Noise	Power Drop	Oil Leakage	Oil Consumption	White/black Smoke	Blue Smoke	
Before Removal								
1	Is the intake hose torn or deformed?	○	○	○		○		Replace hose
2	Is the clamp tightened firmly?	○	○	○	○			Tighten bolt/nut correctly
3	Is the air filter intact?	○	○	○		○		Replace air filter and check turbocharger impeller for damage
4	Does turbocharger or oil hose leak?	○		○	○	○		Replace hose and gasket
5	Is gas leaked from exhaust manifold gasket?	○						Replace nut and gasket
6	Do solenoid valve and EGR system intact?	○	○			○		Replace solenoid and EGR valve
7	Does the turbocharger actuator operate correctly?	○	○	○		○		Replace turbocharger
During Removal								
1	Is there a sign of leak between the engine block and exhaust manifold?	○	○	○	○		○	Check engine
2	Is the amount of oil and foreign material led with blow-by gas normal?	○	○	○	○	○		Check turbocharger impeller and turbocharger intake air outlet
3	Is there a sign of interference of the wheel with the wall due to excessive play of the wheel?	○	○	○	○	○		Check for foreign materials (sand, metallic object)
4	Is the wheel damaged?	○	○	○	○	○		Check for foreign materials (sand, metallic object)
After Removal								
1	Is the wheel damaged or is the shaft broken?	○	○	○	○	○		Check for foreign materials (sand, metallic object)
2	Does the wheel rotate properly?	○	○	○	○	○		

Inspection

Daily Inspection and Service

It is important to handle the engine and maintain its optimum condition according to the instructions as the performance of the turbocharger is highly affected by the maintenance condition of the engine.

1. Intake system

   In the intake system, the air filter should be maintained with care. For a wet type air filter, if the oil level is below the specified level, its filtering performance is deteriorated. On the other hand, if the oil level is too high, it sucks in oil and contaminates the case. Especially, if the rotor is contaminated, the precisely adjusted balance is destroyed and the bearing is applied with large force, resulting in vibration, seizure and abnormal wear. Therefore, the air filter should be well-maintained and handled with care. A dry air filter should feature low possible intake air restriction.

2. Exhaust system

   If exhaust gas is leaked from the exhaust pipe or turbocharger connection in the exhaust system, the turbocharger's performance is deteriorated. Extra care is needed to prevent a gas leak and seizure. A heat resisting steel nut is used for parts, which can become hot during driving, such as the turbine housing. Make sure not to mix it with a general nut, and apply screw's anti-seize compound to the specified mounting nut.

3. Lubrication system

   In the lubrication system, the oil quality and the cartridge replacement interval of the oil filter should be monitored with care. Degraded engine oil can affect not only the engine body, but also the turbocharger negatively.

Periodic Inspection and Service

Check the turbocharger for its condition and contamination periodically.

1. How to check rotating condition of rotating part

   When checking the rotating condition of a rotating part, check for abnormal noise. When using a sound bar, touch the turbocharger housing with its tip and rev up the engine slowly. If a high pitch note is continuously heard, it is abnormal. If abnormal condition is found, it is possible that the bearing or rotating part is defective. In this case, replace or repair the turbocharger.

2. How to check play of rotating part

   Separate the turbocharger from the engine and check the axial play and circumferential play of the rotating part. When separating the turbocharger, make sure to seal the oil inlet and outlet with plastic tape.

   - Axial play of rotating part

Reference Number	Description
A	Dial Gauge
B	Magnet Vice
C	Turbine Compartment
D	Move the Turbine Shaft in the Axial Direction.
E	Service Standard (0.038 ~ 0.093 mm)
F	Wear Limit (0.24 mm)

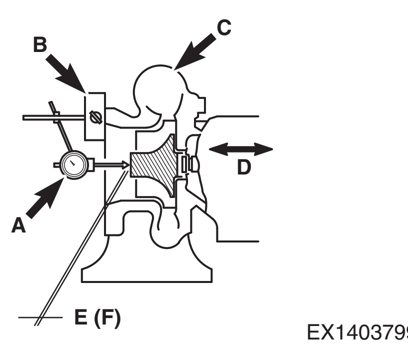


Figure 206

- Circumferential play of rotating part

Reference Number	Description
A	Oil Outlet
B	Dial Gauge
C	Magnet Vice
D	Move the Turbine Shaft to the Left and Right in the Circumferential Direction.
E	Standard Circumferential Play (0.326 ~ 0.496 mm)
F	Standard Wear (0.50 mm)

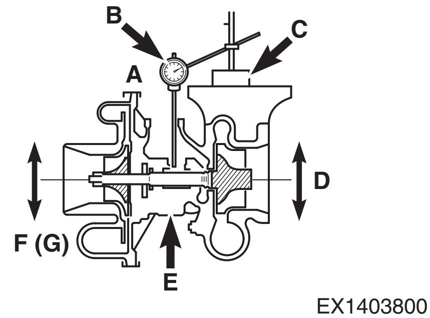


Figure 207

- If the axial or circumferential play is over the wear limit, replace or remove and repair the turbocharger.

3. Tips for turbocharger disassembly and inspection

   Remove the turbocharger from the engine to clean or check it. Make sure to seal the oil inlet and outlet with plastic tape after its removal.

4. Cautions for turbocharger installation

   When or after installing the turbocharger to the engine, make sure keep the followings: Make sure that no foreign material enters the turbocharger.

   - Lubrication system

     Before installation to the engine, add new oil through the oil filler hole and turn the turbine shaft with a hand to lubricate the journal bearing and thrust bearing.

     Clean the pipes between the engine and oil inlet and between the pipe and oil outlet thoroughly and check them for damage and foreign materials.

     Tighten each connection of the oil pipes firmly to prevent an oil leak.

   - Intake system

     Check if there is no foreign material in the intake system.

     Install each connection of the intake system and air filter firmly to prevent an air leak.

   - Exhaust system

     Check if there is no foreign material in the exhaust system.

     Make sure to use only heat resisting bolts and nuts. Be careful not to mix them with general bolts and nuts during assembly. Apply anti-seize compound to the bolt and nut before installing them.

     Tighten each connection of the exhaust system firmly to prevent any gas leak.

EGR (Exhaust Gas Recirculation) System

General Description

The EGR (Exhaust Gas Recirculation) system recirculates a portion of exhaust gas back to the intake system to cool it down and supply it to the engine for re-combustion in order to reduce NOx emission.

To reduce NOx and other emissions from the engine, it circulates exhaust gas containing almost no oxygen toward the intake system to decrease the density of oxygen supplied to the engine and induce combustion at a low temperature. As a result, a reduced amount of NOx is produced.

This system is equipped with the EGR cooler to reduce the temperature of hot exhaust gas in order to reduce the amount of NOx and enhance engine combustion efficiency.

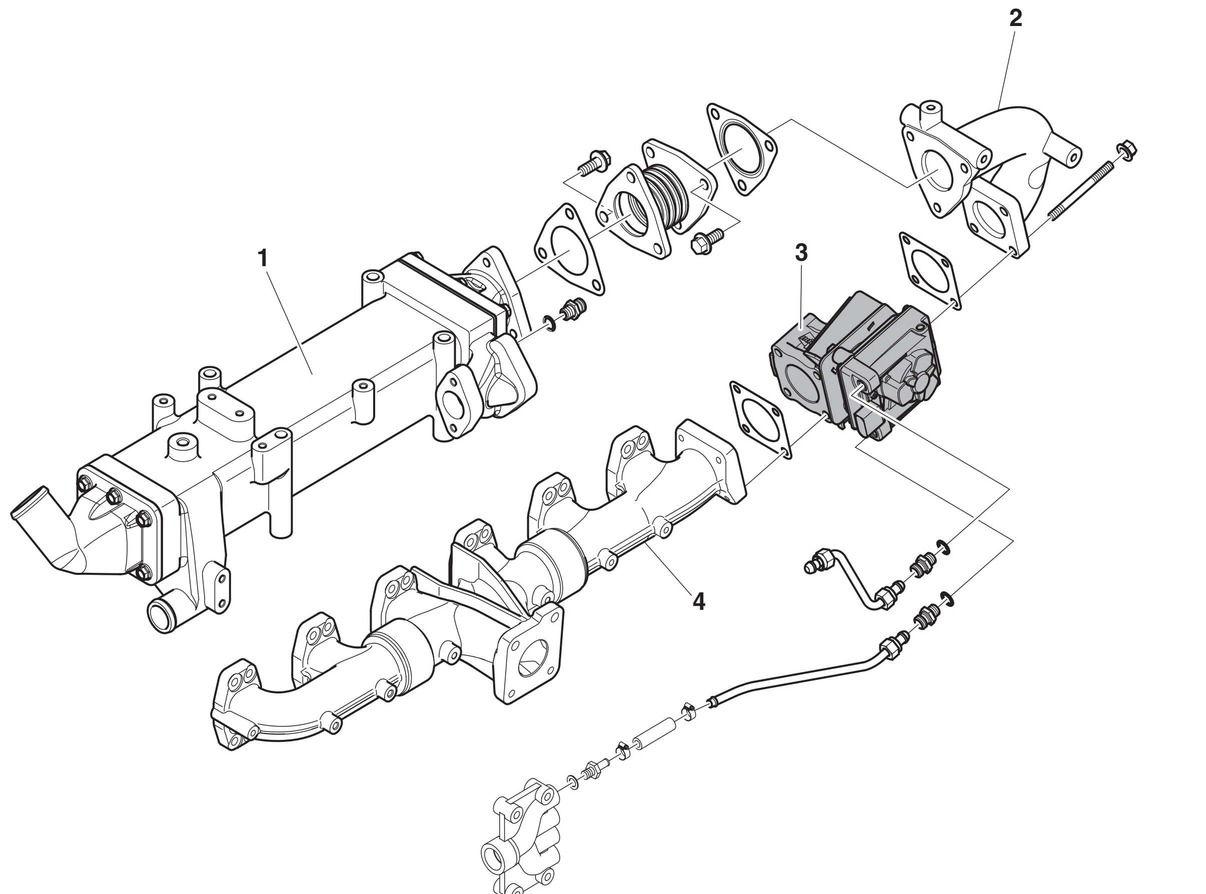


Figure 208

Reference Number	Description
1	EGR Cooler
2	Exhaust Pipe

Reference Number	Description
3	EGR Valve
4	Exhaust Manifold

Function

The EGR system is active between approximately 900 rpm and the maximum engine speed with a positive torque and when the coolant temperature exceeds approximately 50°C.

The principle of the EGR system is that some of the exhaust gases are returned to the engine. The quantity of oxygen is reduced by mixing the intake air with exhaust gases resulting in a lower combustion temperature. In this way, the quantity of nitrogen oxides.

NOx, in the exhaust gases is reduced.

The reduced nitrogen oxide emissions make it possible to meet emissions regulations and to optimize engine power and fuel consumption.

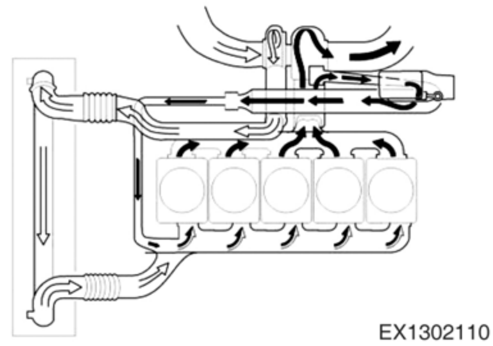


Figure 209

Flow of Air and Exhaust Gases

Part of the exhaust gases leaving the engine by the exhaust manifold are led by the EGR valve through the EGR cooler, where they are cooled.

The cooled exhaust gases are drawn back to the intake and mixed with the intake air.

Controlling the Flow

The engine control unit controls the flow of exhaust gases. The control unit regulates EGR content, i.e. the volume of exhaust gases that are returned to the engine. The level is measured in percent 10% EGR content means that 10% of the total flow into the engine is exhaust gas and 90% is air.

The mass flow sensor detects and informs the control unit of how much air passes into the engine. The control unit also receives information from the charge air pressure and temperature sensors and the exhaust gas pressure sensor. The control unit uses information from the sensors to calculate the total volume of gas (air and exhaust gases) which enter the cylinders. By measuring the total volume of gases and subtracting from this the airflow from the mass flow sensor, the control unit calculates the EGR content.

To increase measurement accuracy and to avoid incorrect values, the control unit shuts the EGR valve for a preset time interval, to avoid any gases flowing back to the cylinders. The control unit compares the value from the mass flow sensor with the calculated gas volume entering the cylinders. These two values must be the same. If the values do not agree, the control unit calibrates the mass flow sensor. The system is set in motion when the engine is started and warmed up.

If a fault occurs in the system which results in the control unit not being able to control the components as expected, fault codes are generated and the control unit reduces the engine power until fault is rectified.

Cold Engine

The EGR valve is closed until engine has been warmed up. No exhaust gases are then circulated.

Warm Engine

Once the engine has been warmed up, the EGR valve is open and exhaust gases then circulate in the EGR system. Where the throttle is rapidly opened, the engine control unit reduces the EGR content. This is intended to compensate for the shortage of induction air that occurs before the turbocharger begins to charge.

Shut-off Conditions

- The control unit shuts down the EGR system if:
- The charge air temperature falls below a specific value. There is then a risk of freezing in the intake manifold.
- The engine is at such a high altitude that air pressure affects its performance.
- Coolant temperature is too high. At very high coolant temperature, the control unit closes the EGR valve to avoid loading the engine with additional heat from the EGR cooler.
- The white smoke limiter is active.
- There is a risk of the EGR system freezing if the ambient temperature is very low.

Parts List

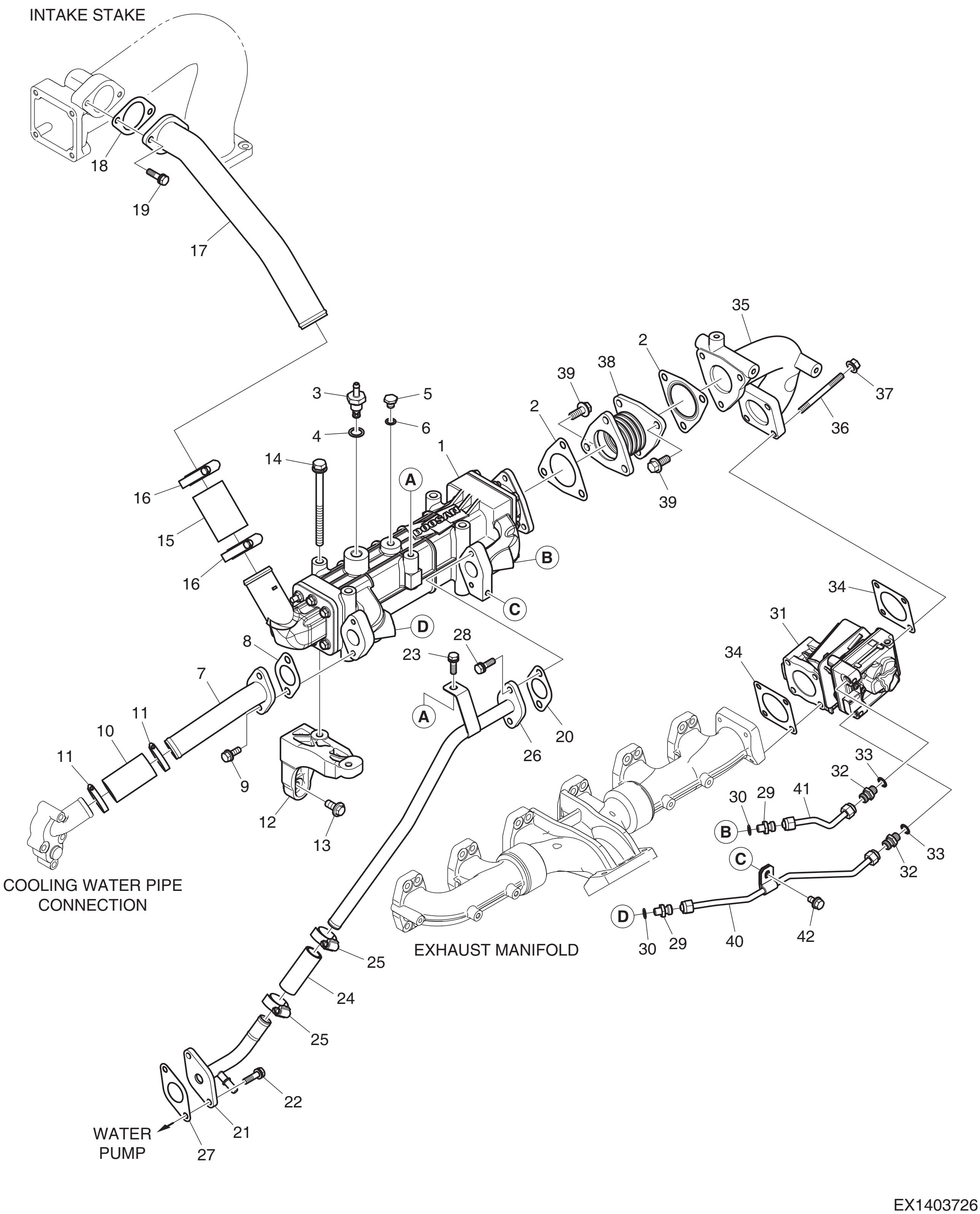


Figure 210

Reference Number	Description
1	Cooler; EGR
2	Gasket; EGR Cooler
3	Adapter; Connector
4	Seal; Ring
5	Screw; Plug M10 x 1.5
6	Ring; Seal
7	Pipe Assembly; Cooling Water
8	Gasket; Water Pipe
9	Bolt Assembly M8 x 25
10	Hose; Rubber
11	Clamp; Hose
12	Bracket
13	Bolt; Collared Hex.
14	Bolt Assembly M10 x 140
15	Hose; Rubber
16	Clamp; Hose
17	Pipe Assembly; Exhaust
18	Gasket; Manifold
19	Bolt Assembly M8 x 30
20	Gasket; Water Pipe
21	Pipe Assembly; Cooling Water

Reference Number	Description
22	Bolt Assembly M8 x 25
23	Bolt Assembly M8 x 25
24	Hose; Cooling Water
25	Clamp; Hose
26	Pipe Assembly; Cooling Water
27	Gasket; Water Pipe
28	Bolt Assembly M8 x 25
29	Adapter
30	Ring; Seal
31	Valve; EGR
32	Adapter
33	Ring; Seal
34	Gasket; EGR Valve
35	Exhaust Pipe Assembly
36	Bolt; Stud
37	Nut
38	Pipe; Exhaust
39	Bolt; Hex.
40	Pipe Assembly; Cooling Water
41	Pipe Assembly; Cooling Water
42	Bolt Assembly M8 x 18

Disassembly

1. Remove the EGR valve and disconnect the elbow pipe.

   NOTE: *Perform the process with the heat shield and bellows pipe removed.*

   CAUTION

   AVOID INJURY

   As the EGR system is hot by exhaust gas, it should be disassembled after it is sufficiently cooled down.

   A. Remove the nut from the stud bolt.

   B. The cooling pipe should be disconnected to remove the EGR valve.

2. Remove the EGR bracket.

   NOTE: *Components available for removal after removal of exhaust manifold*

Assembly

Assemble in the reverse order of disassembly.

CAUTION

AVOID INJURY

Any used gasket should be replaced with a new one.

EGR Cooler Disassembly and Assembly

Disassembly

As the EGR system becomes hot by exhaust gas while the engine is running, it should be disassembled after it is sufficiently cooled down.

1. Disconnect the coolant inlet/outlet pipes and hoses.
2. Remove the gas pipe outlet and hose.
3. Remove the heat shield.
4. Disconnect the bellows pipe.
5. Remove the EGR cooler mounting bolts.
6. Remove the EGR cooler from the EGR bracket.

Assembly

Assemble in the reverse order of disassembly.

CAUTION

AVOID INJURY

Any used gasket should be replaced with a new one.

Checking EGR System

Leak test and functional inspection of the EGR system components

It is normal to find a certain amount of soot coating in engines with EGR systems.

Component	How
EGR Valve	Search for heavy soot accumulation. Check that EGR valve is properly closed. Check that EGR valve springs back to the closed position.
The Pipe between the EGR Valve and the EGR Cooler	Check that there is no abnormally large leakage.
The Pipe between the Cooler and the Inlet Pipe	Check that there is no abnormally large leakage.
EGR Cooler	Searching for leakage in the EGR cooler.
The Hoses to and from the Air-cooled EGR Cooler	Check that there is no abnormally large leakage.
Control Cylinder to EGR Valve	Check using checking tool that EGR valve control cylinder is working properly.

If it does leak, the EGR components may need cleaning.

DNOx System

General Description

The Doosan engine is equipped with the DOC (Diesel Oxidation Catalyst) and SCR (Selective Catalytic Reduction) systems in order to comply with Tier 4 final (and stage IV) emission control. This SCR system consists of the dosing module, supply module, ECU (Engine Control Unit) and other components. The DEF (Diesel Exhaust Fluid) is stored in the DEF tank. Once it is needed, it is pressurized by the supply module and is delivered to the dosing module under a certain level of pressure. The dosing module is attached to the exhaust manifold to spray DEF into the exhaust manifold in front of the SCR system.

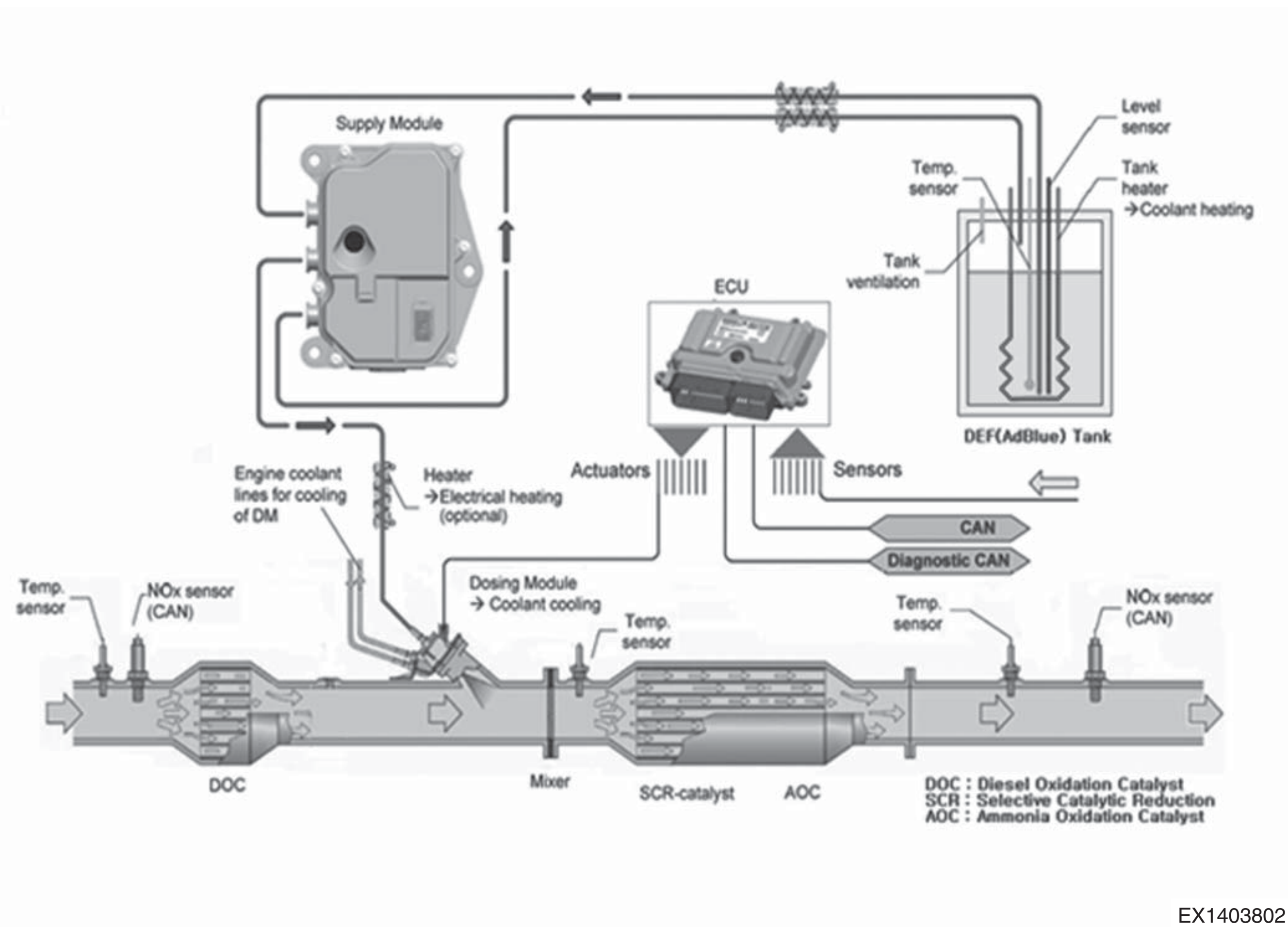


Figure 211

Aftertreatment Muffler and Catalyst

The aftertreatment muffler consists of the DOC muffler, SCR muffler, mixer pipe and other pipes. The DOC muffler contains DOC (Diesel Oxidation Catalyst) while the SCR muffler contains SCR (Selective Catalytic Reduction).

Reference Number	Description
1	DOC Converter
2	Mixer
3	SCR Muffler

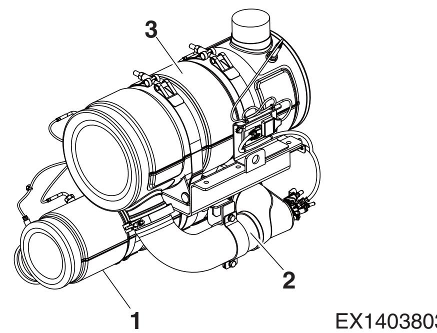


Figure 212

DNOx2.2 System

The DNOx2.2 system is used to reduce NOx in emissions by spraying urea into the SCR catalyst. It consists of the SM (Supply Module), which functions as a pump, DM (Dosing Module) to spray urea, DCU to control the overall system, urea tank to store urea and urea/cooling water line.

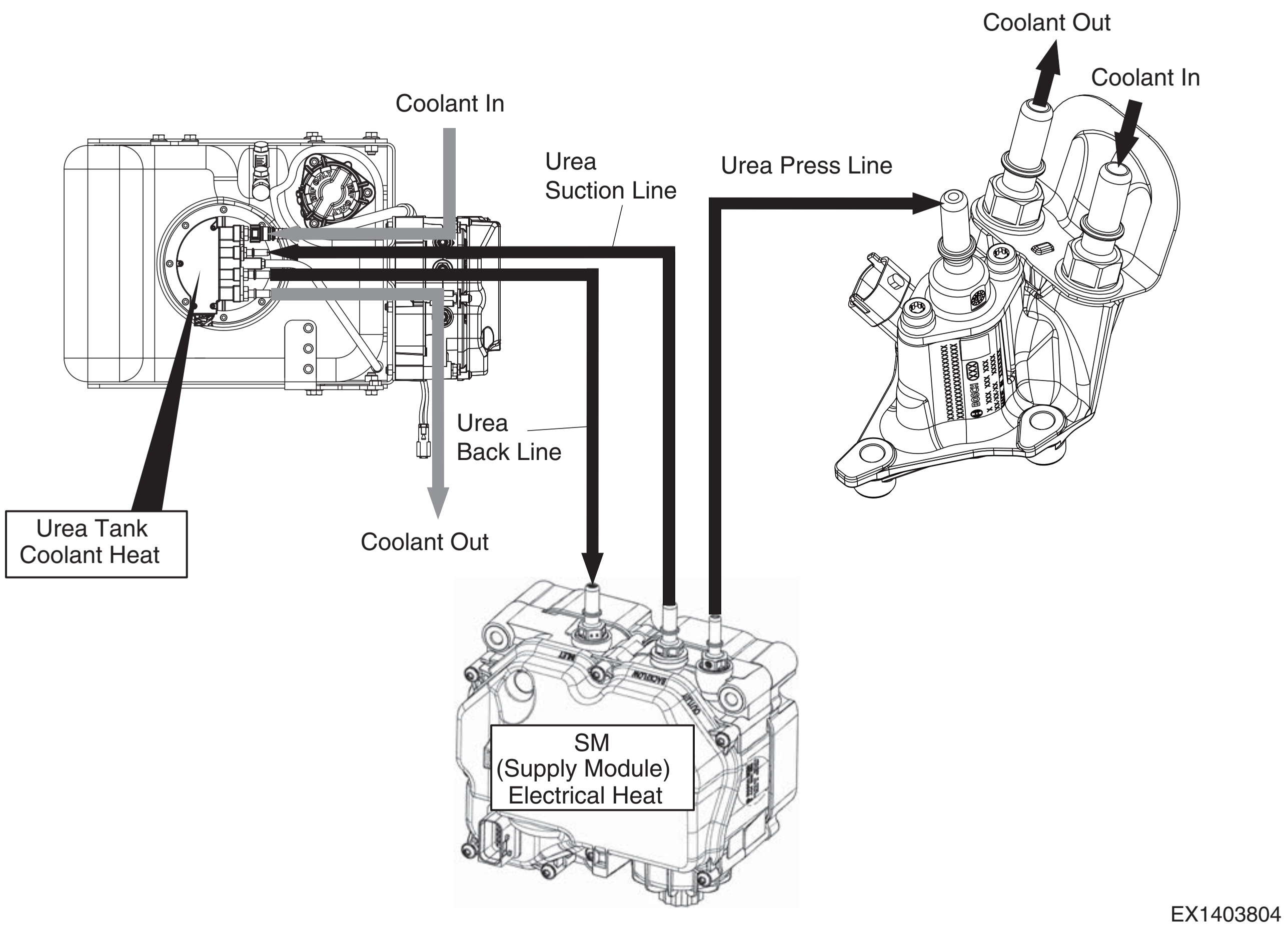


Figure 213

Urea Tank

The urea tank is used to store urea liquid. Connect lines to the specified positions. Also, be careful not to apply impact to the urea tank during its service.

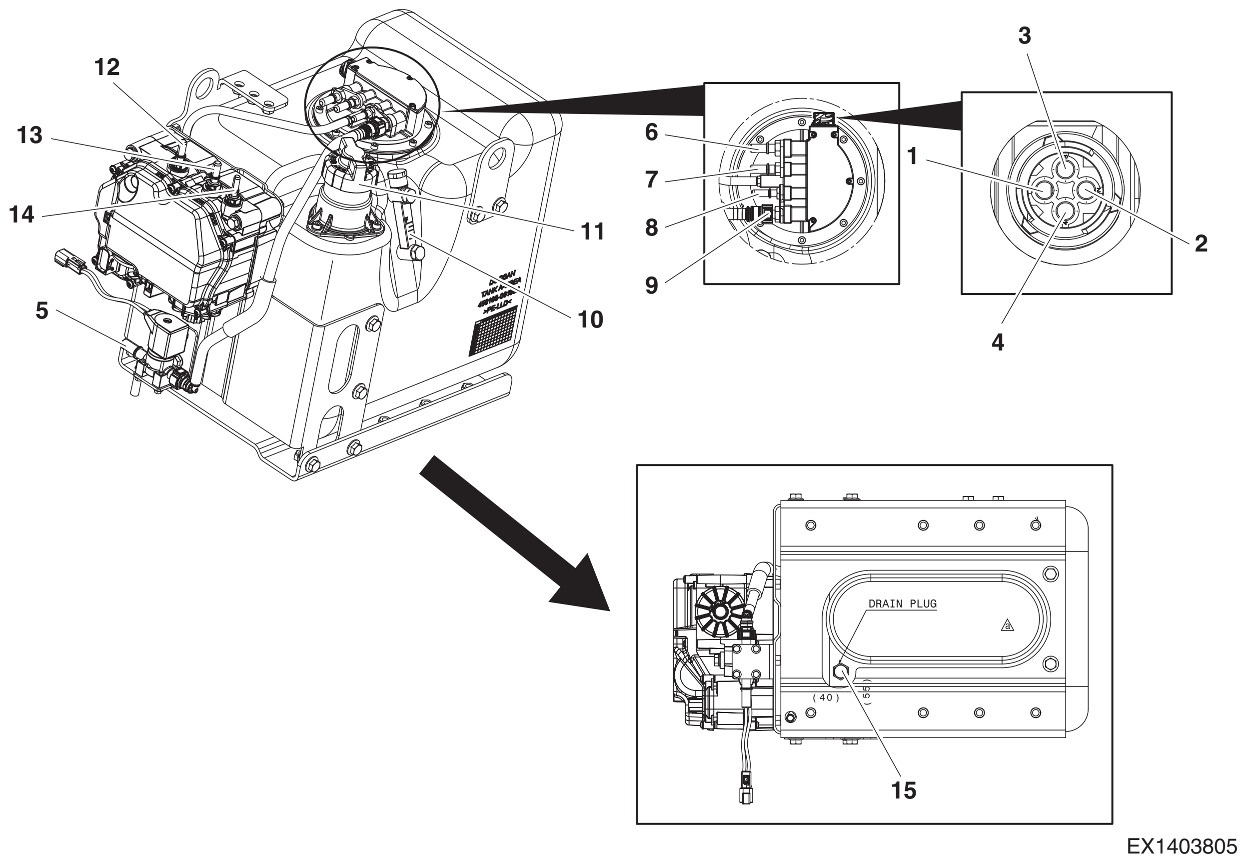


Figure 214

Reference Number	Description
1	+24 V (Pin No. 1)
2	Ground (Pin No. 2)
3	CAN High (Pin No. 3)
4	CAN Low (Pin No. 4)
5	Coolant Inlet
6	Coolant Outlet
7	Urea Outlet
8	Urea Inlet

Reference Number	Description
9	Coolant Inlet
10	Level Indicator
11	Urea Tank Cap
12	Inlet
13	Backflow
14	Outlet
15	Drain Plug

IMPORTANT

The replacement interval of the DEF (urea solution) filter is different by the amount of foreign materials in DEF.

Make sure to use only the specified DEF and container and keep the surrounding area of the tank clean to prevent possible foreign materials.

1. Remove filter cover.

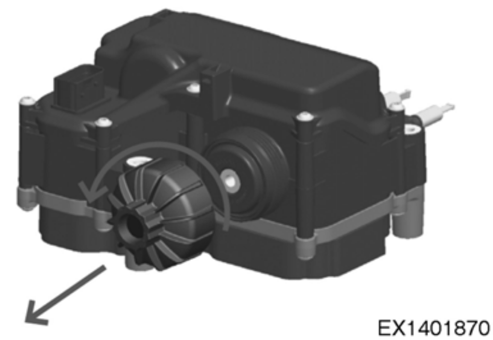


Figure 215

2. Remove equalizing element.

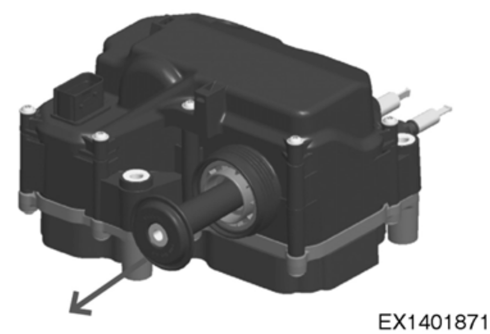


Figure 216

3. Check the color (gray/green) in the filter.

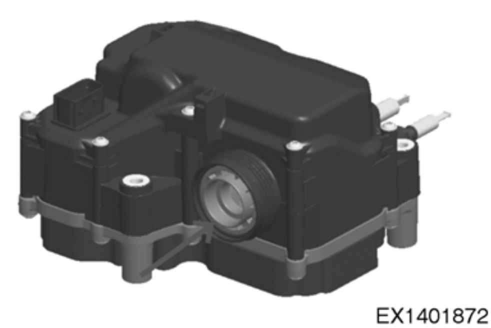


Figure 217

4. Set the color of the mark on the end of the filter removing tool in the same direction with the filter color section.

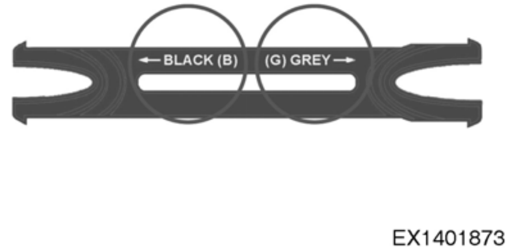


Figure 218

5. Insert the end of the filter removing tool until a clicking sound is heard or engagement with the filter is felt.

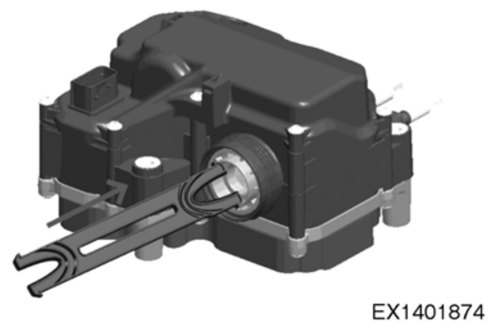


Figure 219

6. Pull the filter removing tool to remove filter.

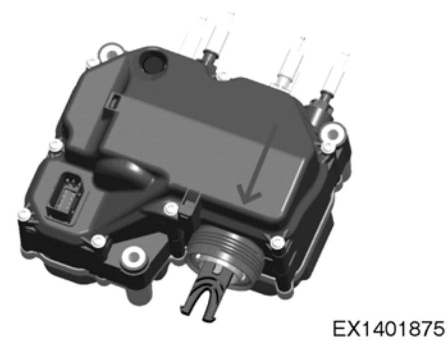


Figure 220

7. The surface must be kept clean. It can be cleaned with water only.

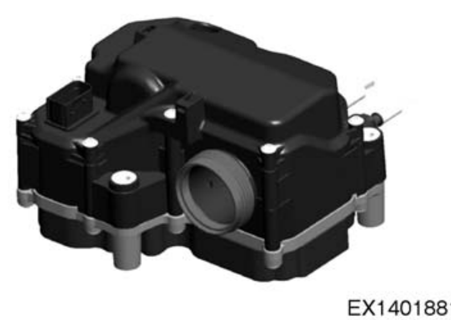


Figure 221

8. Apply oil to the O-ring and install a new filter.

CAUTION

AVOID INJURY

Use Mobil Velocite No. 6 oil from Bosch.

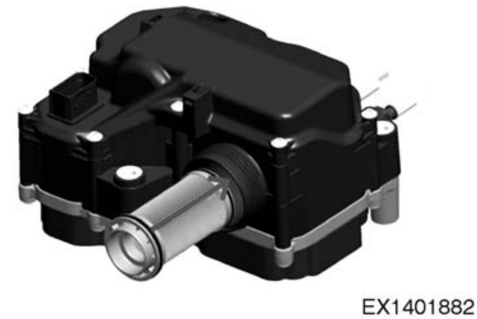


Figure 222

9. Install a new equalizing element.

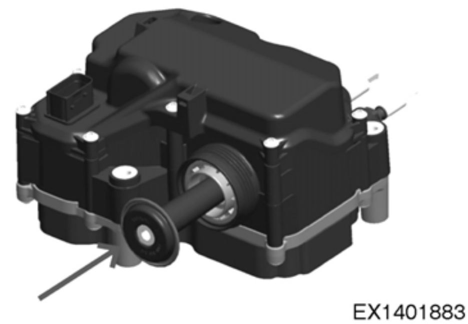


Figure 223

10. Tighten the filter cover to 20 N.m + 5 N.m.

CAUTION

AVOID INJURY

Check that filter surface is clean. It can be cleaned with water only.

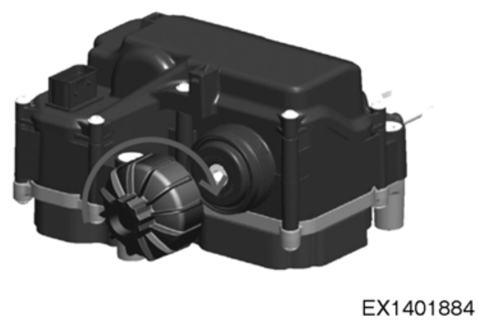
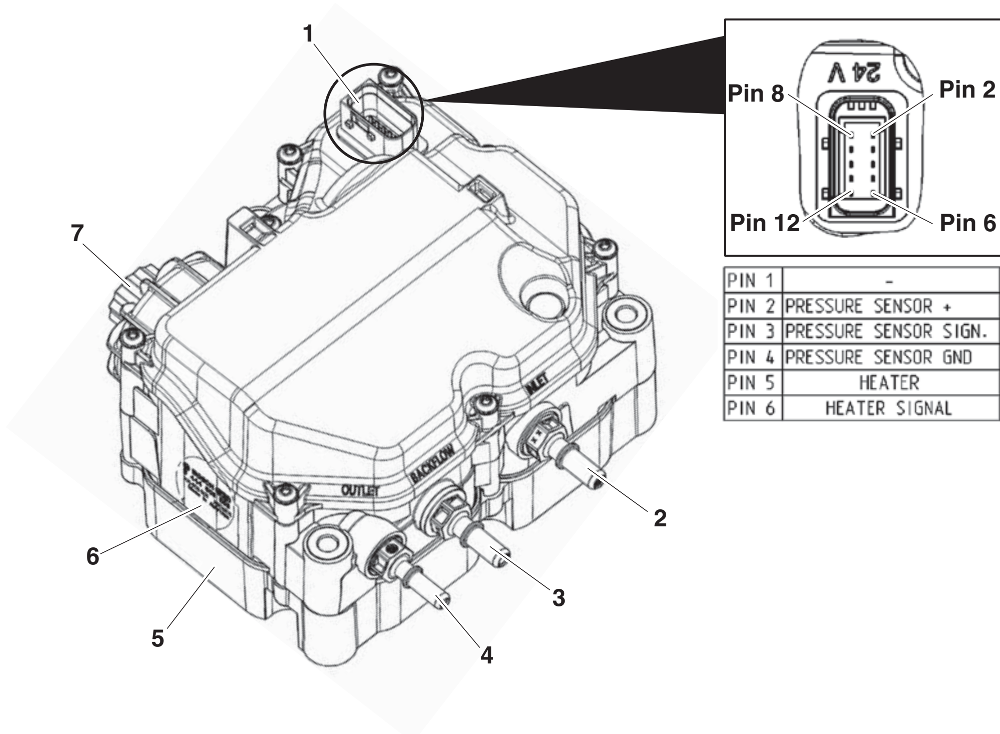


Figure 224

Supply Module

The supply module is used to pressurize DEF in the DEF tank to a certain level and supply this pressurized DEF to the dosing module.



PIN 1	-	PIN 7	-
PIN 2	PRESSURE SENSOR +	PIN 8	PUMP MOTOR GND
PIN 3	PRESSURE SENSOR SIGN.	PIN 9	PUMP MOTOR +
PIN 4	PRESSURE SENSOR GND	PIN 10	PUMP MOTOR PWM
PIN 5	HEATER	PIN 11	RVV
PIN 6	HEATER SIGNAL	PIN 12	RVV SIGNAL

EX1403806

Figure 225

Reference Number	Description
1	Connector
2	Adblue Inlet
3	Adblue Backflow Outlet
4	Adblue Outlet

Reference Number	Description
5	Cover Plate
6	Detail Marking
7	Filter Cover

Dosing Module

The dosing module is attached to the exhaust manifold in front of the SCR system to receive DEF from the supply module and spray it into the exhaust manifold.

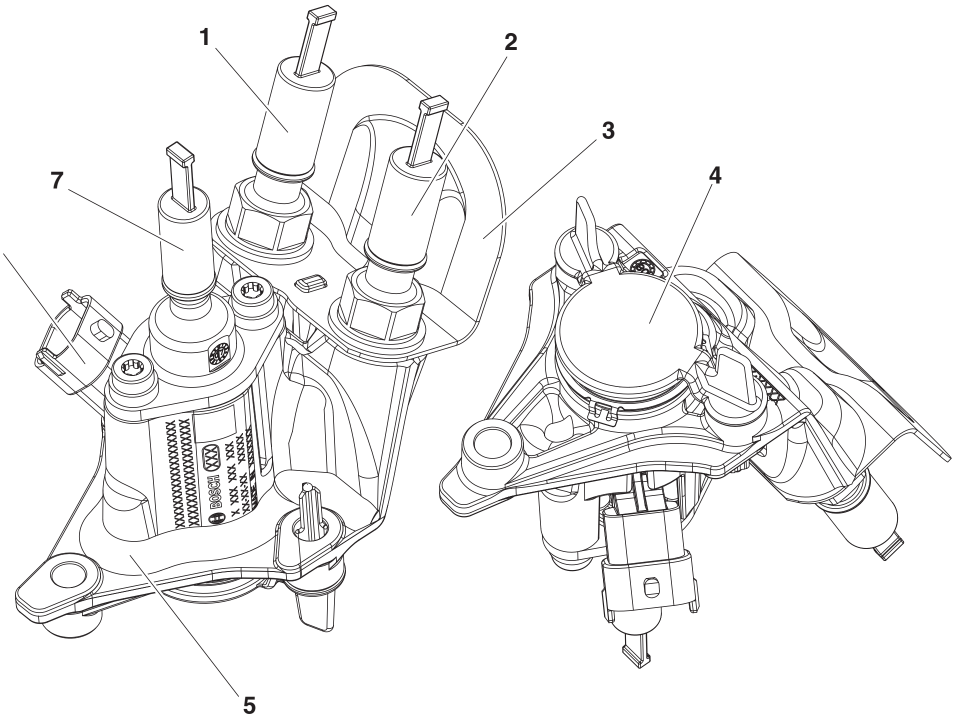


Figure 226

Reference Number	Description
1	Coolant Outlet
2	Coolant Inlet
3	Head Shield
4	Protective Cap

Reference Number	Description
5	Cooling Adapter
6	Dosing Valve
7	Adblue Inlet

Checking DNOx2.2 System

Dosing Module

Dosing Moduel fault is cause of the high temperature exposure of nozzle tip injecting urea, electric harness contact failure, urea hose line break or poor contacet, and more. Visual inspection of dosing module failure are as follows.

1. When replacing dosing module, dosing module and bolts is the leakage or damage caused by under tightening bolts or over tightening.
2. Electric connector misassembly or debris contamination inside of connector.
3. Urea leakage is caused by urea line misassembly.
4. Coolant leakage is caused by coolant line misassembly. The high temperature exposure of dosing module is caused by disconnected from the coolant line.
5. The high temperature exposure of dosing module is caused by gasket misassembly.
6. Urea leakage is caused by gasket reuse.

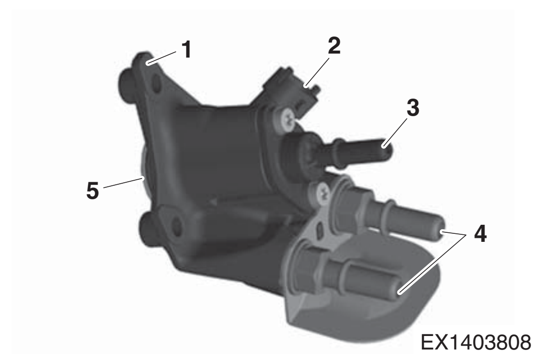


Figure 227

Supply Module

The supply module (SM) failure mode is associated with urea line and electric connector damage and poor connection. When replacing urea main filter regularly, supply module failure can occur caused by disassembly.

CAUTION

AVOID INJURY

When replacing new filter, open the package right before the replacement.

1. When connecting urea line, the failure caused by urea line misassembly.
2. Electric connector misassembly or debris contamination inside of connector.
3. When replacing supply module filter, the damage caused by not using the special tool. Also, it caused by filter remnants inside supply module filter.
4. When replacing filter, the urea cap damage is caused by overtihgtneing and the filter detachment is caused by not tightening.

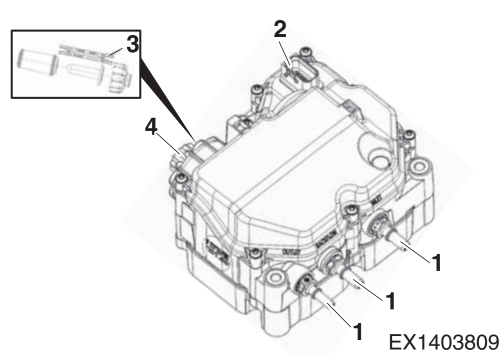


Figure 228

Urea Tank

Urea Tank is keeping the urea solution. Assembly connected line to correct location. When maintenance of urea tank, be careful not to external impacts.

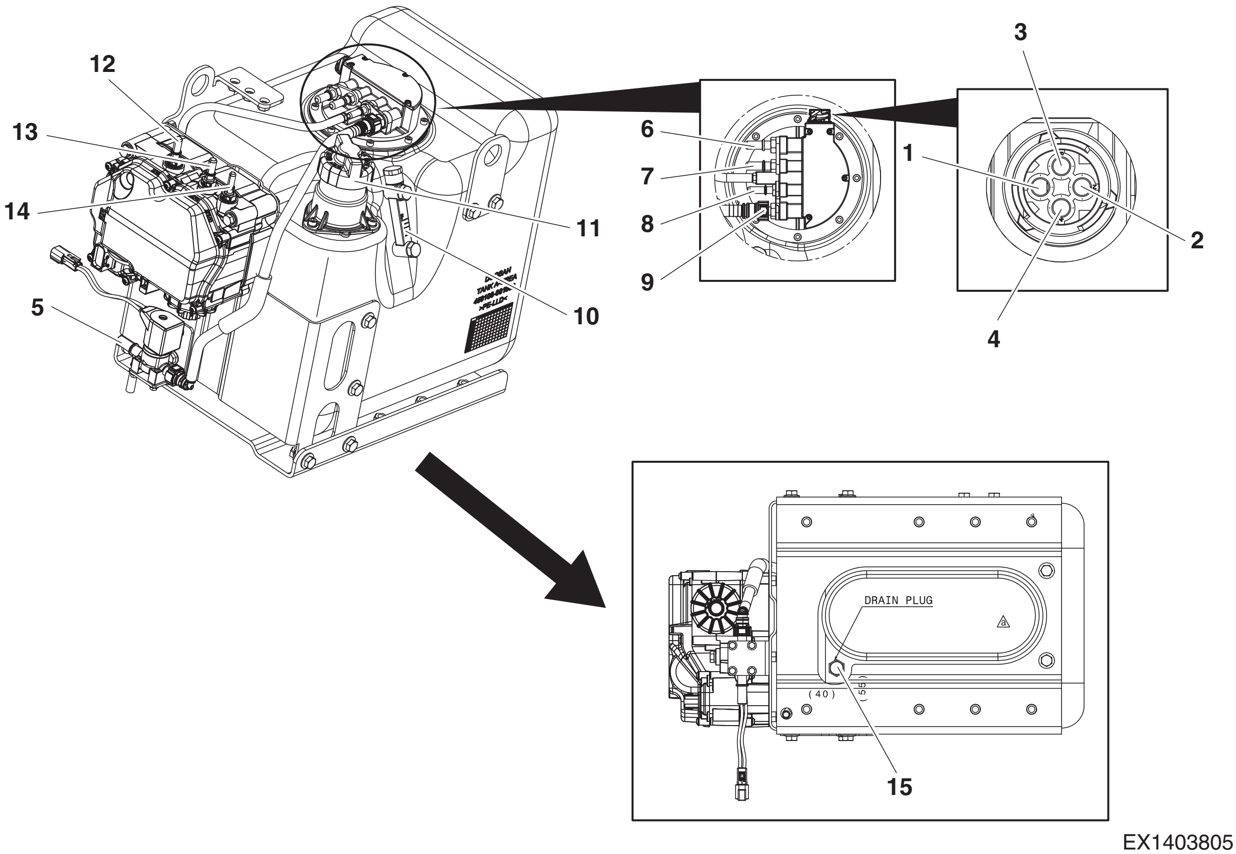


Figure 229

1. Urea inlet hose and backflow hose are incompatible, do not use them together. Be careful to damage the connector, assemble the connector.

CAUTION

AVOID INJURY

Urea inlet hose is marked red color, backflow hose is marked yellow color.

2. Make sure that urea tank fixing bracket mount is tightened. If it is not tightened, it could occur the damage caused by vibration.
3. Make sure that the connection condition of tank temperature and level sensor connector. Be careful to damage connector and be contaminated debris.
4. Assembly coolant line to correct location. If it is not tightened, it could leak coolant.

5. Make sure that the connection condition of urea line heater (2-pin). Not running a heater in winter season there is a danger of frost.

Muffler and Other Pipes

It is no necessary to replace, disassemble and move mounted muffler and other pipes except by failure caused by external impact. Tighten the each parts at tightening torque not to leakage, when replacing, disassembling and moving muffler and other pipes caused by failure.

COOLING SYSTEM

General information

General Description

This engine is a water-cooled type. Combustion heat from the combustion chamber and heat from engine oil are absorbed by coolant and dissipating them to the outside air to ensure optimum engine operation.

In the cooling system, coolant supplied from the coolant pump is sent to the oil cooler through the coolant pipe to absorb heat from oil before it passes through the coolant jacket of the cylinder block and through the cooling passage of the cylinder head to absorb combustion heat.

After this coolant absorbs oil heat and combustion heat, it is led to the thermostat through the coolant pipe. If the coolant temperature is below the valve opening temperature of the thermostat, the coolant flows into the coolant pump. If the temperature is over the opening temperature, it flows into the radiator. In the radiator, it releases heat and returns back to the coolant pump in a low temperature condition again.

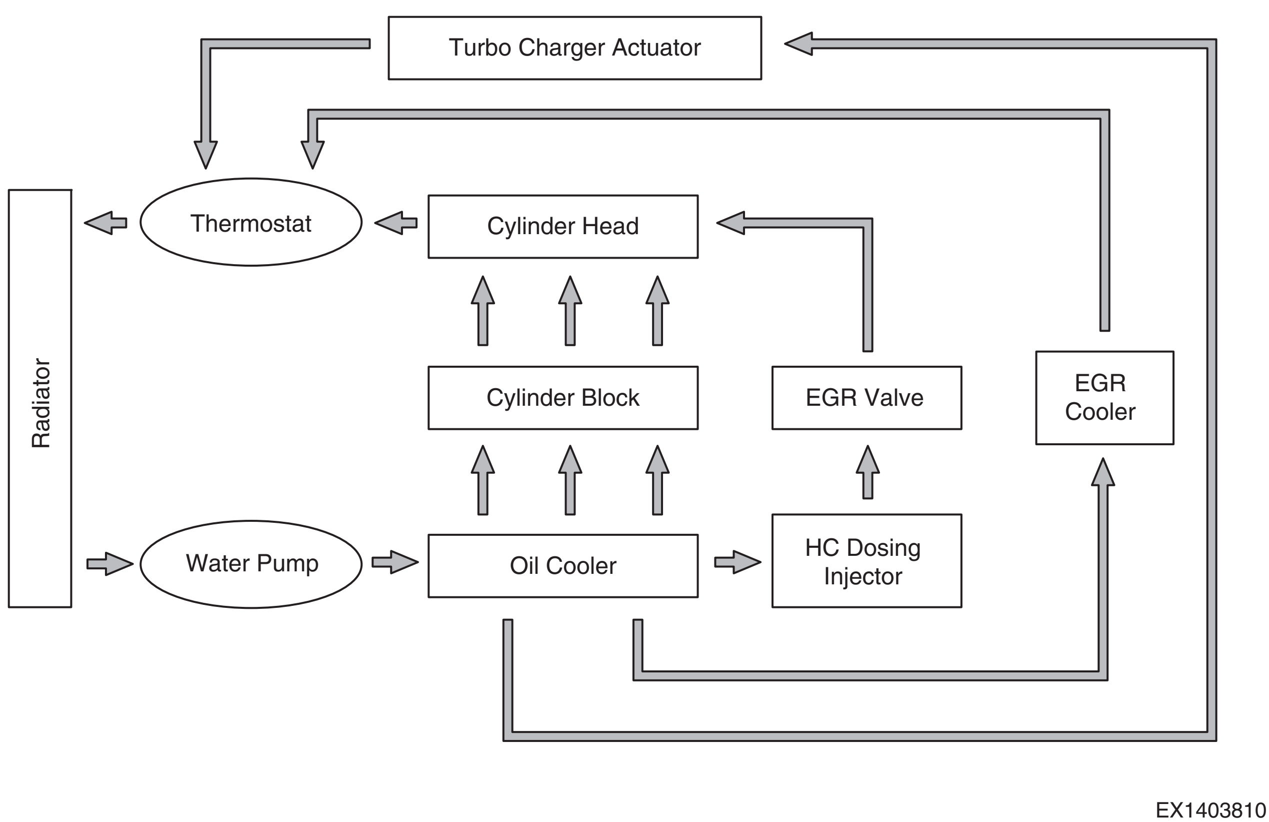


Figure 230

Thermostat

General Description

The thermostat maintains water temperature in the engine consistently and prevents heat loss to improve heat efficiency of the engine.

When the coolant temperature is below the normal temperature, the thermostat is closed and the coolant is bypassed and directly flows into the water pump. When the coolant temperature reaches the normal temperature or is higher than the temperature, the thermostat is fully open and the bypass circuit is closed. So the coolant flows into the radiator.

CAUTION

AVOID INJURY

- **The wax pellet type thermostat shows slower response to the change of cooling water than the bellows type thermostat. This happens because the heat capacity of the wax pellet type thermostat is larger than that of the bellows type thermostat. Therefore, to prevent a rapid increase in the engine coolant's temperature, you must first operate the engine at idle until the engine is fully warmed up. When the weather is very cold, do not operate the engine in an overloaded condition or at a high speed after starting the engine.**
- **When draining water from the engine cooler or injecting water to the engine cooler, work slowly to ensure that all air inside the cooler is expelled.**
- **When a defect is found in the thermostat, replace it with a new one.**

Reference Number	Description
1	Heat Exchanger
2	Bypass Valve
3	Water Pump
4	Coolant Pipe

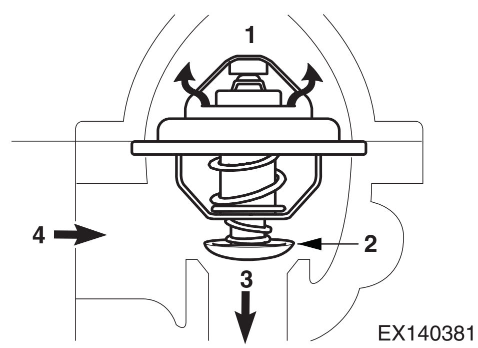


Figure 231

Parts List

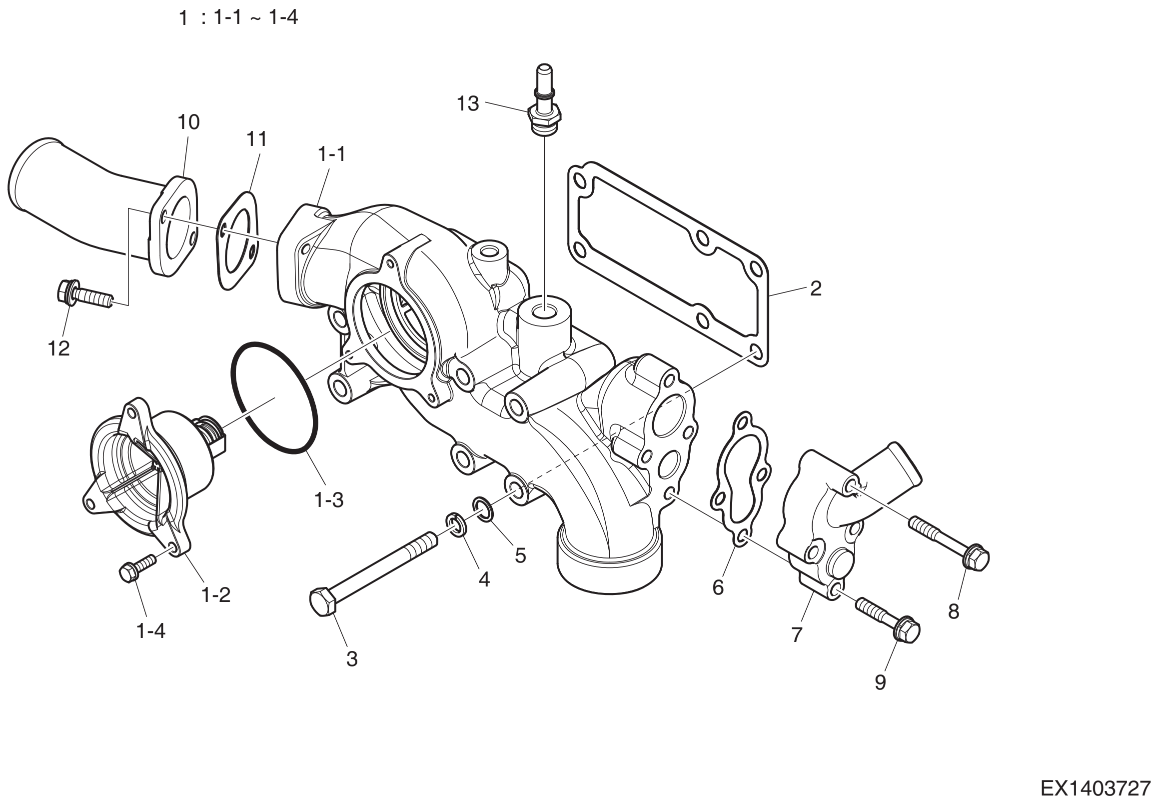


Figure 232

Reference Number	Description
1	Thermostat Assembly
1-1	Housing; Thermostat
1-2	Thermostat
1-3	O-ring
1-4	Bolt; Hex
2	Gasket; Thermostat
3	Bolt; Hex
4	Washer; Spring
5	Washer; Plain

Reference Number	Description
6	Gasket
7	Connection
8	Bolt Assembly M8 x 60
9	Bolt Assembly M8 x 45
10	Outlet; Water
11	Gasket; Water Pump
12	Bolt Assembly M8 x 30
13	Connection; Screw

Cautions for Replacement and Handling of Thermostat

1. Cautions for handling

   A wax pellet type thermostat features relatively slow response for change in coolant temperature compared to a bellows type. This is because the wax pellet type has larger thermal capacity. Therefore, it needs to idle the engine sufficiently before running it in order to prevent surge of engine coolant temperature. In cold weather, never overload the engine or speed drive.

2. When adding or draining coolant to/from the engine cooling system, do it slowly to let air in the system escape.

3. Thermostat replacement

   If any defect is found on the thermostat, replace it with a new one.

Thermostat inspection

1. Check if the wax pellet and spring are damaged.

2. Put the thermostat into water and heat the water gradually to check for operation of the thermostat.

   If the thermostat starts to open at 83°C (water temperature) and it is fully open at 95°C, it is normal.

3. Check if there is any foreign material in the thermostat.

   NOTE: *Clean the inside of the thermostat using a air gun.*

4. Check the hose for internal or external damage or foreign materials.

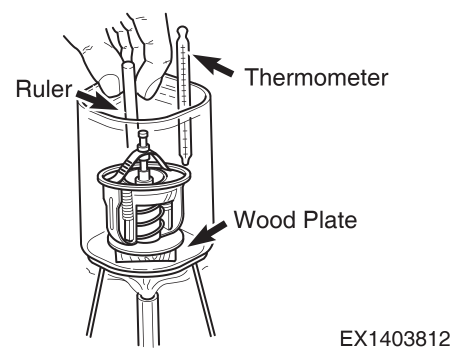


Figure 233

Cooling fan

General Description

The speed of the cooling fan is controlled by the electronic fan clutch in order to maintain its optimum speed. The electronic fan clutch adjusts the cooling fan speed electrically according to the coolant temperature, hydraulic oil temperature, CAC (Charge Air Cooler) temperature and engine speed to reduce cooling fan noise and obtain superior efficiency.

Specification

Weight	Approximately 9.0 kg
Tightening Torque for M8 bolt	21.6 N.m (2.2 kg.m, 15.9 ft lb)
Tightening Torque for M10 bolt	43.1 N.m (4.4 kg.m, 31.8 ft lb)

Parts List

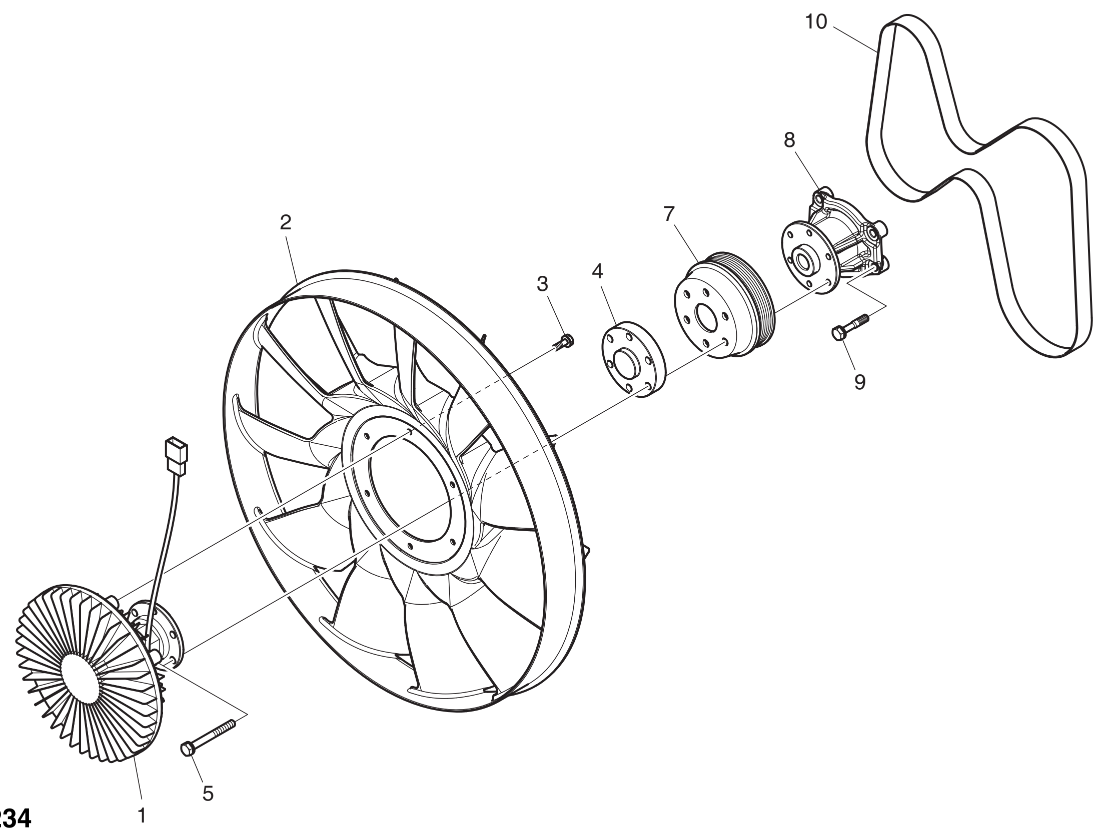


Figure 234

Reference Number	Description
1	Fan Clutch Assembly
2	Fan; Cooling
3	Bolt Assembly M8 x 18
4	Flange; Fan
5	Bolt Assembly

Reference Number	Description
7	Pulley; Fan
8	Fan Drive Assembly
9	Bolt Assembly M10 x 40
10	V Belt

Troubleshooting

Phenomenon	Causes	Troubleshooting
Overheated Engine	Not enough coolant	Replenish the coolant
	Defective radiator cap	Replace it
	Contaminated radiator	Clean the exterior of the radiator
	Defective V-belt offset	Adjust or replace it
	Contaminated or damaged V-belt	Replace it
	Damaged impeller	Replace the water pump
	Defective impeller fix	Replace the water pump
	Bad water pump operation	Replace it
	Bad thermostat operation	Replace it
	Bad coolant flow	Clean the coolant path
	Improper injection time	Check it with the failure diagnosis unit
	Damaged cylinder head gasket	Replace it
Overcooled Engine	Bad thermostat operation	Replace it
	Too low ambient temperature	Heat the block
Leaking Coolant	Damaged radiator	Repair or replace it
	Loosened or damaged radiator connection	Repair or replace the connection
	Defective radiator cap	Replace it
	Badly mounted water pump	Repair or replace it
	Bad or damaged water pump gasket	Replace the gasket
	Badly mounted thermostat	Repair or replace it
	Bad or damaged thermostat gasket	Replace the gasket
	Damaged cylinder head gasket	Replace the gasket
	Damaged cylinder head or block	Replace it
Noise	Bad water pump bearing	Replace the bearing
	Bad or damaged cooling fan	Repair or replace it
	Bad rotation of the cooling fan	Replace it
	Defective V-belt offset	Adjust or replace it

FUEL SYSTEM

General Information

This diesel engine compresses air delivered into its cylinders and sprays fuel with its injection nozzles to burn fuel with compression heat.

When the high-pressure pump produces high-pressure fuel, this fuel is kept by the common rail and its injection timing and injection amount are calculated by the ECU (Electronic Control Unit). The ECU (Electronic Control Unit) operates the solenoid valves of the injectors on each cylinder to inject fuel.

This common rail fuel injection system has the high-pressure producing part and the fuel injection part separated. The ECU determines the fuel injection amount, injection timing and injection pressure according to the operating condition of the engine before injecting fuel into the cylinders in order to ensure optimum engine performance.

As the high-pressure pump produces high-pressure fuel, this fuel is kept by the common rail. When a driver operates the vehicle, the optimum fuel injection timing and injection amount are determined by the ECU (Electronic Control Unit) based on the preset data, vehicle speed and driving condition. Then the ECU operates the solenoid valves of the injectors on each cylinder to inject a proper amount of fuel into the cylinders.

The fuel tank should be made of non-corrosive material, and the fuel low-pressure pump should not leak at twice the operating pressure. Also, the pressure in the tank should not exceed 0.3 bar (0.3 kg/cm^2, 4.4 psi).

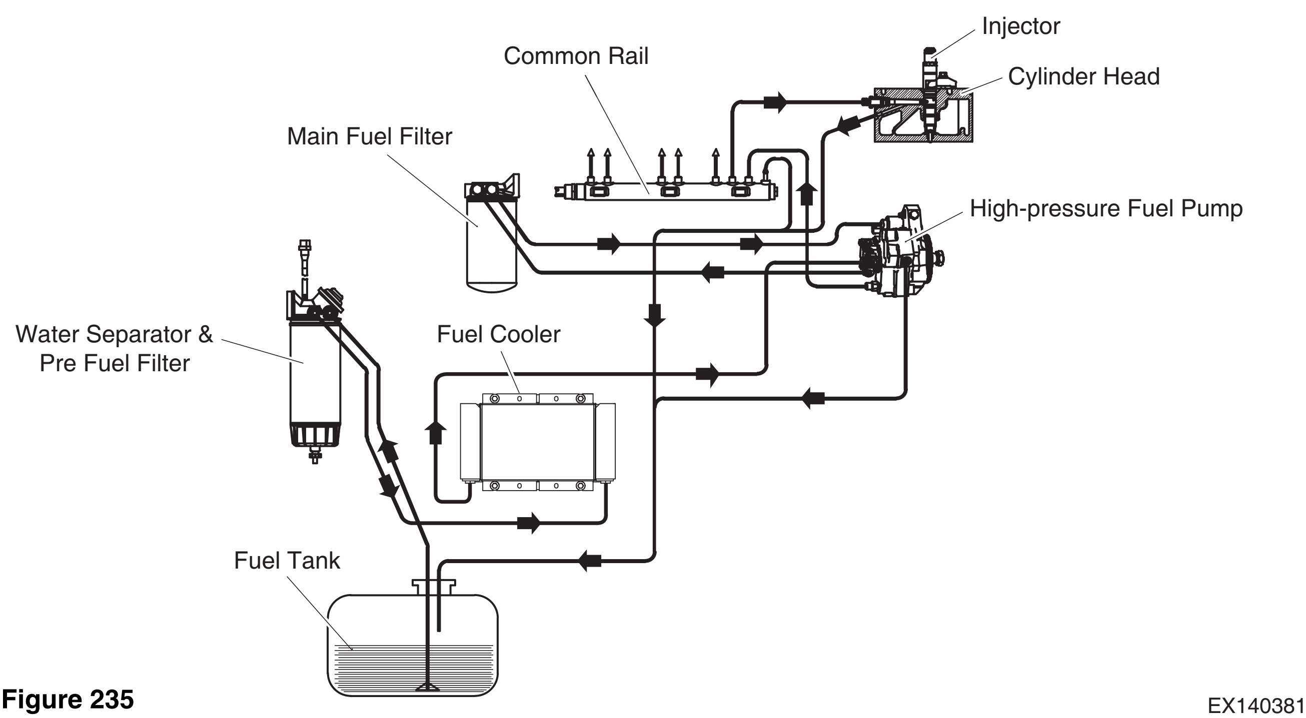


Figure 235

Fuel High-pressure System Components

The common rail fuel injection system consist of the low-pressure stage for low-pressure fuel delivery, high-pressure stage for high-pressure fuel delivery, and electronic control unit.

1. Fuel high-pressure pump

   The fuel high-pressure pump pressurizes fuel up to approximately 1,835.5 kg/cm^2 (1,800 bar, 26,106.8 psi) and sends this pressurized fuel to the common rail (pipe shape) through the high-pressure line.

2. Common rail

   Even after the injector uses fuel from the common rail to inject fuel, the fuel pressure in the common rail is still maintained at a constant level. The common rail pressure sensor detects the fuel pressure while the pressure control valve maintains the fuel pressure at the desired level. The fuel pressure in the common rail is controlled to max. 1,835.5 kg/cm^2 (1,800 bar, 26,106.8 psi) by the pressure control valve.

3. Injector

   As the solenoid valve is operated, fuel flows to the injector nozzle which then sprays fuel directly into the combustion chamber. When the injector nozzle opens and sprays the commanded amount of fuel, the excess fuel is returned to the tank through the return line. Also, fuel returned from the fuel pressure control valve and low-pressure stage and fuel used to lubricate the high-pressure pump are returned back to the fuel tank through the return line as well.

4. Fuel high-pressure pipe

   The fuel high-pressure pipe carries high-pressure fuel at 1,835.5 kg/cm^2 (1,800 bar, 26,106.8 psi). Therefore, this pipe is made of special material to be able to withstand the maximum pressure of the system and fluctuation of high pressure occurred during fuel injection. The high-pressure pipe has 8.0 mm of outside diameter and 3.5 mm of inside diameter. Also, the fuel high-pressure pipes installed between the common rail and injectors should be in the same length and they are installed as short as possible.

Injector

General Description

The injector uses the nozzle to inject fuel to the combustion chamber directly. To control the injection, the solenoid valve is used. Fuel is delivered as much as required from the open injector nozzle and the remaining fuel is returned to the fuel tank through the fuel return line. In addition, the fuel which has been used to lubricate the high-pressure pump and returned from the fuel pressure adjustment valve is returned to the fuel tank through the return line.

The solenoid valve controls the fuel injection timing and amount. The injector works instead of the nozzle and the nozzle holder mounted on the existing engine. Fuel is delivered to the injector through the high-pressure connector mounted on the cylinder head and then delivered to the valve control chamber through the delivery hole.

The valve control chamber is opened by the solenoid valve. It is connected to the fuel return line via the discharge hole. The hydraulic force which has been increased by the valve control plunger with closed discharge hole exceeds the pressure value of the nozzle needle. As a result, fuel delivery to the combustion chamber is blocked by the force given to the contact surface of the nozzle needle.

When the solenoid valve of the injector is pulled, the discharge hole is opened. This lowers the pressure in the control chamber and the hydraulic power given to the plunger. When hydraulic force is lower than the force given to the nozzle needle pressure, the nozzle needle is opened. Finally, fuel is injected to the combustion chamber through the injection nozzle hole.

The reason that the nozzle needle is controlled by hydraulic force is that the power required to open the needle quickly cannot be directly generated from the solenoid valve. Fuel control amount required to open the nozzle needle is added to the fuel amount injected. The used fuel is discharged to the fuel return line through the hole of the valve control chamber.

Fuel loss occurs on the nozzle needle, the valve plunger guide as well as the valve control chamber. The control leakage fuel and the fuel gathered from the line, which connects the over flow valve, the high-pressure pump, and the pressure control valve, is returned to the fuel tank through the fuel return line.

Parts List

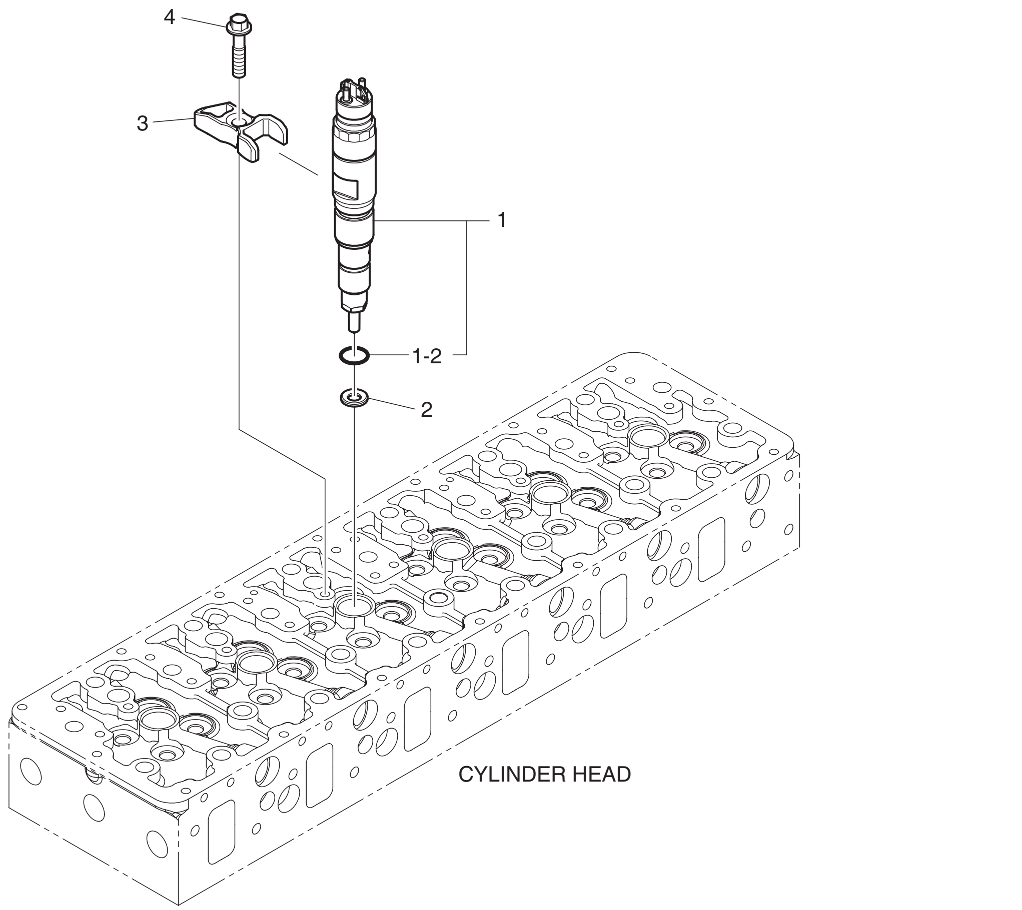


Figure 236

Reference Number	Description
1	Injector Assembly
1-2	O-ring
2	Ring; Seal

Reference Number	Description
3	Fixture
4	Bolt; Collared Hex.

How to Operate an Injector

Injector operation is classified into four operation stages to operate the engine and create pressure in the high-pressure pump.

- The injector is closed (high fuel pressure state)
- The injector is open (starting fuel injection).
- The injector is fully open (injecting fuel).
- The injector is closed (ending fuel injection). These operation stages are decided by balancing the force given to the injector components. If there is no pressure on the common rail or the engine is stopped, the injector nozzle does not work.

1. The injector is closed (pause state)

   Under the pause state that no power is provided to the solenoid valve of the injector, the injector does not operate. The surface where the discharge hole exists is tightly closed with the valve ball by the force from a valve spring or magnet. High pressure in the common rail is kept by the fuel control valve and the same pressure is generated in the nozzle chamber of the injector. The common rail fuel pressure, which is applied to the end face of the valve control chamber of the injector, and the force of the spring at the nozzle of the injector are larger than the force to open the nozzle. Therefore, the injector is closed.

2. The injector is open. (starting fuel injection)

   When power is supplied while the injector solenoid valve is closed, the fuel discharge hole is open by the pulling force of the solenoid valve. Almost simultaneous with that, the high current given to the solenoid valve is reduced to the low current. This is because the air gap of the electromagnet circuit gets smaller. Fuel in the valve control chamber flows to the discharge valve hole on the upper side and then goes into the fuel tank via the fuel return line. The discharge hole completely breaks the pressure balance and lowers the pressure in the valve control chamber. As a result, the pressure in the valve control chamber is lower than the nozzle chamber pressure which has been equal to the common rail pressure. The lowered pressure of the valve control chamber lowers the force from the control plunger. So the nozzle needle is open and fuel injection starts.

3. The injector is fully open. (injecting fuel)

   The valve control plunger is stopped at the upper position because fuel is full as fuel flows from the fuel delivery hole. At this time, the injector nozzle is fully open and fuel is injected to the combustion chamber at the pressure equal to that of the common rail.

4. The injector is closed. (ending fuel injection)

   As soon as the supply to the solenoid vale of the injector is blocked, the valve spring applies force to the armature downward and the valve ball closes the discharge hole. The armature consists of two components. The armature plate is guided by the driving shoulder and pressed downward. However, in this case, an overspring is used. It is a return spring that prevents the force from being applied to the armature and the valve ball. As the discharge hole is closed, fuel is delivered from the delivery hole and generates pressure in the control chamber. This fuel pressure is equal to the pressure of the common rail and puts pressure on the valve control plunger through the end face of the valve control plunger. As a result, the force of the spring is added to the pressure exceeding the pressure of the nozzle chamber. Therefore, the nozzle needle is closed. The speed of closing the nozzle needle is decided by the flow that passes through the delivery hole. As soon as the nozzle needle is positioned to the stop position, fuel injection is blocked.

Injector Protrusion

1. Insert the seal ring to the cylinder cylinder head, and install the injector.

   NOTE: *Refer to the engine assembly instruction for installation steps.*

2. Measure the protrusion of the injector from the cylinder head, and adjust it as necessary.

A (Seal Ring Thickness)	2.0 mm
B (Injector Protrusion)	3.0 mm

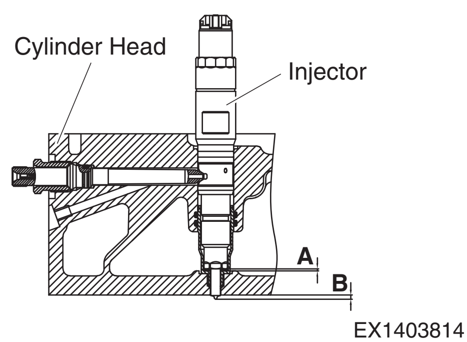


Figure 237

Common Rail

General Description

This common rail fuel injection system has the high-pressure producing part and the fuel injection part separated.

The ECU determines the fuel injection amount, injection timing and injection pressure according to the operating condition of the engine before injecting fuel into the cylinders in order to ensure optimum engine performance.

The common rail stores fuel under high pressure delivered from the high-pressure fuel pump.

Even after the injector draws fuel from the common rail, the pressure pulsation in the common rail is still maintained by the volume of the rail to keep the fuel pressure at a constant level.

The common rail pressure sensor detects the fuel pressure while the pressure control valve maintains the fuel pressure at the desired level. The fuel pressure in the common rail is controlled to max. 1,835.5 kg/cm^2 (1,800 bar, 26,106.8 psi) by the pressure control valve.

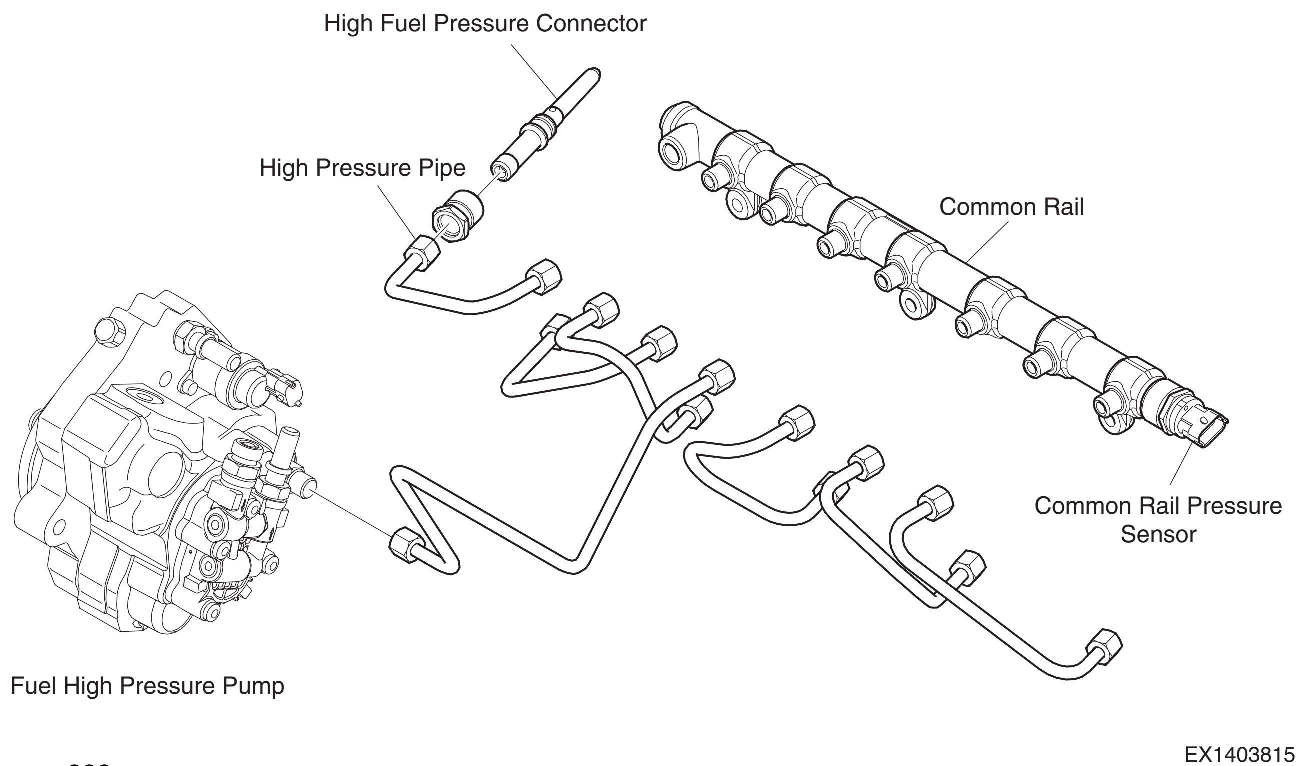


Figure 238

The common rail fuel injection system consists of the following main components:

1. ECU (Electronic Control Unit)
2. Crankshaft speed sensor
3. Camshaft speed sensor
4. Accelerator pedal sensor
5. Fuel temperature sensor
6. Boost pressure and temperature sensor, oil pressure and temperature sensor
7. Common rail pressure sensor
8. Coolant temperature sensor
    - As a driver depresses the accelerator pedal, the ECU (Electronic Control Unit) receives information from various sensors mentioned above to operate the engine and vehicle according to the operating condition instantly. Also, the ECU controls engine and open/closed circuits of the vehicle based on such information.
    - The crankshaft speed sensor detects the engine speed while information from the camshaft speed sensor is used to determine the ignition order. The potentiometer of the accelerator pedal sensor produces an electric signal to inform the ECU of how deep the pedal is depressed. Also, the turbocharger and intake pressure sensor are installed, the intake pressure sensor is used to measure the intake air pressure.
    - When the engine temperature is low in cold weather, the ECU receives information from the coolant temperature sensor and air temperature sensor to operate the engine ideally based on the current operating condition.

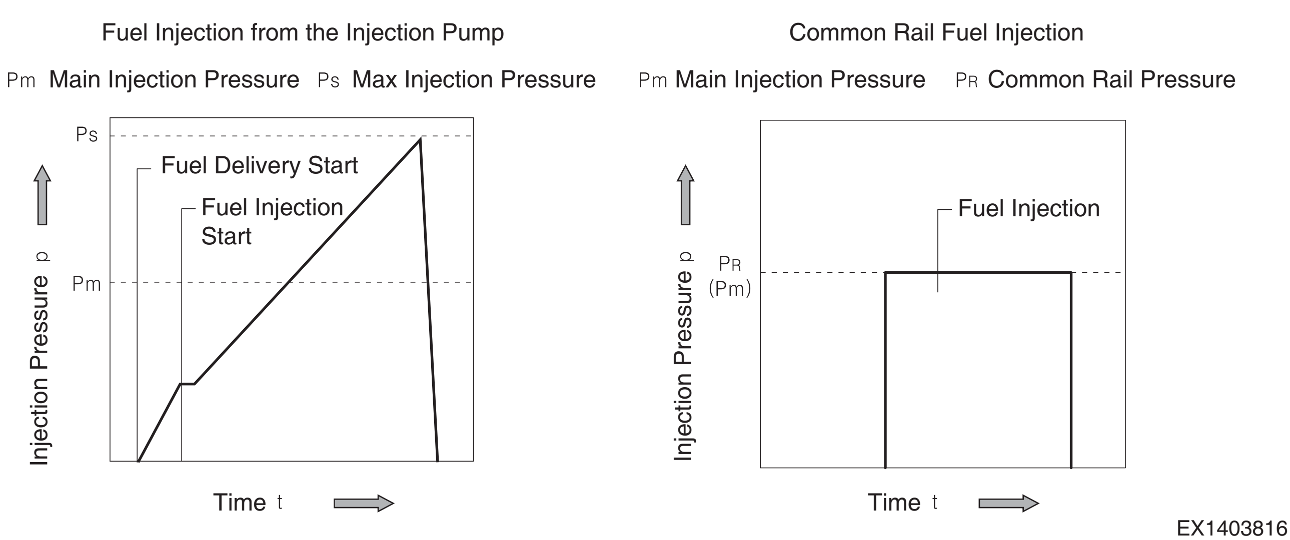


Figure 239

The common rail features the injection characteristics as follows:

1. Compared to the conventional system's injection characteristics, the common rail manages the fuel injection amount and injection pressure separately to satisfy with any engine condition in order to ensure optimum fuel injection.
2. In the initial fuel injection period, i.e. the ignition delay from the beginning of fuel injection until the beginning of combustion, the fuel injection amount should be adjusted to a low level.
3. The common rail system is a modular type and has the following major components for is injection characteristics:
   A. Injector solenoid valve (installed to cylinder head)
   B. Common rail
   C. Fuel high-pressure pump
   D. ECU (Electronic Control Unit)
   E. Crankshaft speed sensor

Parts List

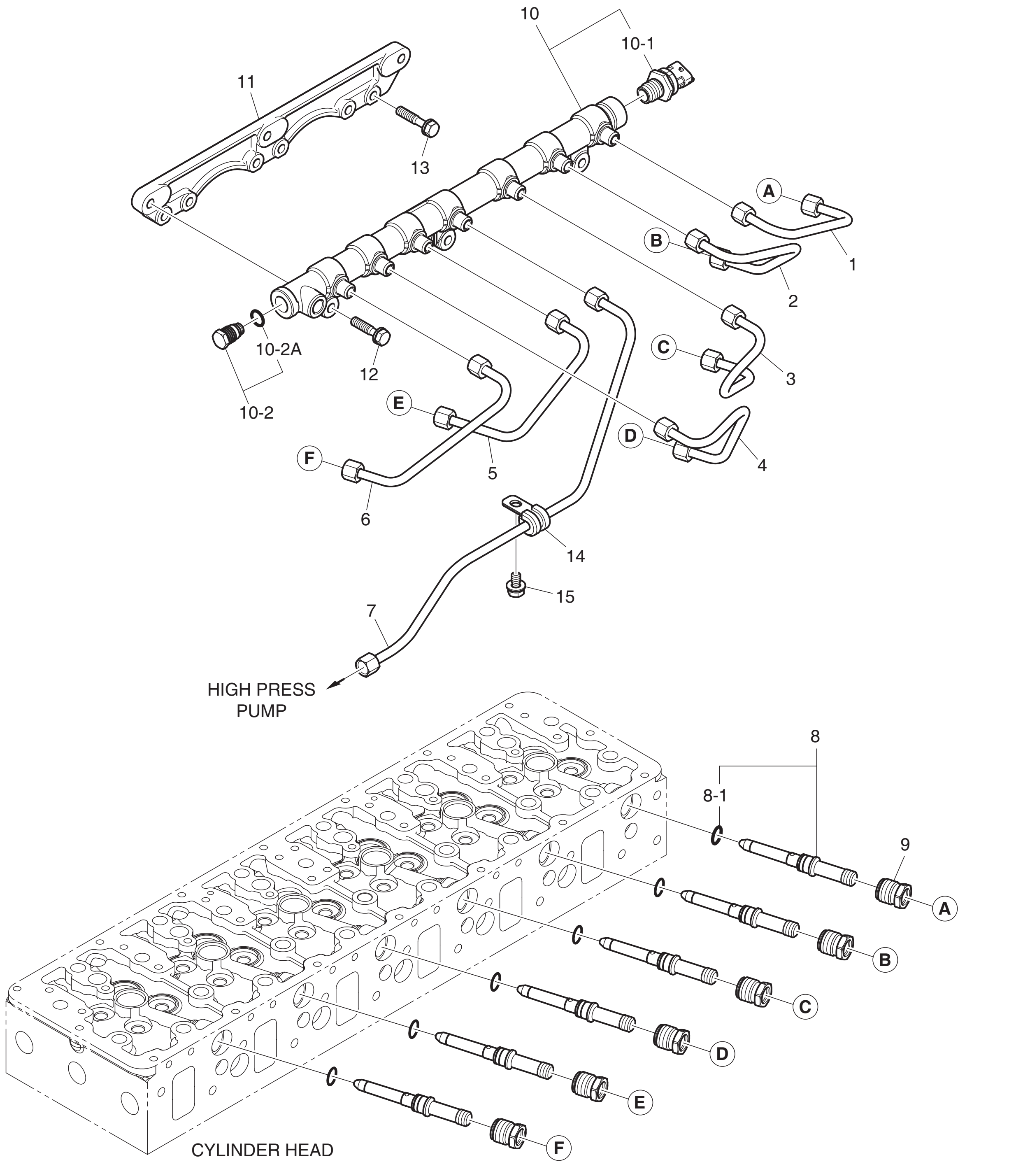


Figure 240

Reference Number	Description
1	Pipe; Injection
2	Pipe; Injection
3	Pipe; Injection
4	Pipe; Injection
5	Pipe; Injection
6	Pipe; Injection
7	Pipe; Injection
8	Connector; High Pressure
8-1	O-ring
9	Nut

Reference Number	Description
10	Rail; Common
10-1	Sensor; Pressure
10-2	Valve; Pressure Limits
10-2A	O-ring
11	Bracket; Common Rail
12	Bolt Assembly M8 x 30
13	Bolt Assembly M8 x 35
14	Clip; Pipe
15	Bolt Assembly M8 x 12

Fuel Injection Pump

General Description

The high-pressure fuel pump is a radial shaped piston type pump. Pressure is independently generated during the fuel injection process. The high-pressure fuel pump is directly connected to the engine crankshaft, thus it turns always in synchronization with the engine. Compared to the conventional injection system, the common rail injection system delivers a certain amount of fuel constantly.

The injector is connected to the common rail with the high-pressure pipe. It consists of the nozzle and solenoid valve which is energized by the ECU when the ignition switch is operated. When the ignition switch is blocked, the solenoid valve ends the injection operation.

As the switching (opening/closing) operation of the injector's solenoid valve is performed by high voltage and current, the injectors' solenoid valves are operated in sequence according to the preset value in the ECU. The crankshaft speed sensor and camshaft speed sensor are used to detect the engine speed in order to adjust the fuel injection timing and the beginning of fuel injection correctly.

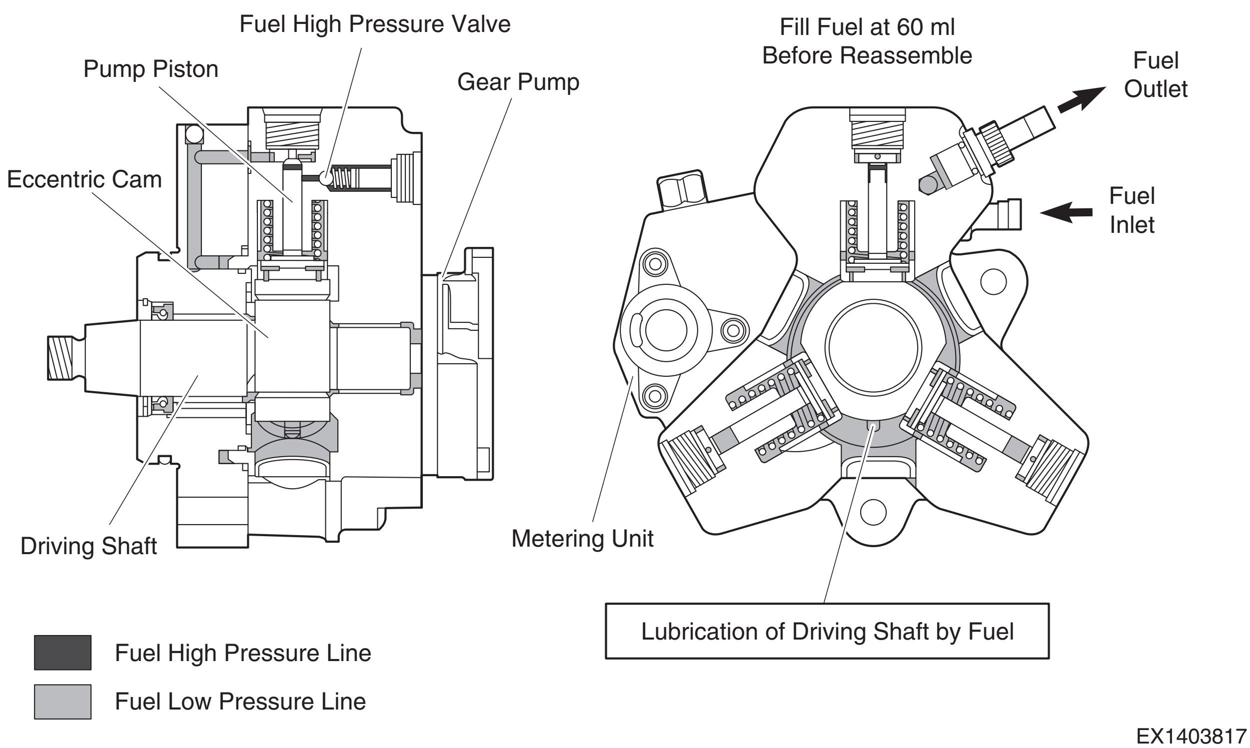


Figure 241

Function

The fuel high-pressure pump has both low pressure stage and high pressure stage. It carries high pressure fuel under any operating circumstance during the service life of the vehicle.

Also, it supplies a proper amount of fuel to the common rail to handle any harsh condition, such as abrupt vehicle start or rapid change of pressure in the common rail. The fuel high-pressure pump produces the system pressure required in the common rail constantly.

Structure Fuel High-pressure Pump

The fuel high-pressure pump has three pump pistons set 120° apart from each other in it to compress fuel in the circumferential direction. As every rotation creates three compression strokes, the pump drive system's stress is maintained steadily and it needs low driving force. The common rail needs low pump driving force which is only approximately 1/9 of force required for the conventional pump system.

Operation

The fuel feed pump supplies fuel to the high-pressure pump through the fuel inlet and safety valve. Then, this fuel is transferred to the high-pressure pump's lubrication and cooling circuits through the safety valve. The drive shaft is equipped with the eccentric cam to move the pump's piston up and down according to the shape of the cam.

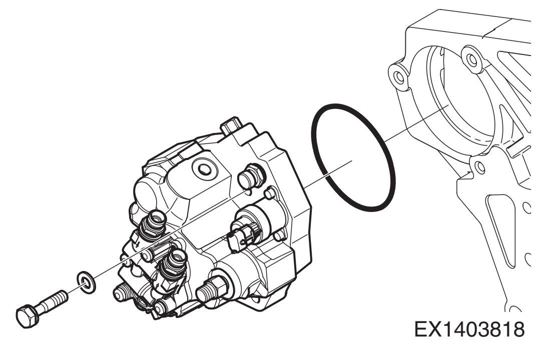


Figure 242

If the fuel pressure delivered from the fuel feed pump exceeds the fully open pressure of the safety valve, fuel moves the pump piston downwards through the intake valve of the fuel high-pressure valve to the intake stroke position of the pumping chamber. When the pump piston passes the B.D.C., the valve is closed. Then, as fuel cannot escape the pumping chamber, it is compressed further over the delivered pressure.

As soon as the fuel pressure reaches the common rail pressure, it opens the exhaust valve. Then, this compressed fuel enters the high-pressure circuit. The pump piston continues to carry fuel until it reaches the T.D.C. Then, as soon as the pressure drops, the exhaust valve is closed. Then, fuel left in the pumping chamber is depressurized and the pump piston moves downwards again. When the pressure in the pumping chamber drops below the pressure of the fuel feed pump, the intake valve opens and the above steps are repeated.

Fuel Return

The fuel high-pressure pump is designed to supply a large amount of fuel. While the engine is running at an idle speed or with partial load, excess fuel is returned to the tank through the pressure control valve.

Fuel High-pressure Pumping Cut-off Valve

When the switch of the fuel high-pressure pumping cut-off valve is turned off, the fuel amount delivered to the common rail is increased. When the switch is turned off, the fuel pumping solenoid valve is pulled, so the pin attached to an electric magnet keeps the valve open. Therefore, fuel led into the pumping valve cannot be compressed during the delivery stroke. As this fuel is returned to the low-pressure passage, no pressure is produced. Since the pumping cut-off valve is operated only with a small amount of force, it is possible to switch between the delivery phase and cut-off phase at short intervals.

Parts List

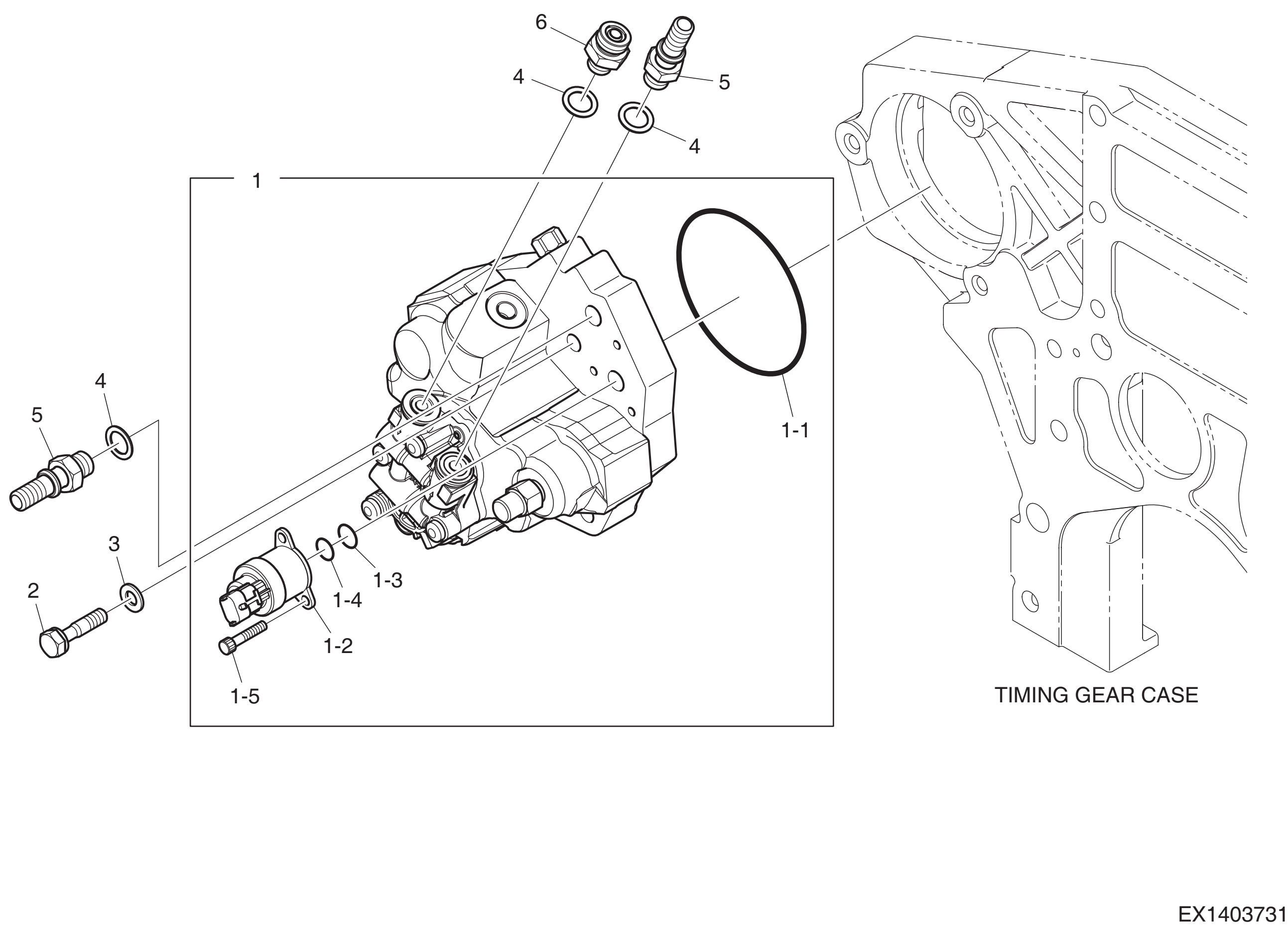


Figure 243

Reference Number	Description
1	Injection Pump Assembly
1-1	O-ring
1-2	Flow Meter; Fuel
1-3	O-ring
1-4	O-ring
1-5	Bolt

Reference Number	Description
2	Bolt Assembly M10 x 45
3	Washer; Plain
4	Ring; Seal A14 x 20
5	Nipple
6	Adapter

ELECTRICAL SYSTEM

Electrical Parts

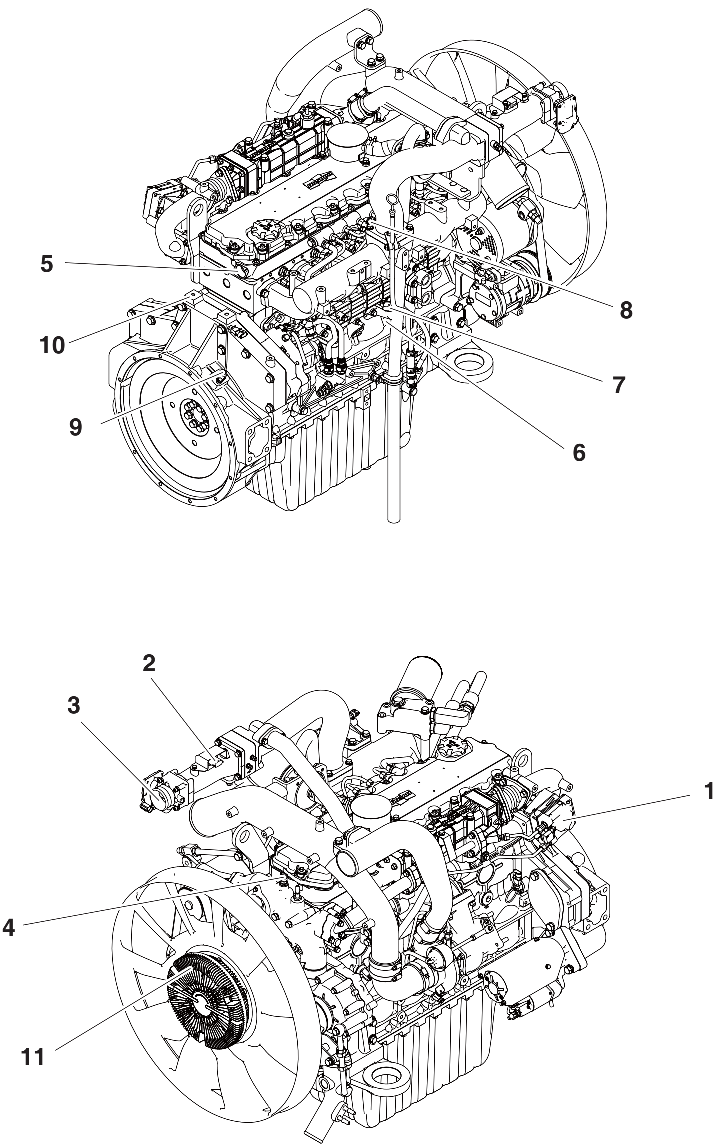


Figure 244

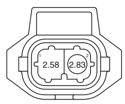
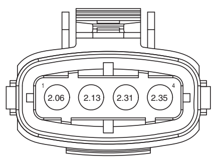
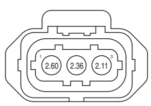
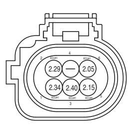
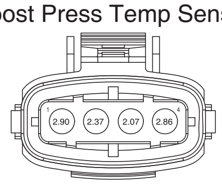
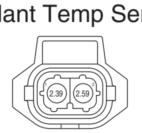
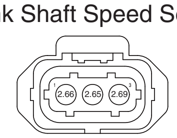
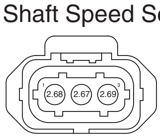
DS1801715

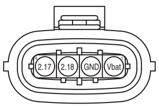
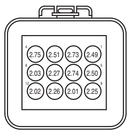
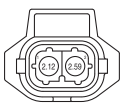
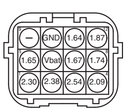
Reference Number	Description
1	EGR (Exhaust Gas Recirculation) Motion Sensor
2	Boost Pressure and Temperature Sensor (BPTS)
3	Throttle Valve Position Sensor (TVA)
4	Coolant Temperature Sensor (CTS)
5	Injector Connector (INJ)

Reference Number	Description
6	Oil Pressure and Temperature Sensor (OPTS)
7	Resistance Connector
8	Rail Pressure Sensor (RPS)
9	Crankshaft Speed Sensor (CRS)
10	Camshaft Speed Sensor (CAM)
11	Fan Clutch

Switches and Sensors

ECU (Electronic Control Unit)

Shape	Symbol	Pin No.	Circuit name
Fuel Metering Unit 	FMU	2.58	Fuel Metering Unit (O_V_MEU)
		2.83	Fuel Metering Unit (O_T_MEU)
Oil Press Temp Sensor 	OPTS	2.06	Oil Pressure/Temperature Sensor GND (G_R_OPS)
		2.13	Oil Temperature Sensor SIG (I_A_OTS)
		2.31	Oil Pressure/Temperature Sensor Voltage (V_V_5VSS1F)
		2.35	Oil Pressure Sensor SIG (I_A_OPS)
Rail Press Sensor 	RPS	2.60	Rail Pressure Sensor GND (G_R_RAILPS)
		2.36	Rail Pressure Sensor SIG (I_A_RAILPS)
		2.11	Rail Pressure Sensor Voltage (V_V_5VSS3B)
Throttle Plate Actuator / Position Sensor 	TVA	2.34	Throttle Valve Voltage (V_V_5VSS3C)
		2.29	Throttle Valve Motor - (O_T_DCNEG1)
		2.40	Throttle Valve GND (G_R_TVA)
		2.15	Throttle Valve SIG (I_A_TVA)
		2.05	Throttle Valve Motor + (O_T_DCPOS1)
Boost Press Temp Sensor 	BPTS	2.90	Boost Pressure/Temperature Sensor GND (G_R_BPS)
		2.37	Boost Temperature Sensor SIG (I_A_BTS)
		2.07	Boost Pressure/Temperature Sensor Voltage (V_V_5VSS1A)
		2.86	Boost Pressure Sensor SIG (I_A_BPS)
Coolant Temp Sensor 	CTS	2.39	Coolant Temperature Sensor SIG (I_A_CTS)
		2.59	Fuel Temperature/Coolant Temperature Sensor GND (G_R_AN18)
Crank Shaft Speed Sensor 	CRS	2.66	Crankshaft Speed Sensor POS (I_F_CRSPOS)
		2.65	Crankshaft Speed Sensor NEG (I_F_CRSNEG)
		2.69	Crankshaft/Camshaft Speed Sensor Protective GND (G_C_GND)
Cam Shaft Speed Sensor 	CAM	2.68	Camshaft Speed Sensor POS (I_F_CASPOS)
		2.67	Camshaft Speed Sensor NEG (I_F_CASNEG)
		2.69	Crankshaft/Camshaft Speed Sensor Protective GND (G_C_GND)

Shape	Symbol	Pin No.	Circuit name
EGR Valve 	EGR	Vbat	24 V Battery Voltage (O_V_RH32)
		GND	Body GND
		2.18	CAN 2 Low (B_D_CAN2L)
		2.17	CAN 2 High (B_D_CAN2H)
Injector Connector 	INJ	2.49	Cylinder 1, Injector 1 High (O_P_SVH11)
		2.73	Cylinder 1, Injector 1 Low (O_P_SVL11)
		2.51	Cylinder 1, Injector 3 High (O_P_SVH13)
		2.75	Cylinder 1, Injector 3 Low (O_P_SVL13)
		2.50	Cylinder 1, Injector 2 High (O_P_SVH12)
		2.74	Cylinder 1, Injector 2 Low (O_P_SVL12)
		2.27	Cylinder 2, Injector 3 High (O_P_SVH23)
		2.03	Cylinder 2, Injector 3 Low (O_P_SVL23)
		2.25	Cylinder 2, Injector 1 High (O_P_SVH21)
		2.01	Cylinder 2, Injector 1 Low (O_P_SVL21)
		2.26	Cylinder 2, Injector 2 High (O_P_SVH22)
		2.02	Cylinder 2, Injector 2 Low (O_P_SVL22)
Fuel Temp Sensor 	FTS	2.12	Fuel Temperature Sensor SIG (I_A_FTS)
		2.59	Fuel Temperature/Coolant Temperature Sensor GND (G_R_AN18)
Inter Connector for Vehicle 	Interconnector (HFM, FAN Clutch)	2.30	HFM Sensor GND (G_R_AMS)
		2.38	HFM Sensor Temperature SIG (I_A_IATS)
		2.54	HFM Sensor (I_A_IATS)
		2.09	HFM Sensor PWR (V_V5VCAH)
		1.65	Fan Speed Sensor GND (G_R_FSS)
		Vbat	24 V Battery Voltage
		1.67	Fan Speed Sensor PWR (O_V_5VSS2A)
		1.74	Fan Actuator Control SIG (O_V_RH21)
		GND	Body GND
		1.64	Fan Speed Sensor SIG (I_F_FSS)
		1.87	Fan Actuator Control SIG (O_T_FAN1)
Resistance 	Resistance	2.17	CAN 2 High (B_D_CAN2H)
		2.18	CAN 2 Low (B_D_CAN2L)

Boost Pressure and Temperature Sensor

1. The boost pressure and temperature sensor is connected to the intake manifold with the O-ring to measure the absolute pressure and temperature in the intake manifold.
2. Its output signal is sent to the ECU which then calculates the boost pressure based on the programmed characteristic curve.

Engine Oil Pressure and Temperature Sensor

The engine oil pressure and temperature sensor detects the pressure and temperature of engine oil and sends these information to the ECU (Electronic Control Unit).

Engine Coolant Temperature Sensor

The engine coolant temperature sensor detects the temperature of engine coolant and sends this information to the ECU (Electronic Control Unit).

Common Rail Pressure Sensor

Fuel passes through the passage in the common rail before it heads to the common rail pressure sensor.

The tip of this pressure sensor is sealed with the diaphragm. After fuel is pressurized, it reaches the diaphragm of the sensor through the hole.

A sensor to convert a fuel pressure value into an electric signal is connected to this diaphragm. This sensor produces a signal by amplifying the detected value before it delivers the signal to the ECU (Electronic Control Unit) and evaluation circuit.

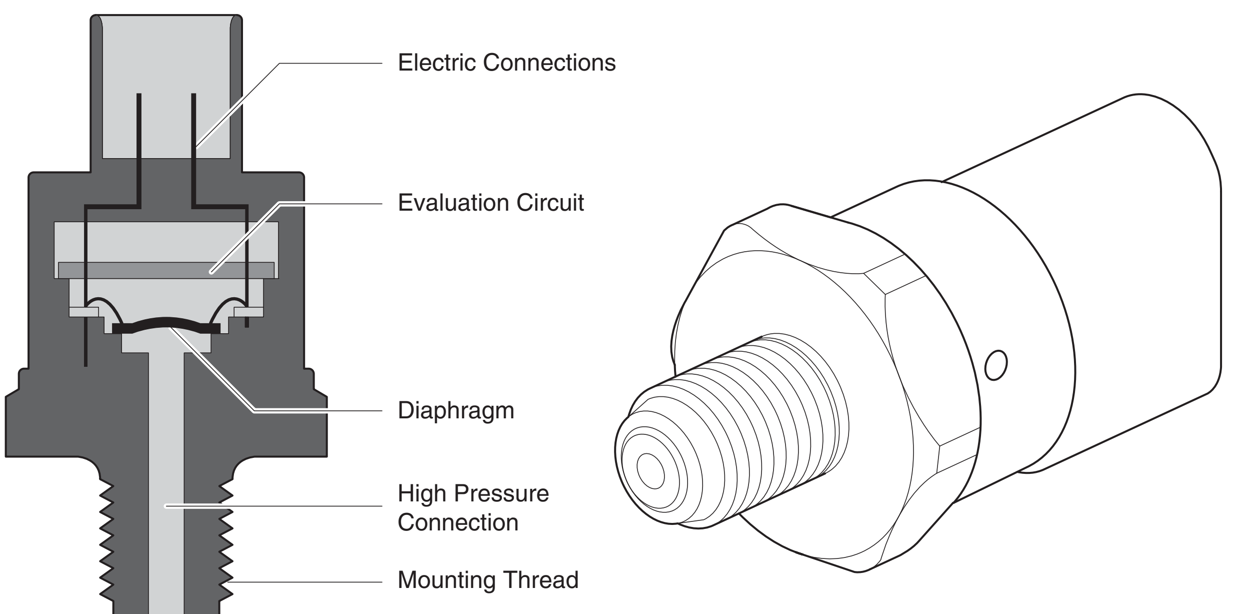


Figure 245

Crankshaft Speed Sensor

The position of the pistons in the combustion chamber has a major role in the fuel injection process.

All pistons in the engine are connected to the crankshaft by the connecting rod.

The flywheel housing is equipped with the crankshaft speed sensor to supply information for the position of all pistons.

This speed sensor detects the rotation per minute of the crankshaft, and this information is used by the ECU (Electronic Control Unit) for calculation as an important factor.

Camshaft Speed Sensor

The camshaft speed sensor is used to control the intake and exhaust valves of the engine.

This rotates at half speed of the crankshaft. When the piston is moving toward T.D.C., it determines whether the camshaft position is in the compression stage or in the exhaust stage.

This information cannot be detected by the crankshaft speed sensor.

On the other hand, during normal operation, information supplied by the crankshaft speed sensor is enough to tell the condition of the engine.

In other words, if the camshaft speed sensor cannot detect the camshaft position while the engine is running, the ECU (Electronic Control Unit) receives engine condition information from the crankshaft speed sensor.

Pressure Limiter Valve

1. The pressure limiter valve is connected to the end of the common rail, and its body houses a conical plunger valve in it. This valve is normally closed by force of the spring at a normal operating pressure (1,800 bar (1,835.5 kg/cm^2, 26,106.8 psi)) to keep the pressure in the common rain.
2. As soon as the pressure exceeds the operating pressure limit, load is applied to the spring of the valve to keep the fuel pressure at a normal level. After fuel passes through the valve, it is returned to the fuel tank through the return pipe.

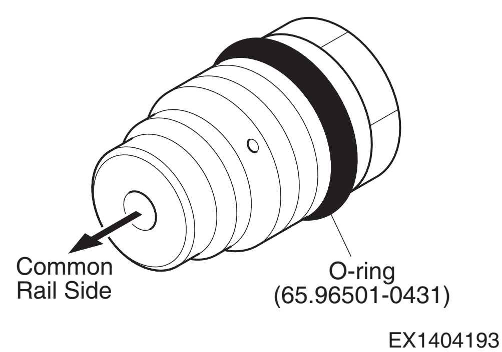


Figure 246

ECU (Electronic Control Unit)

ECU (Engine Control Unit) Connector

There are two ECU (Engine Control Unit) connectors: one for connection to the vehicle and one for connection to the engine.

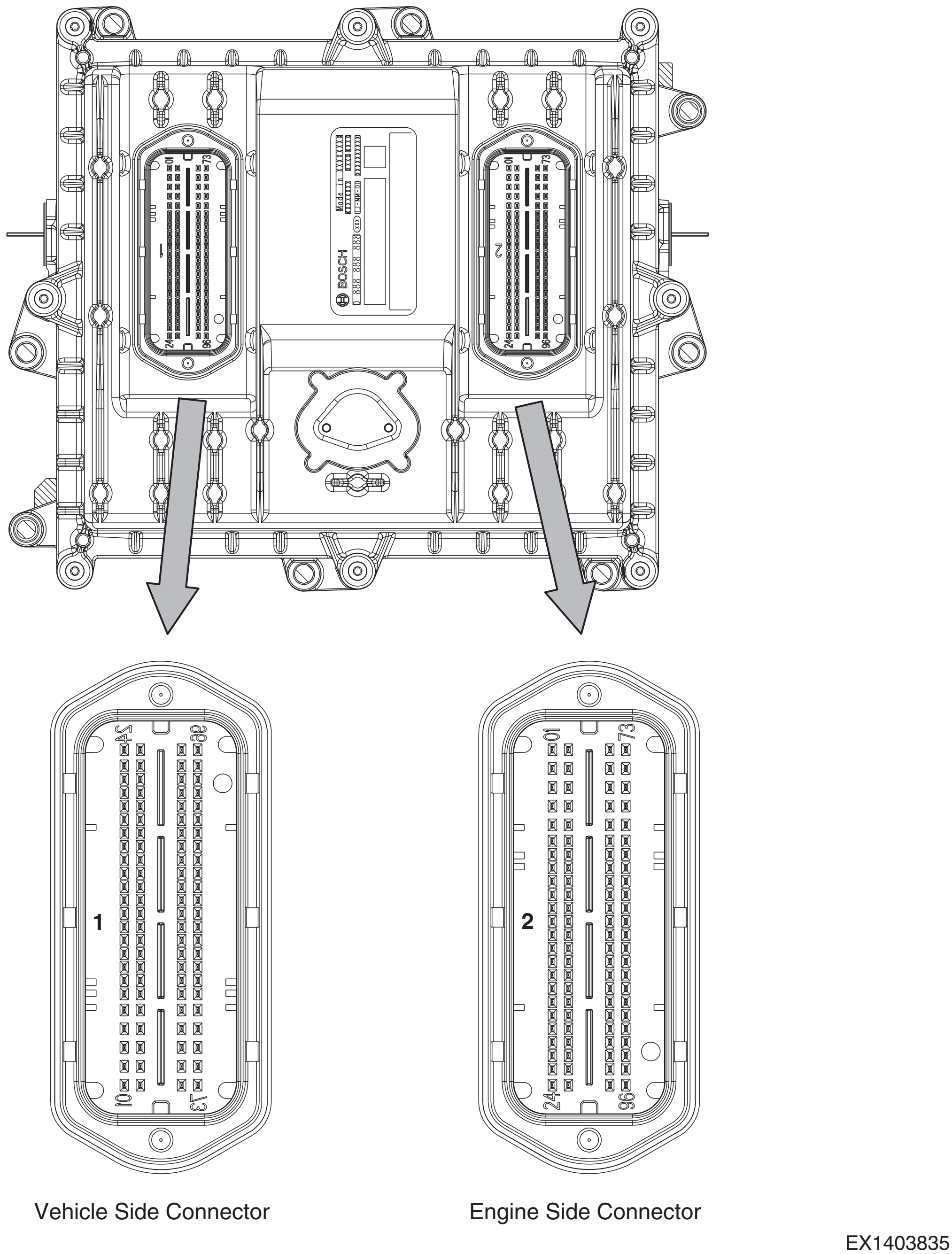


Figure 247

Operational Conditions of Electronic Control Unit (ECU)

Engine Start

1. Sets the reference temperature for determining preheat to the lowest temperature among coolant temperature, fuel temperature, intake air temperature, and oil temperature.
2. Sets the reference temperature for determining fuel volume by setting the engine cooling temperature.
3. Determines the appropriate fuel volume to start the engine, delivers the fuel to the engine, and measures the rpm signal by using the crankshaft rev-count sensor.

Vehicle Driving

Calculates the required data for driving a vehicle, such as CAN data and the rpm transferred from the vehicle control unit.

Driver-requested Adjustment of rpm

Controls the rpm based on request from the driver and controls the engine based on the rpm requested by the vehicle control unit.

Limp Home

1. A function that allows drivers to drive their vehicle to the repair center safely with the minimum conditions for driving the vehicle when a fault code occurs.
2. Limp Home function is applied under the following conditions.
   - Accelerator pedal has failed: Regardless of pressing the accelerator pedal, the vehicle is driven at a consistent RPM.
   - Sensor has failed: When sensors have failed, the vehicle is driven with the consistent alternative values.
   - Output is limited: According to the fault type, the fuel volume delivered to the engine is limited. The limit is classified into four levels. The fuel volume is limited according to the severity of the fault.
   - Diagnosis Information display lamp: Provides information of fault state to drivers for safe driving.

Failure Diagnosis

1. When a fault occurs, the failure diagnosis information display lamp on the gauge board is turned on.
2. With the failure diagnosis information display lamp, drivers can see the fault code.

   NOTE: *It can be checked from the failure diagnosis information on the gauge board.*

3. It can be diagnosed by connecting the diagnosis unit to the check connector at the back of the driver's seat.

Driving Record

1. Writes the information related driving to the ECU.
2. The information on fuel consumption, engine use time, and ECU use time is written in the ECU.
3. The information can be monitored with the ECU diagnosis device.

Starter

General Description

The start motor is installed behind the flywheel housing. When disassembling the engine, soak the start motor's pinion gear and ring gear into fuel and clean them with a brush thoroughly. Then, apply grease to them prevent their corrosion.

24V X 6.0kW

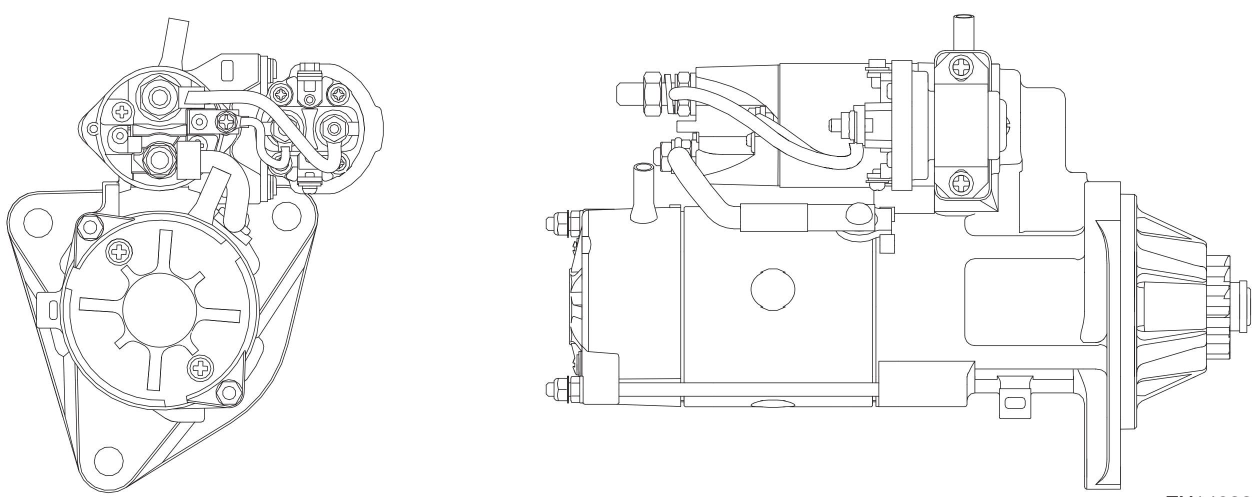


Figure 248

IMPORTANT

The start motor should always be protected from moisture and humid condition.

Circuit Diagram

Circuit Diagram

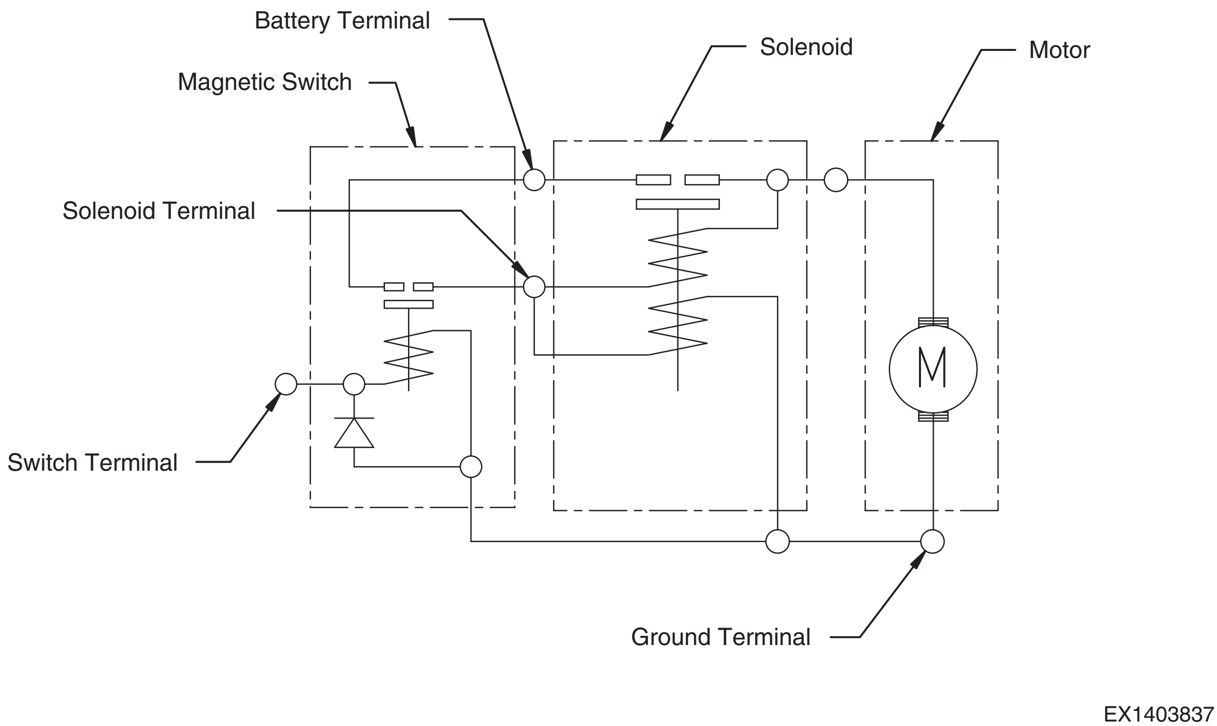


Figure 249

IMPORTANT

Before working on any electric system, make sure to disconnect the negative battery cable in advance. Connect the ground cable last after work to avoid a short circuit during work.

Exhaust Gas Reduction

General Description

Connector

1. Mark by connector part

Reference Number	Description
1	Wire Cover
2	Cable Tie
3	C/Tube
4	Tube (White)

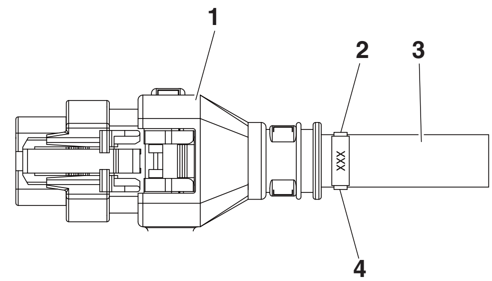


Figure 250 EX1403838

2. If the connector has no cover, wrap end of the connector with plastic tape.

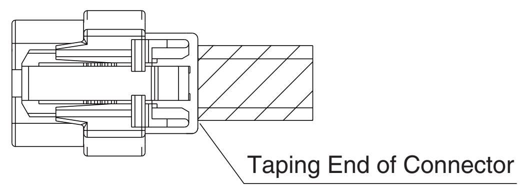
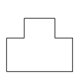
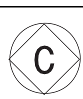


Figure 251 EX1403839

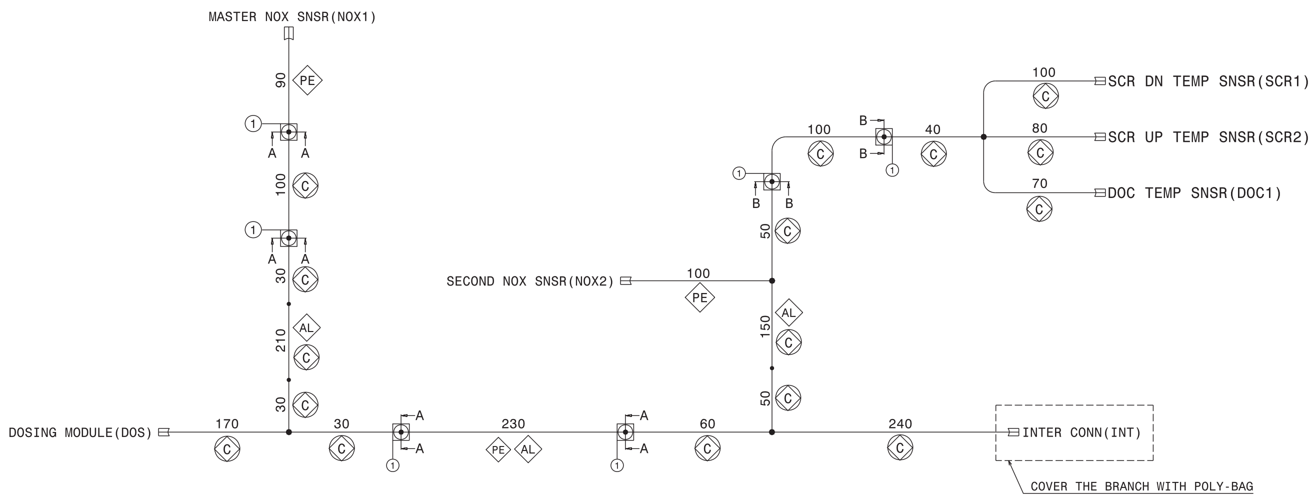
Tolerance for Allowable Wiring Distance

1. Between fixed points: +5 mm
2. Between fixed points before junction: +5 mm
3. Connector end or fixed point or junction of terminal type: +10 mm

NOTE: *End of injector junction: +5 mm*

	Symbol	Description
1		Apply Aluminum Tape
2		Apply Manifold
3		Apply Cross Taping
4		Apply Heat Resisting Transparent Tape (125 or Higher)
5		Apply Corrugate Tube

Circuit Diagram



EX1403845

Figure 252

Aftertreatment Connector

Wiring Label	Wiring Size	Circuit Name	From		To		Remark
			Name	No	Name	No	
1.23	1.50	Dosing Valve High Side	a	1	b	1	
1.96	1.50	Dosing Valve Low Side	a	2	b	2	
1.16	0.75	DOC Upstream (T4) Signal	c	1	b	3	
1.18	0.75	DOC Upstream (T4) Ground	c	2	b	4	
1.32	0.75	SCR Upstream Signal	d	1	b	5	
1.43	0.75	SCR Upstream Ground	d	2	b	6	
1.09	0.75	SCR Downstream Signal	e	1	b	7	
300	0.75	SCR Downstream Ground	e	2	1.43	S01	SPLICE_1.43
301	0.75	Master NOx Sensor Ubatt	f	1	b	8	
302	0.75	Master NOx Sensor GND	f	2	b	9	
303	0.75	Master NOx Sensor CAN Low	f	3	b	11	
304	0.75	Master NOx Sensor CAN High	f	4	b	10	
305	0.75	Secondary NOx Sensor Ubatt	g	1	301		SPLICE_301
306	0.75	Secondary NOx Sensor GND	g	2	302		SPLICE_302
307	0.75	Secondary NOx Sensor CAN Low	g	3	303		SPLICE_303
308	0.75	Secondary NOx Sensor CAN High	g	4	304		SPLICE_304
309	0.75	GND NOX PIN2 Common	g	5	305		SPLICE_305

a. Dosing Module (DOS)

b. Inter Connector (INT)

c. DOC Temperature Sensor (DOC1)

d. SCR Upstream Sensor (SCR2)

e. SCR downstream sensor (SCR2)

f. Master NOx Sensor (NOX1)

g. Secondary NOx Sensor (NOX2)

Switches and Sensors

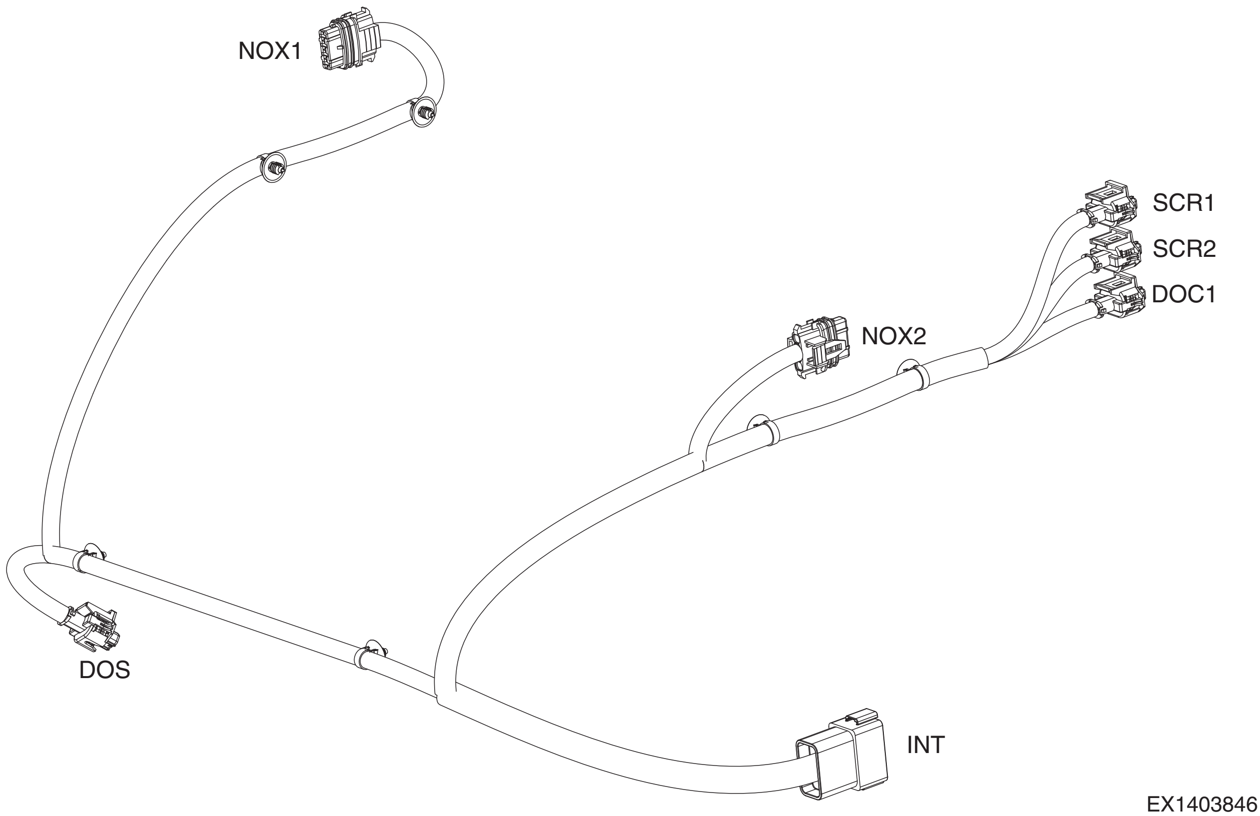


Figure 253

1. Dosing module (DOS)

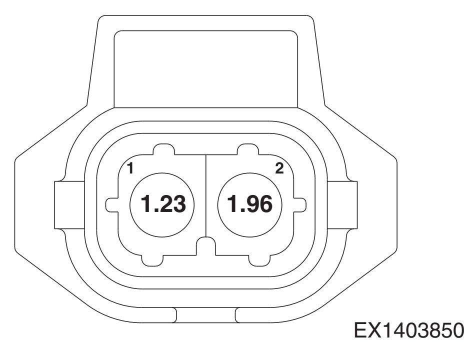


Figure 254

2. Master NOx sensor (NOx1)

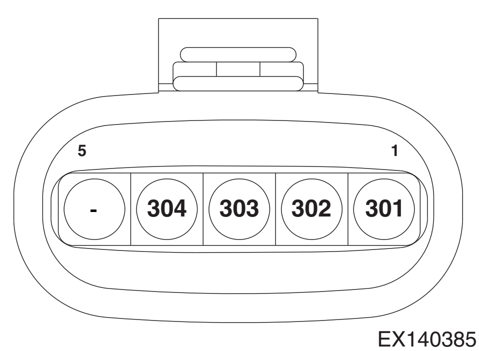


Figure 255

3. Secondary NOx sensor (NOx2)

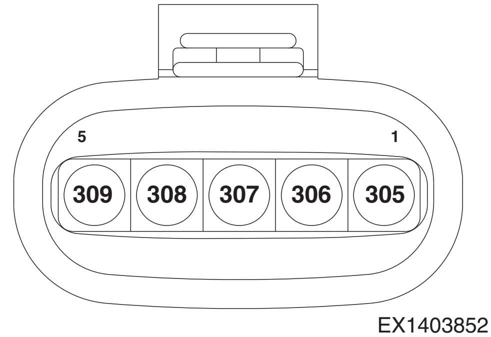


Figure 256

4. SCR downstream temperature sensor (SCR1)

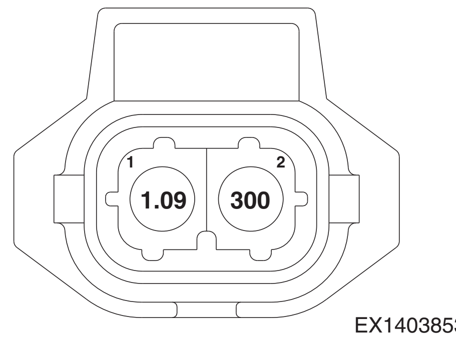


Figure 257

5. SCR upstream temperature sensor (SCR2)

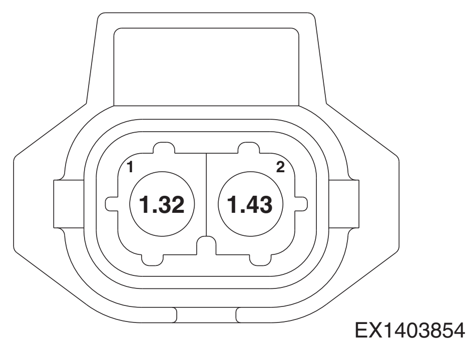


Figure 258

6. DOC temperature sensor (DOC1)

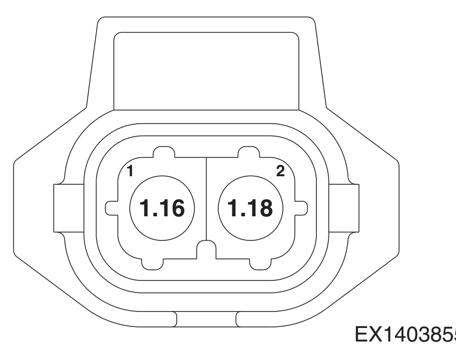
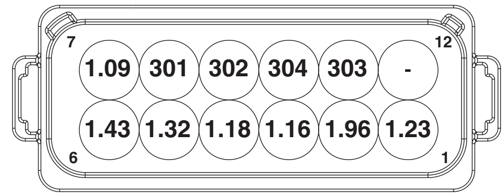


Figure 259

7. Inter connector (INT)



EX1403856

Figure 260

Circuit Diagram

General Description

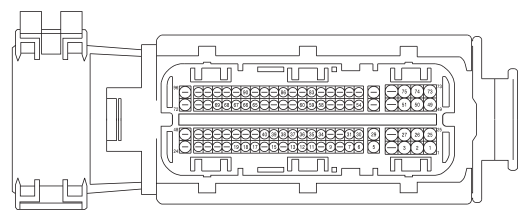
1. It is possible to identify the circuit number for the connector and engine wire harness information.

2. The wiring colors can be identified as follows:

Symbol	Color
B	Black
Brn	Brown
G	Green
Gra	Gray
L	Blue
O	Orange
P	Purple
RW	Red and White
W	White
Y	Yellow

3. The ECU pin No. means each pin number of an engine connector.

4. The sensor pin No. means each pin number of a sensor connector.



EX1403857

Figure 261

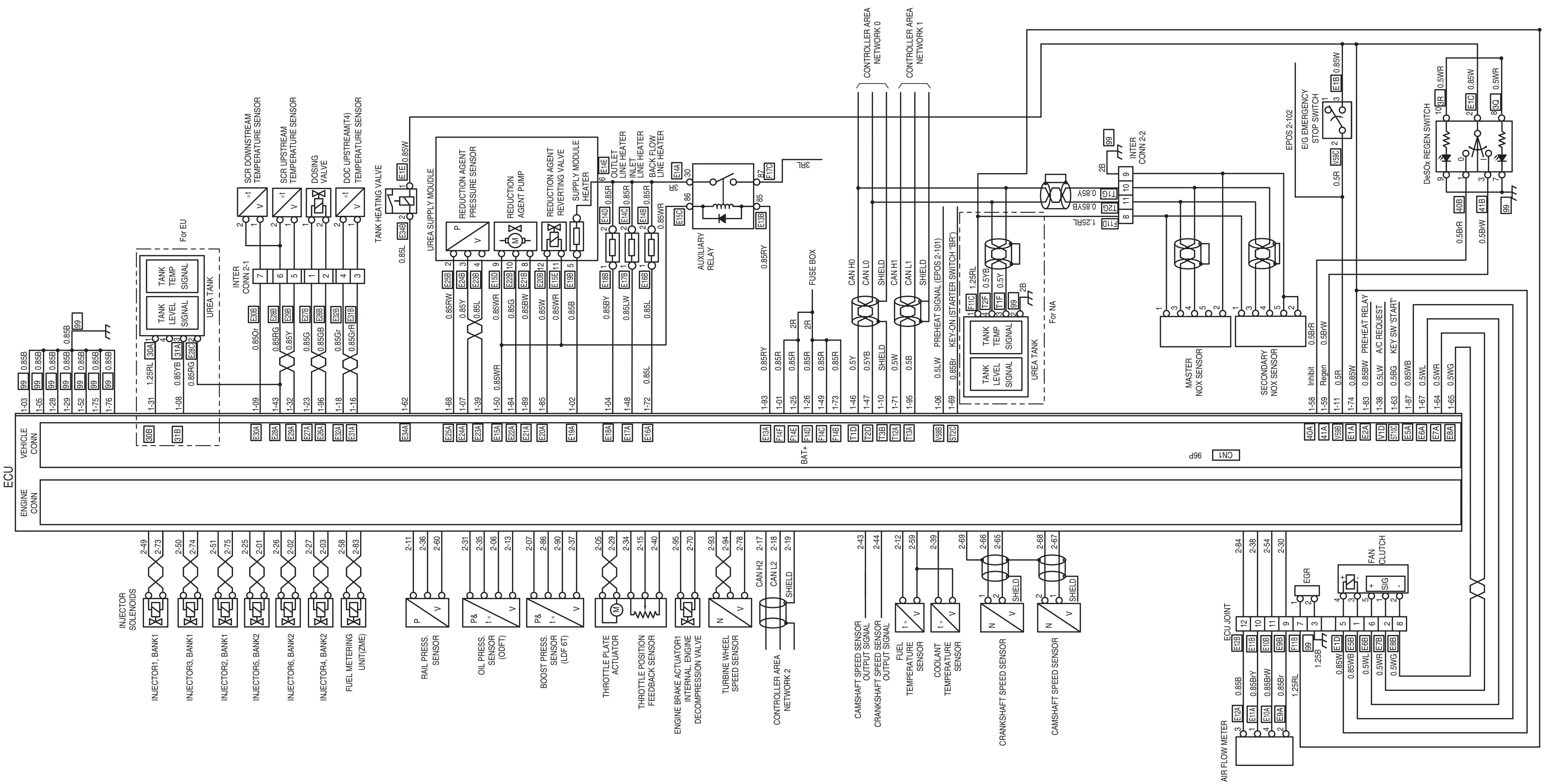
ECU (Engine Control Unit) Engine Connector

Wiring Label	Wiring Size	Wiring Color	Wiring Type	Circuit Name	ECU Pin No.	Sensor Pin No.	Remark
2.01	1.50	Y	a	Injector 1, Bank 2 Low	1	10	Twist Pair (2.01/2.25)
2.02	1.50	G	a	Injector 2, Bank 2 Low	2	12	Twist Pair (2.02/2.26)
2.03	1.50	L	a	Injector 3, Bank 2 Low	3	8	Twist Pair (2.03/2.27)
2.05	0.75	R	a	Throttle Plate Actuator POS	5	6	Twist Pair (2.05/2.29)
2.06	0.75	B	a	Oil Pressure/Temperature Sensor GND	6	1	
2.07	0.75	O	a	Boost Pressure/Temperature Sensor PWR	7	3	
2.09	0.75	R	a	HFM Sensor PWR	9	4	
2.11	0.75	O	a	Rail Pressure Sensor PWR	11	3	Shield 2.11/2.36
2.12	0.75	R	a	Fuel Temperature Sensor SIG	12	1	
2.13	0.75	Brn	a	Oil Temperature Sensor SIG	13	2	
2.15	0.75	B	a	Throttle Plate Position Sensor SIG	15	5	
2.17	0.75	O	b	CAN 2 High	17		Joint, Shield 2.17/2.18
2.18	0.75	W	b	CAN 2 Low	18		Joint, Shield 2.17/2.18
2.19	0.75	B	a	CAN 2 GND	19		Shield Drain (2.17/2.18)
2.25	1.50	W	a	Injector 1, Bank 2 High	25	9	Twist Pair (2.01/2.25)
2.26	1.50	W	a	Injector 2, Bank 2 High	26	11	Twist Pair (2.02/2.26)
2.27	1.50	W	a	Injector 3, Bank 2 High	27	7	Twist Pair (2.03/2.27)
2.29	0.75	Y	a	Throttle Plate Actuator NEG	29	2	Twist Pair (2.04/2.29)
2.30	0.75	Brn	a	HFM Sensor GND	30	1	
2.31	0.75	R	a	Oil Pressure/Temperature Sensor PWR	31	3	
2.34	0.75	W	a	Throttle Plate Position Sensor PWR	34	1	
2.35	0.75	Y	a	Oil Pressure Sensor SIG	35	4	
2.36	0.75	W	b	Rail Pressure Sensor SIG	36	2	Shield 2.11/2.36
2.37	0.75	Y	a	Boost Temperature Sensor PWR	37	2	
2.38	0.75	O	a	HFM Sensor SIG	38	2	
2.39	0.75	W	a	Coolant Temperature Sensor SIG	39	1	
2.40	0.75	Brn	a	Throttle Plate Position Sensor GND	40	3	
2.49	1.50	W	a	Injector 1, Bank 1 High	49	1	Twist Pair (2.49/2.73)
2.50	1.50	W	a	Injector 2, Bank 1 High	50	5	Twist Pair (2.50/2.74)
2.51	1.50	W	a	Injector 3, Bank 1 High	51	3	Twist Pair (2.51/2.75)
2.54	0.75	W	a	HFM Sensor Frequency Output	54	3	
2.58	0.75	R	a	Fuel Metering Unit	58	1	Twist Pair (2.58/2.83)

Wiring Label	Wiring Size	Wiring Color	Wiring Type	Circuit Name	ECU Pin No.	Sensor Pin No.	Remark
2.59	0.75	B	a	Fuel Temperature/Coolant Temperature Sensor GND	59		Joint
2.60	0.75	B	a	Rail Pressure Sensor GND	60	1	Shield Drain (2.11/2.36)
2.65	0.75	O	b	Crankshaft Speed Sensor NEG	65	2	Shield 2.65/2.66
2.66	0.75	W	b	Crankshaft Speed Sensor POS	66	1	Shield 2.65/2.66
2.67	0.75	Brn	b	Camshaft Speed Sensor NEG	67	2	Shield 2.67/2.68
2.68	0.75	Y	b	Camshaft Speed Sensor POS	68	1	Shield 2.67/2.68
2.69	0.75	B	a	Crankshaft/Camshaft Sensor Shield	69	3	Shield Drain (2.65/2.66, 2.67/2.68)
2.73	1.50	Gra	a	Injector 1, Bank 1 Low	73	2	Twist Pair (2.49/2.73)
2.74	1.50	O	a	Injector 2, bank 1 Low	74	6	Twist Pair (2.50/2.74)
2.75	1.50	Brn	a	Injector 3, Bank 1 Low	75	4	Twist Pair (2.51/2.75)
2.83	0.75	Brn	a	Fuel Metering Unit	83	2	Twist Pair (2.52/2.83)
2.86	0.75	W	a	Boost Pressure Sensor SIG	86	4	
2.90	0.75	B	a	Boost Pressure/Temperature Sensor GND	90	1	
Vbat	0.75	R	a	24 V (Vbat)			ICV PIN 6
GND	0.75	B	a	Ground			ICV PIN 10
1.64	0.75	O	a	Fan Speed Sensor Output (FSS Out)		1	ICV PIN 11
1.65	0.75	B	a	Fan Speed Sensor GND		2	ICV PIN 5
1.67	0.75	Y	a	Fan Speed Sensor Supply (U Sensor)		5	ICV PIN 7
1.74	0.75	W	a	Solenoid Coil High (Coil +)		4	ICV PIN 8
1.87	0.75	Brn	a	Solenoid Coil High (Coil -)		3	ICV PIN 12
13B	0.75	O	a	Start S			INT 1 PIN 5
145B	0.75	Brn	a	Preheat Relay C			INT 1 PIN 6
145F	0.75	R	a	Diode 5K			
146D	0.75	R	a	Preheat Relay D		-	INT 1 PIN 7
146C	0.75	B	a	Diode 5A			
99I	8.00	B	a	Alternator E			Engine Ground
4A	8.00	W	a	Alternator B			
4J	5.00	W	a	Alternator B			INT 3 PIN 1
4M	5.00	W	a	Alternator B			INT 3 PIN 2
14A	1.25	W	a	Alternator R			INT 1 PIN 1
9A	2.00	W	a	Alternator I			INT 1 PIN 2
29C	0.75	Y	a	Compressor +		+	Pin 1 Pin 3
99H	0.75	B	a	Compressor -		-	
99G	0.75	B	a	Diode 4A			INT 2 PIN 1

Wiring Label	Wiring Size	Wiring Color	Wiring Type	Circuit Name	ECU Pin No.	Sensor Pin No.	Remark
29B	0.75	W	a	Diode 4K			INT 2 PIN 2
1.23	1.50	L	a	Dosing Valve High Side		1	INT 2 PIN 3
1.96	1.50	B	a	Dosing Valve Low Side		2	INT 2 PIN 4
1.16	0.75	Y	a	DOC Upstream (T4) Signal		1	INT 2 PIN 5
1.18	0.75	Brn	a	DOC Upstream (T4) Ground		2	INT 2 PIN 6
1.32	0.75	W	a	SCR Upstream Signal		1	INT 2 PIN 7
1.43	0.75	B	a	SCR Upstream Ground		2	INT 2 PIN 8
1.09	0.75	R	a	SCR Downstream Signal		1	INT 2 PIN 9
301	1.50	O	a	Master NOx Sensor Ubatt		1	INT 2 PIN 10
302	1.50	Gra	a	Master NOx Sensor GND		2	INT 2 PIN 11
303	0.75	O	b	Master NOx Sensor CAN Low		3	INT 2 PIN 12
304	0.75	W	b	Master NOx Sensor CAN High		4	INT 2 PIN 13

ECU CIRCUIT



EX1403941

Engine Coolant Heater (Option)

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Engine Coolant Heater (Option)

DISASSEMBLY AND ASSEMBLY

Changing the Circulating Pump

Removal

1. Remove heater.
2. Disconnect the electrical connections.
3. Remove screws (4, Figure 1).
4. Remove clip (3, Figure 1) and circulating pump (2, Figure 1).
5. Complete the work on stripped-down components.

Installation

1. Apply acid-free grease to the sealing ring (1, Figure 1).
2. Place the circulating pump (2, Figure 1) in the assembly position and attach with the clip (3, Figure 1) and screws (4, Figure 1).
3. Tighten the screws (4, Figure 1) to 3 N.m ±10%.
4. Connect the electrical connections.
5. Install the heater.

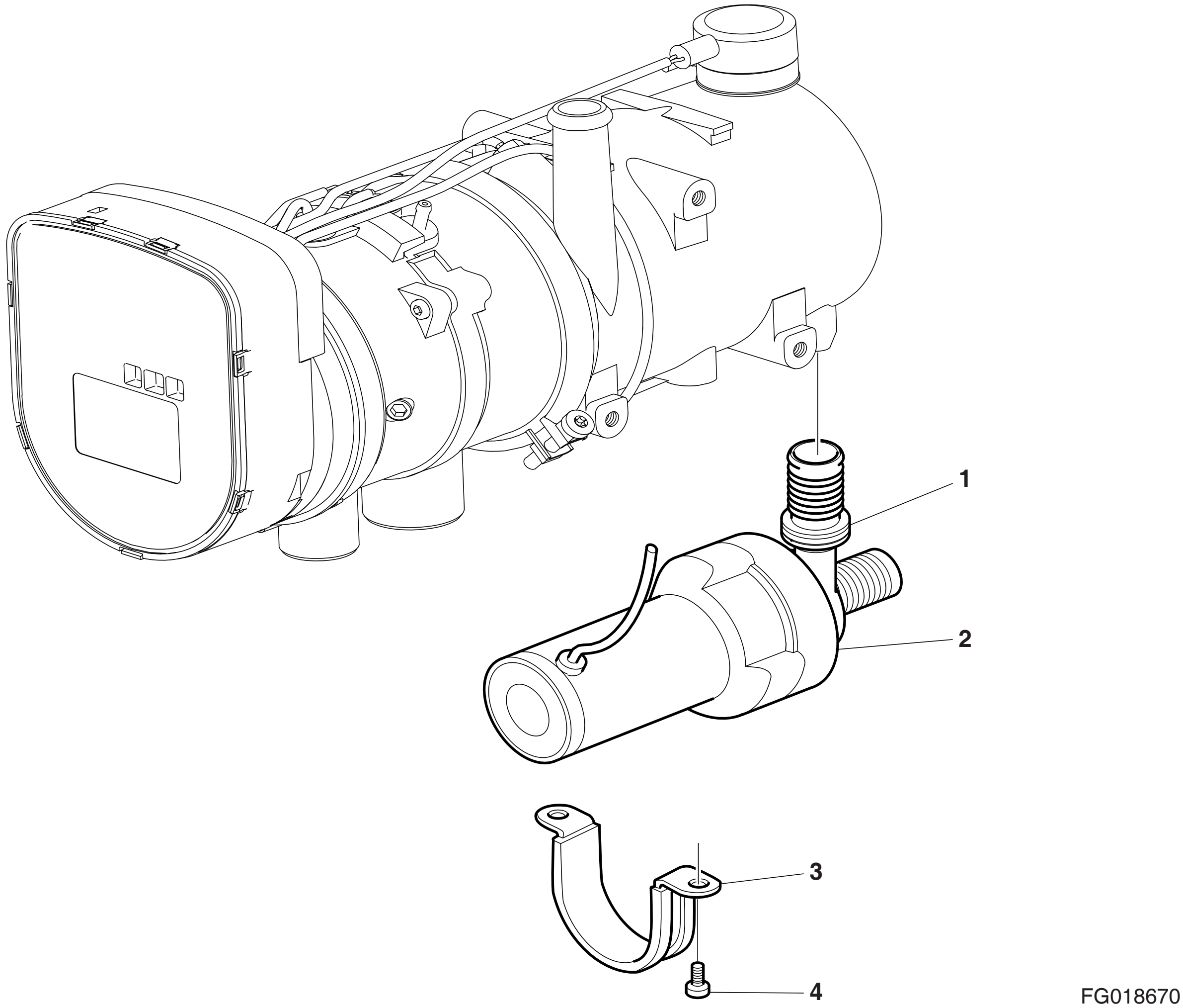


Figure 1 Changing the Circulating Pump

Reference Number	Description
1	Sealing Ring
2	Circulating Pump

Reference Number	Description
3	Clip
4	Screw (2)

NOTE: *A Thermo 90 ST heater is shown. In the Thermo 90 S heater, the control unit can also be arranged on the combustion air fan without having any effect on changing the circulating pump.*

Changing the Temperature Limiter

Removal

NOTE: *The temperature limiter only has to be removed if it is being replaced with a new one.*
The function must be checked in the installed condition.

1. Remove heater.
2. Disconnect the electrical connections.
3. Remove clip (2, Figure 2) and pull off the protective cap (1, Figure 2).
4. Use a screwdriver to lever off the retaining spring and remove temperature limiter (3, Figure 2).
5. Complete the work on stripped-down components.

   NOTE: *It is essential to install a new temperature limiter to replace a removed one!*

Installation

IMPORTANT

Incorrect installation will cause the heat exchanger to melt.

1. Insert the new temperature limiter (3, Figure 2) into the heat exchanger (4, Figure 2) and press in the retaining spring.

   NOTE: *You must be able to hear and feel the spring clip into the groove. Only then is the temperature limiter in the correct installation position.*

   If you do not hear and feel the spring clip in:

   - Clean the contact surface of the temperature limiter on the heat exchanger
   - Clean the groove in the heat exchanger
   - Ensure that detent lugs are present on both sides of the spring. Install a new temperature limiter if necessary.
2. Put on the protective cap (1, Figure 2) and secure it with the clip (2, Figure 2).
3. Tighten the clip to 1 N.m ± 10%.
4. Connect the electrical connections.
5. Install the heater.

Changing the Temperature Sensor

Removal

1. Remove heater.
2. Disconnect the electrical connections.

WARNING

AVOID DEATH OR SERIOUS INJURY

Leaking hot coolant can cause burns.

3. Unscrew and remove temperature sensor (6, Figure 2) and remove it with the round sealing ring (5, Figure 2).
4. Complete the work on stripped-down components.

Installation

1. Apply acid-free grease (Vaseline) to the round sealing ring (5, Figure 2).
2. Install the temperature sensor (6, Figure 2) with the round sealing ring (5, Figure 2) and screw it into the heat exchanger (4, Figure 2).

   Tighten to 1.5 N.m ±10%.
3. Connect the electrical connections.
4. Install the heater.

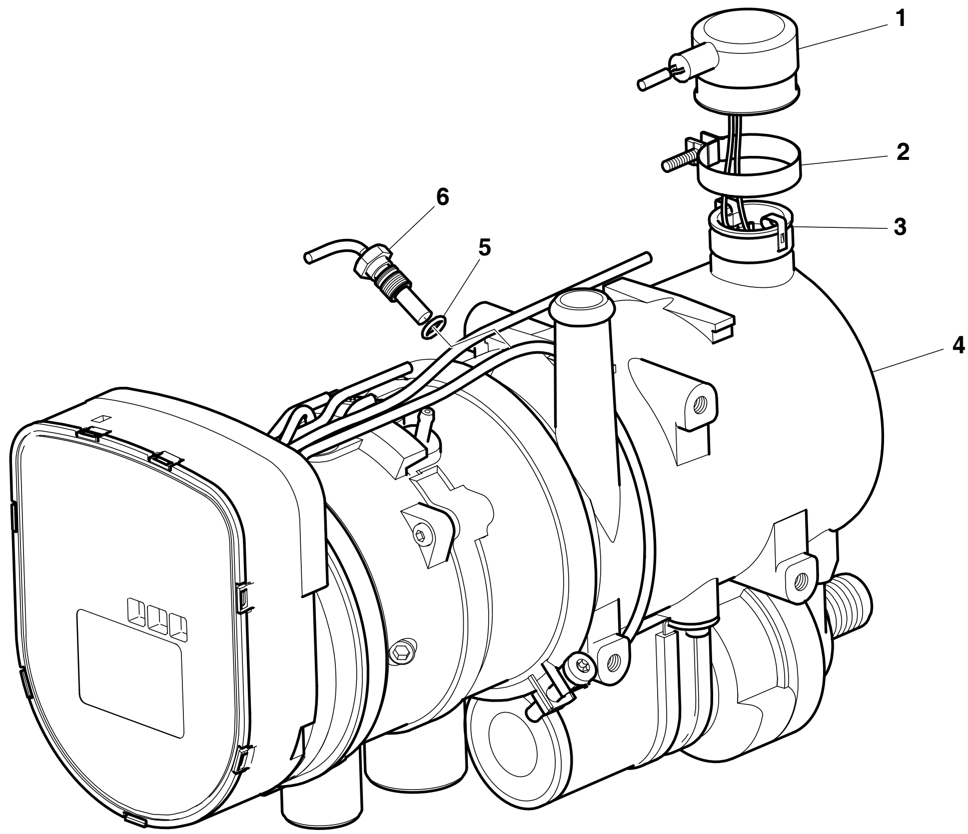


Figure 2 Changing the Temperature Limiter and Temperature Sensor

Reference Number	Description
1	Protective Cap
2	Clip
3	Temperature Limiter

Reference Number	Description
4	Heat Exchanger
5	Round Sealing Ring
6	Temperature Sensor

NOTE: *A Thermo 90 ST heater is shown. In the Thermo 90 S heater, the control unit can also be arranged on the combustion air fan without having any effect on changing the temperature sensor.*

Changing the Combustion Air Fan

Removal

1. Remove heater.
2. Disconnect the electrical connections.
3. Remove screws (2, Figure 3).
4. Pull the combustion air fan (1, Figure 3) off the burner head (4, Figure 3) and remove with the shaped sealing ring (3, Figure 3).

   NOTE: *Remove control unit if necessary from the Thermo 90 S/Thermo 90 ST heater with flange mounted control unit.*

5. Complete the work on stripped-down components.

Installation

NOTE: *Insert the shaped seal (3, Figure 3) correctly and grease it (e.g. with Vaseline). Take care not to squash it.*

1. Install the new shaped sealing ring (3, Figure 3) onto the combustion air fan (1, Figure 3). Bring the fan into the assembly position and secure it with screws (2, Figure 3).
2. Tighten the screws (2, Figure 3) to 3 N.m ±10%.

   NOTE: *Install the control unit if necessary on the Thermo 90 S/Thermo 90 ST heater with flange mounted control unit.*

3. Connect the electrical connections.
4. Install the heater.

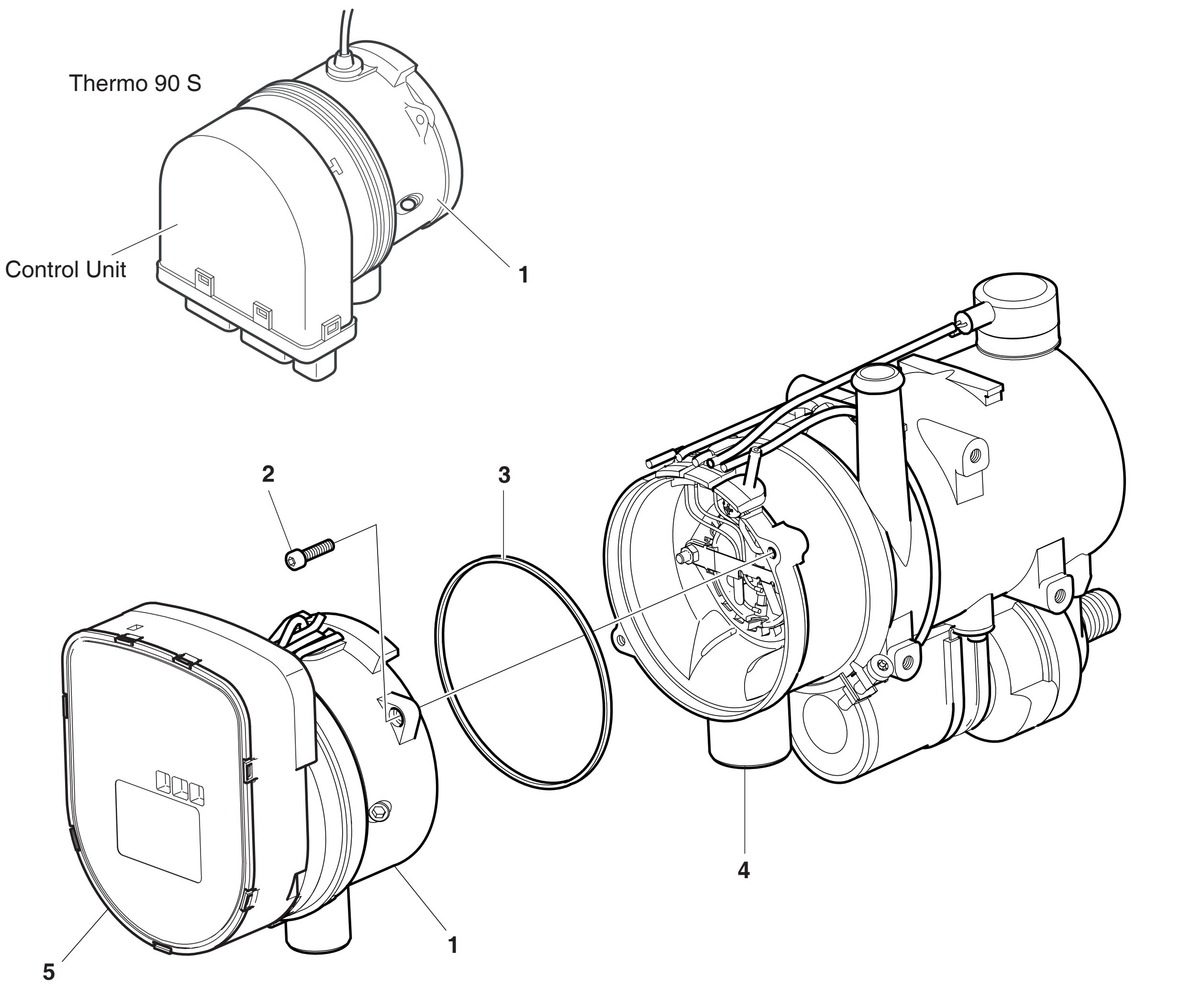


Figure 3 Changing the Combustion Air Fan

Reference Number	Description
1	Combustion Air Fan
2	Screw (2)
3	Shaped Sealing Ring

Reference Number	Description
4	Burner Head
5	Control Unit

NOTE: *A Thermo 90 ST heater is shown.*

Changing the Burner, Flame Monitor and Glow Plug

Removal

1. Remove heater.
2. Remove combustion air fan.
3. Remove screw (5, Figure 5) and washer (4, Figure 5).
4. Remove nuts (10, Figure 5) and pull off the bar (8, Figure 5).
5. Pull the grommets (11 and 12, Figure 5) out of the slots in the housing of the combustion pipe (3, Figure 5).
6. Pull the grommet (13, Figure 5) and burner (1, Figure 5) out of the burner head and remove with the swirl orifice (2, Figure 5).
7. Pull the flame monitor (7, Figure 5) and glow plug (6, Figure 5) from the burner (1, Figure 5) and remove.
8. Perform a visual check for assessing the burner.
9. Complete the work on stripped-down components.

Installation

1. Place the swirl orifice (2, Figure 5) onto the burner (1, Figure 5).
2. Carefully insert the flame monitor (7, Figure 5) and glow plug (6, Figure 5) into the burner up to the stop and push the grommets (11 and 12, Figure 5) into the slots in the housing of the burner pipe (3, Figure 5).
3. Insert the burner (1, Figure 5) and grommet (13, Figure 5) into the burner head (3, Figure 5).

IMPORTANT

During the following procedure, make sure that cables of the flame monitor (7, Figure 5) and the glow plug (6, Figure 5) are routed as shown in the figure.

4. Push the insulation (9, Figure 5) onto the bar (8, Figure 5) and bring the bar into the assembly position.

   NOTE: *Route the cable of the flame monitor and the glow plug as shown in the figure!*

5. Secure the bar (8, Figure 5) using the nuts (10, Figure 5). Tighten the nuts to 3 N.m ±10%.
6. Secure the fuel line using the screw (5, Figure 5) and washer (4, Figure 5). Tighten the screw to 3 N.m ±10%.
7. Install the combustion air fan.
8. Connect the electrical connections.
9. Install the heater.

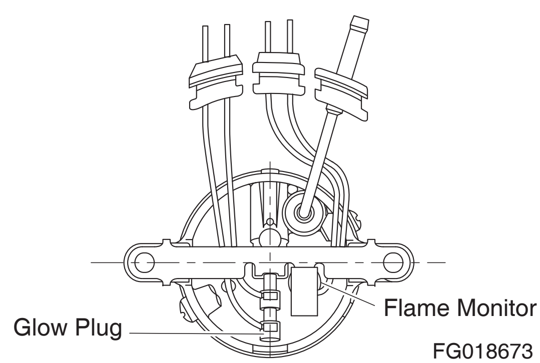


Figure 4

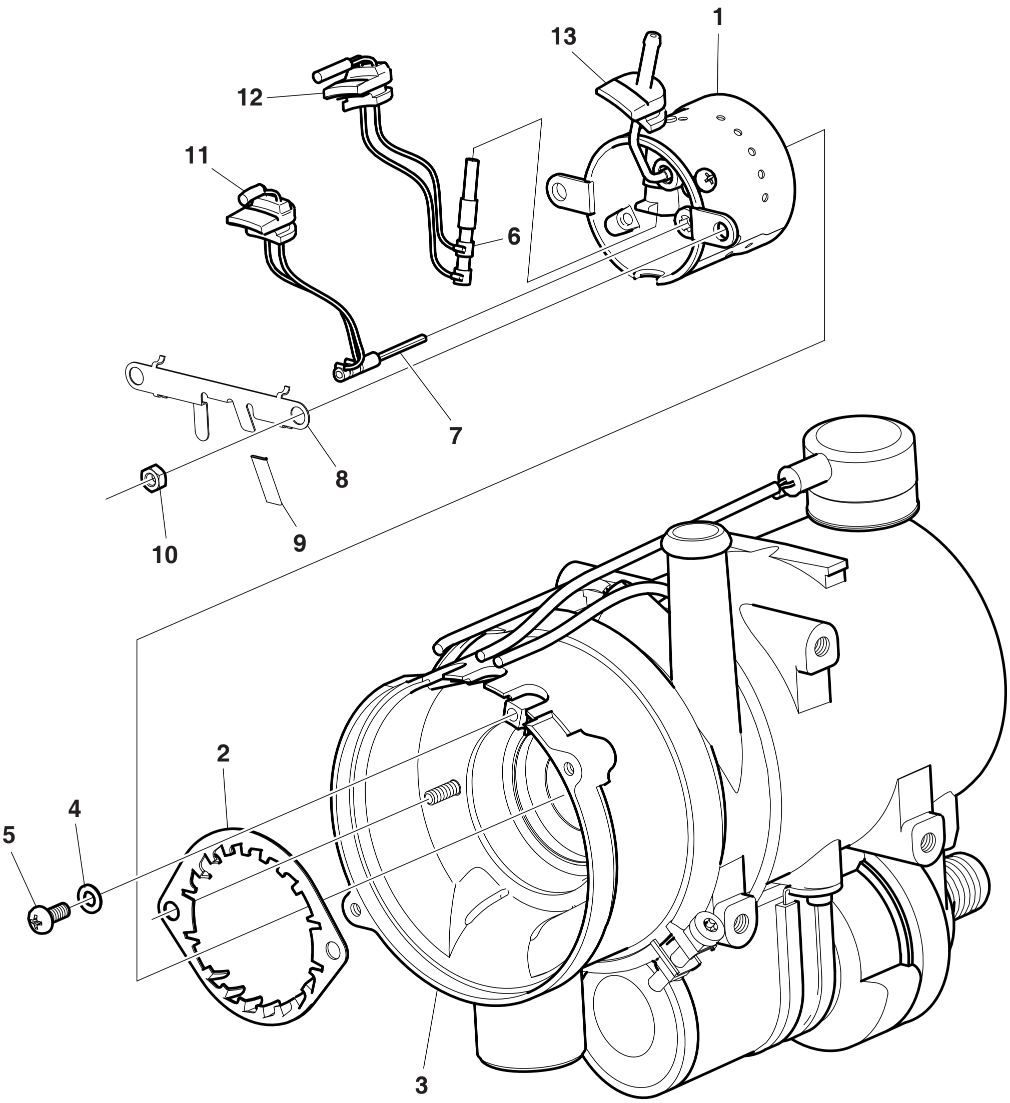


Figure 5 Changing the Burner, Flame Monitor and Glow Plug

Reference Number	Description
1	Burner
2	Swirl Orifice
3	Burner Head
4	Washer
5	Screw
6	Glow Plug
7	Flame Monitor

Reference Number	Description
8	Bar
9	Insulation
10	Nut (2)
11	Grommet
12	Grommet
13	Grommet

NOTE: *A Thermo 90 ST heater is shown. The figure can also be used for the Thermo 90 S heater.*

Changing the Burner Head

Removal

1. Remove heater.
2. Remove combustion air fan.
3. Remove burner, flame monitor and glow plug.
4. Remove mounting screw of the V-clamping collar (2, Figure 6) and pull off the clamping collar.
5. Pull out and remove burner head (1, Figure 6) from the heat exchanger (3, Figure 6).
6. Complete the work on stripped-down components.

Installation

NOTE: *The burner head and exhaust outlet port can also be aligned during installation in the machine.*

1. Guide the burner head (1, Figure 6) into the heat exchanger (3, Figure 6), align it if necessary and secure with the V-clamping collar (2, Figure 6).
2. If necessary, tighten the mounting screw of the V-clamping collar to 3 N.m ±10%.
3. Install the burner, flame monitor and glow plug.
4. Attach the combustion air fan.
5. Install the heater.

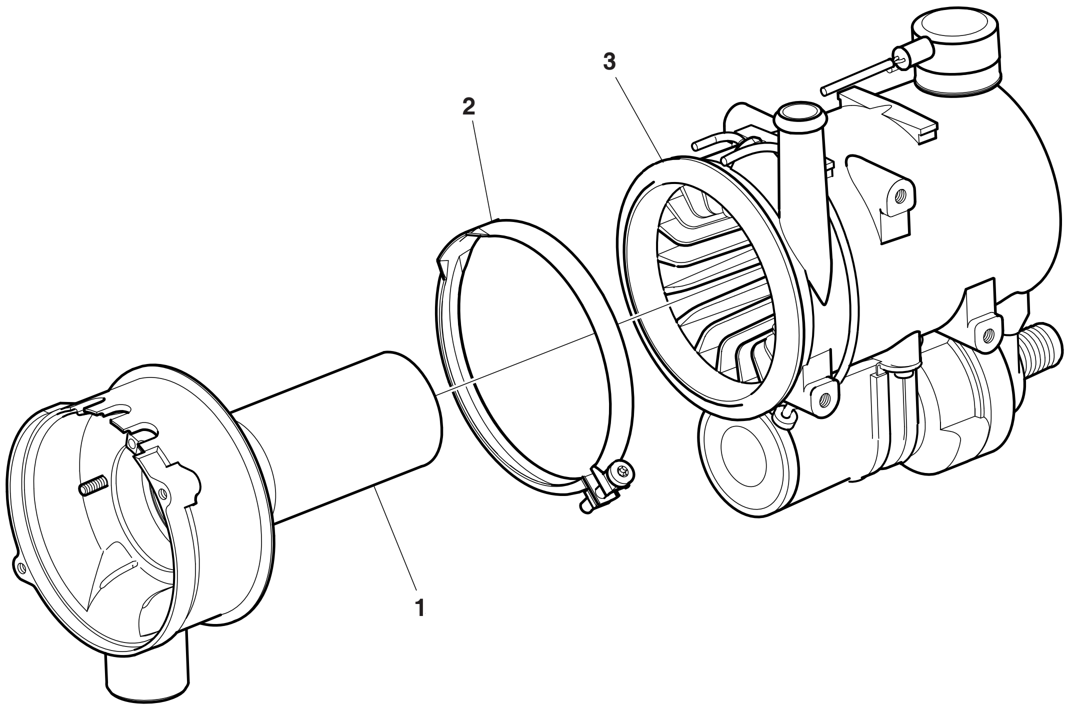


Figure 6 Changing the Burner Head

Reference Number	Description
1	Burner Head
2	V-clamping Collar

Reference Number	Description
3	Heat Exchanger

NOTE: *A Thermo 90 ST heater is shown. The figure can also be used for the Thermo 90 S heater.*

Changing the Heat Exchanger

Removal

1. Remove heater.
2. Remove circulating pump.
3. Remove temperature limiter.
4. Remove temperature sensor.
5. Remove combustion air fan.
6. Remove burner, flame monitor and glow plug.
7. Remove burner head.
8. Remove plug and connector housing.
9. Complete the work on stripped-down components.

Installation

1. Clip the connector housing onto the heat exchanger and insert the plug into the connector housing.
2. Install the burner head.
3. Install the burner, flame monitor and glow plug.
4. Attach the combustion air fan.
5. Install the temperature sensor.
6. Install the temperature limiter.
7. Attach the circulating pump.
8. Install the heater.

Upper Structure

Cabin

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Cabin

CABIN IDENTIFICATION

Falling Object Guards and Structures

The machine may have different types of guards for operator protection. the type of guards might be vary on the applications and work demands.

Inspect and check the guards daily to ensure no cracks, bent or loose. DO NOT modify the protective structure, guards by welding, grinding, drilling holes or adding attachments. Changes to the cabin can cause loss of operator protection from roll-over and falling objects, and result in death or serious injury.

Always wear your seat belt when operating machine.

Logging operation required the protection from flying debris and/or objects. When use a work tool create flying debris, install a front guard. Close the window and wear safety glasses.

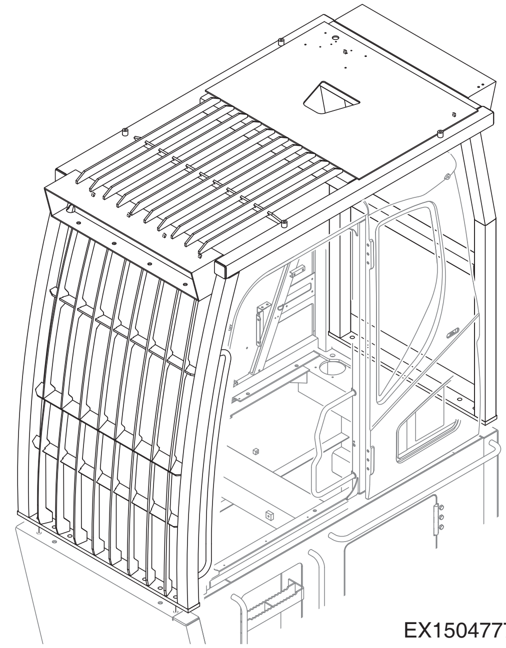


Figure 1

REMOVAL

1. Make the machine swing about 30° rightward on the flat ground as shown in (Figure 2) before lowering all the attachments on the ground and then stop engine.

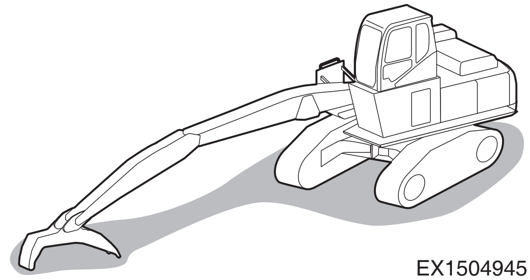


Figure 2

2. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 3)
3. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

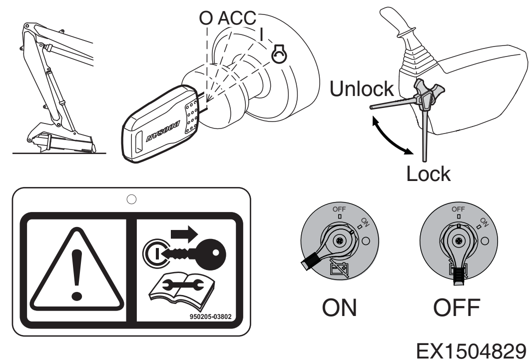


Figure 3

4. To relieve pressure from accumulators, fully stroke work levers in all directions. Movement can occur.
5. Move safety lever to "LOCK" position. (Figure 3)
6. Turn key to "O" (OFF) position and remove from starter switch.
7. Attach maintenance warning tag on controls.
8. Turn battery disconnect switch to "OFF" position. (Figure 4)

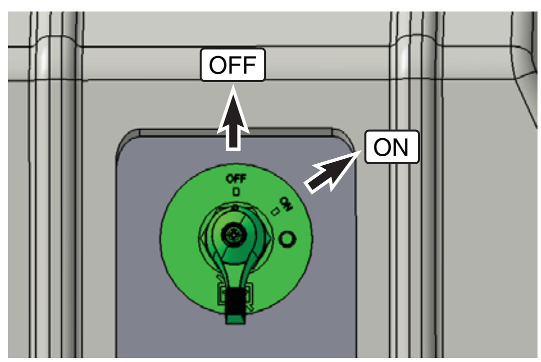


Figure 4 WE1500101

9. Open the cabin riser cover.
Disconnect washer hose.

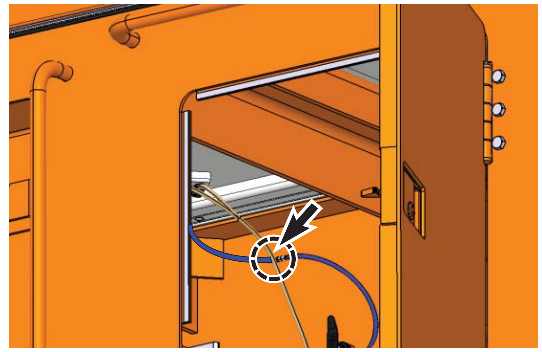


Figure 5 Bottom of Cabin EX1504926

10. Remove floor mat from the cabin.

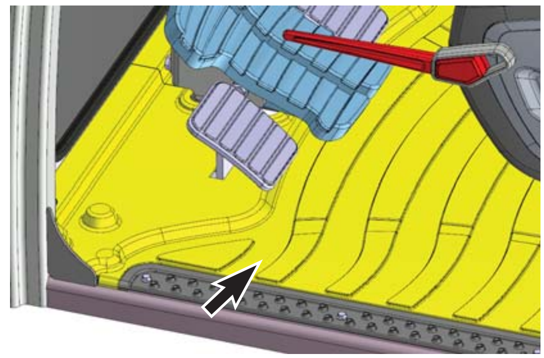


Figure 6 DS1602753

11. Remove cover (1, Figure 7), bolt and washer (2) with safety lever assembly (3) from control stand.

- Tool: 4 mm ( )

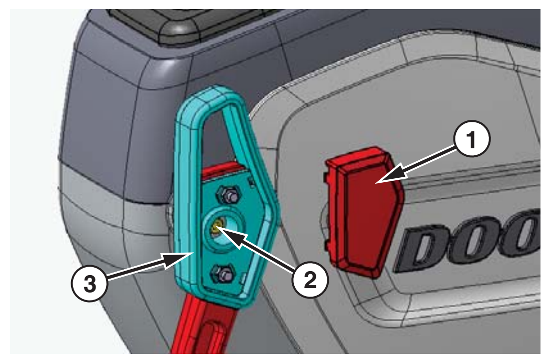
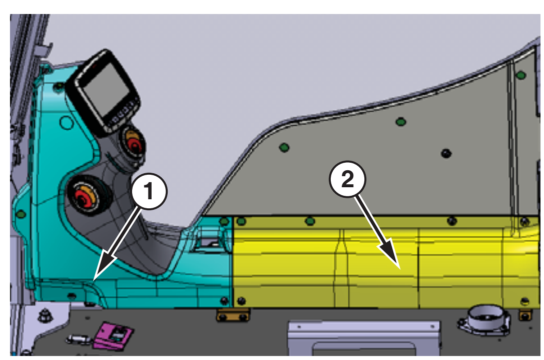


Figure 7 EX1403564

12. Remove duct covers (1 and 2, Figure 8).



WE1400435
Figure 8

13. Disconnect wiper, monitor, sun sensor and hour meter connectors.

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

    NOTE: *If cabin is equipped with additional protective guards over cabin openings, they must be removed.*

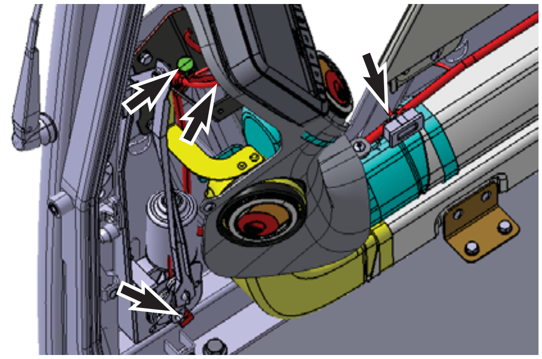


Figure 9

14. Remove air ducts (1 thru 6, Figure 10) on right-hand side of operator's cabin.

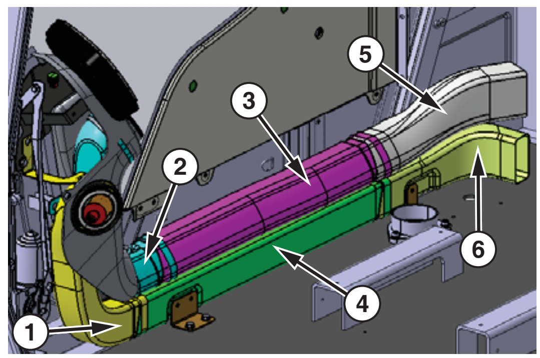


Figure 10

15. Remove glove box pad (1, Figure 11), and two bolts under pad.

    Remove caps and bolts (2, Figure 11) (3 ea) from top of rear cover.

    Remove bolts (3, Figure 11) (2 ea) from bottom of rubber mounts in rear cover.

    Remove rear cover (4, Figure 11).

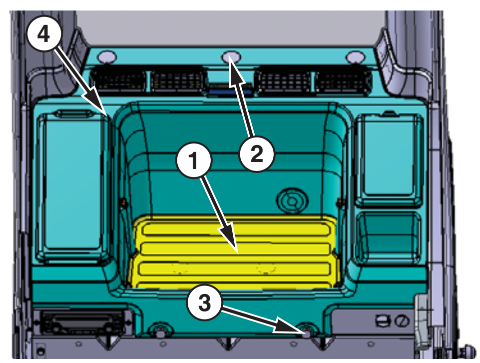


Figure 11

16. Remove air ducts (1 thru 3, Figure 12) and atmospheric air duct (4).

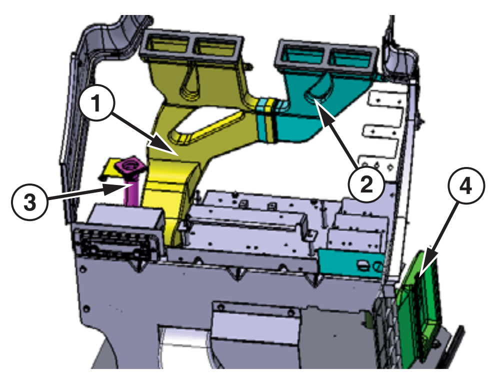


Figure 12

17. Remove all bolts (1, Figure 13) (17 ea) with brackets (2 thru 4) from body of operator cabin.

- Tool: 13 mm ( )
- Torque: 19.6 N.m (2 kg.m, 14.5 ft lb)

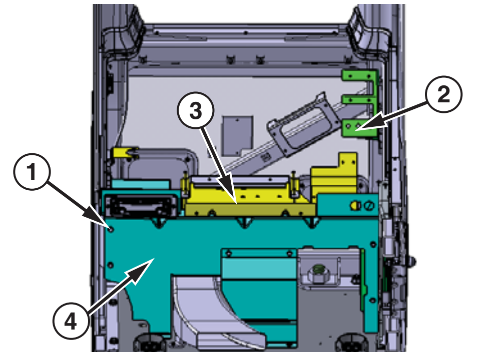


Figure 13

18. Disconnect connectors of interior lights, speakers and antenna.

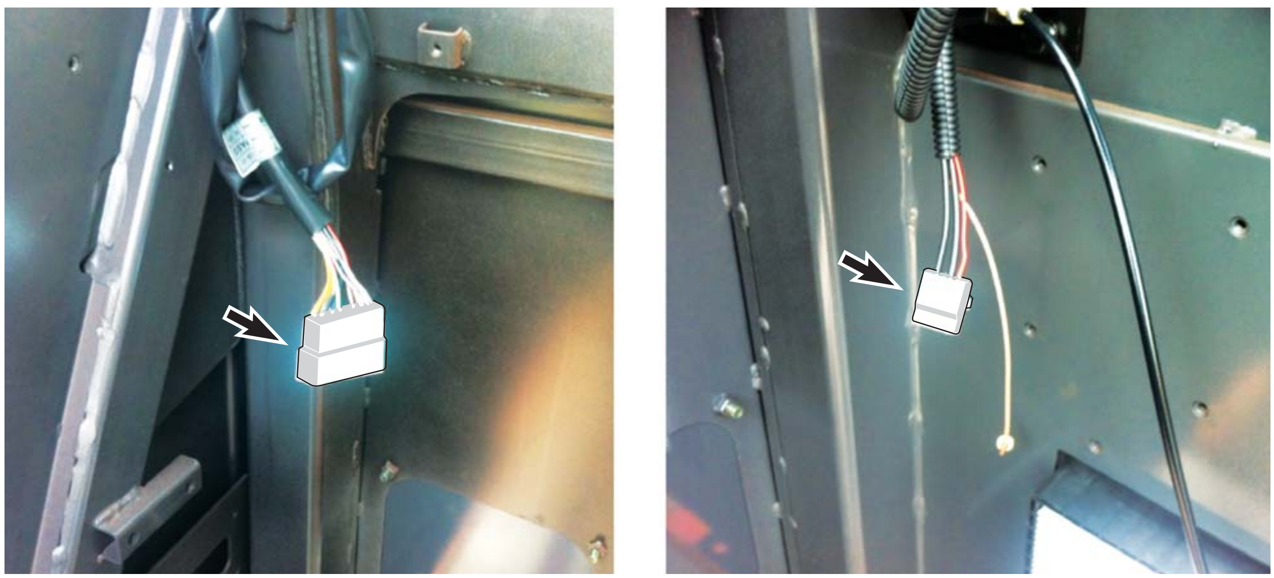


Figure 14

19. Using a suitable lifting device, attach slings to four lift points on top of cabin (Figure 15)

- Lifting hole size: M12 x 1.75, depth: 15 mm
- Cabin weight: about 400 kg (882 lb)

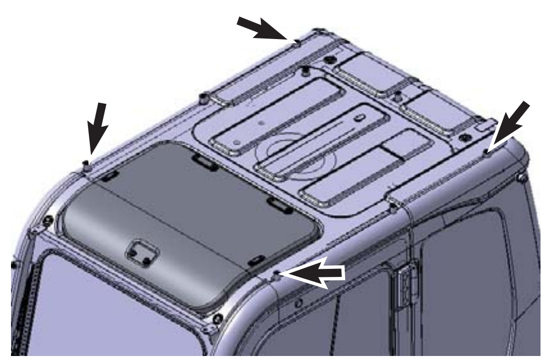


Figure 15

20. Remove bolts and washers (1, Figure 16) (11 ea).

- Tool: 19 mm ( )
- Torque: 88.3 N.m (9 kg.m, 65.1 ft lb)

21. Remove nuts and washers (2) (4 ea) from cabin floor.

- Tool: 24 mm ( )
- Torque: 205.9 N.m (21 kg.m, 151.9 ft lb)

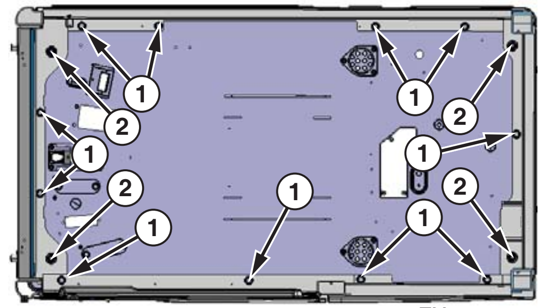


Figure 16

IMPORTANT

Continue lifting with assist crane to remove cabin shell. Lower shell to a prepared safe blocking support.

- **Support size: about 2,000 x 2,800 mm**

Check that all electrical connections have been disconnected and all other items unbolted.

Do not rapidly lift operator's cabin: The bottom of operator's cabin may come into contact with, and scratch, control stand cover.

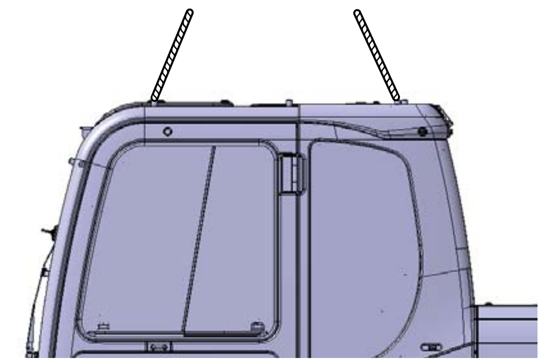


Figure 17

INSTALLATION

1. Using a suitable lifting device, attach slings to four (4) lift points on top of cabin (Figure 18).
   - Cabin weight: 400 kg (882 lb)
2. Lower cabin into position on cabin floor.

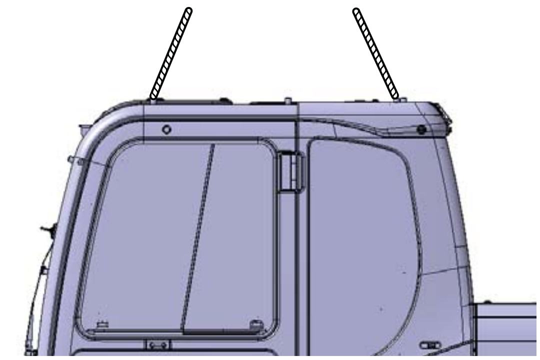


Figure 18

3. Install mounting nuts (Figure 19) (4 ea) and washers in four corners of cabin floor.

   When install the nut, apply Loctite (#262) to nut.
   - Tool: 24 mm ( )
   - Torque: 205.9 N.m (21 kg.m, 151.9 ft lb)

   Perform installation in the reverse order to removal.

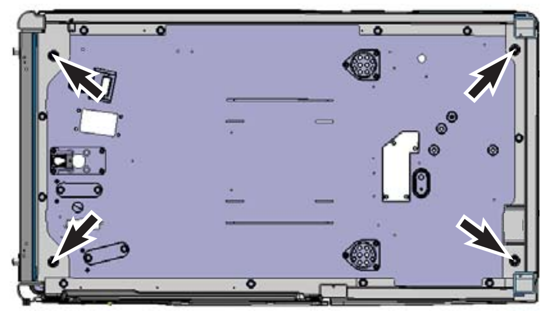


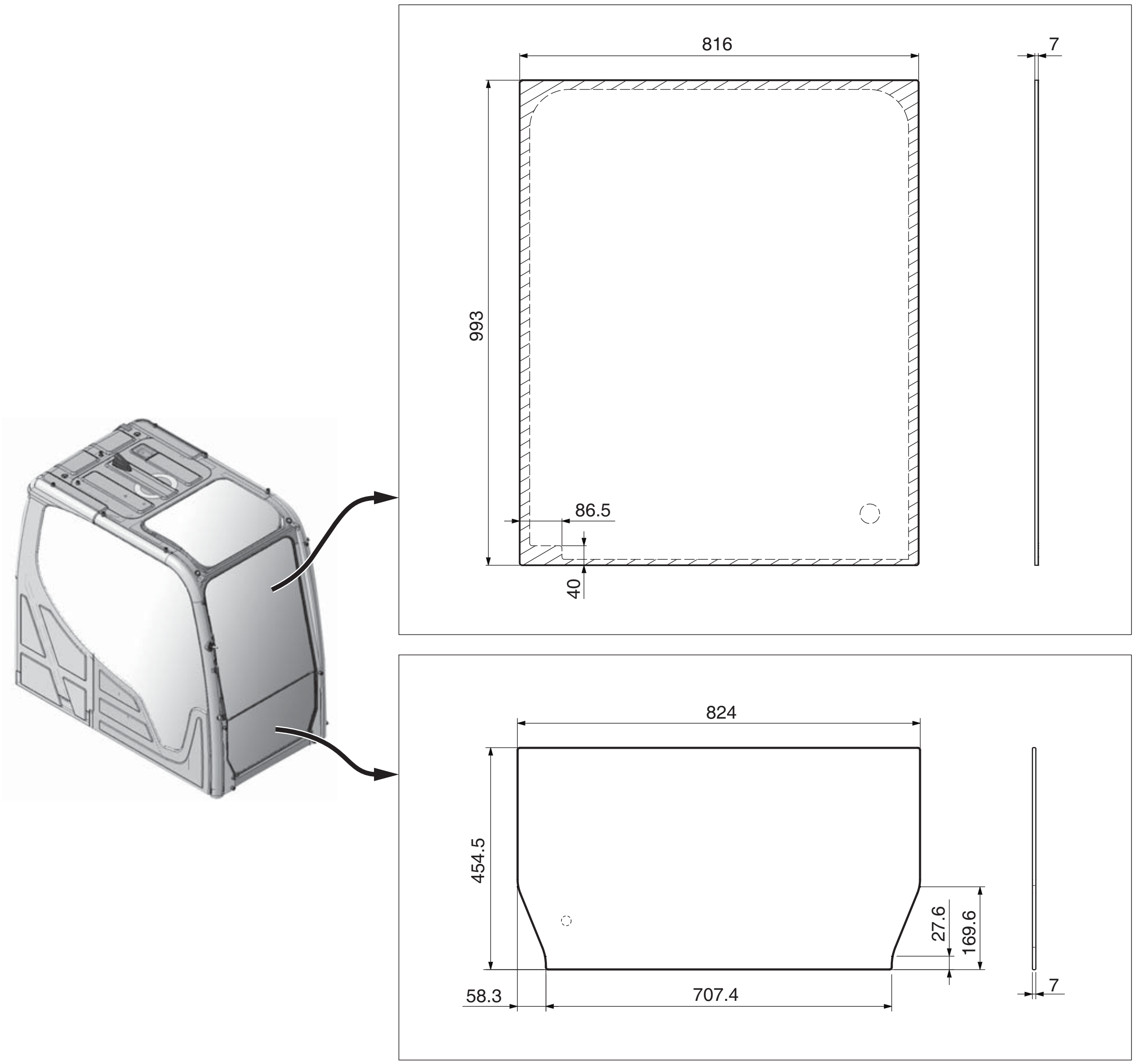
Figure 19

COMPLETING WORK

1. Start the engine and run at low idle for about 5 minutes.
2. Perform the machine performance test.

DIMENSIONS OF CABIN GLASS

Front Glass



EX1301291

Figure 20

NOTE: *Unit: mm (1 mm = 0.039 in)*

Left Glass

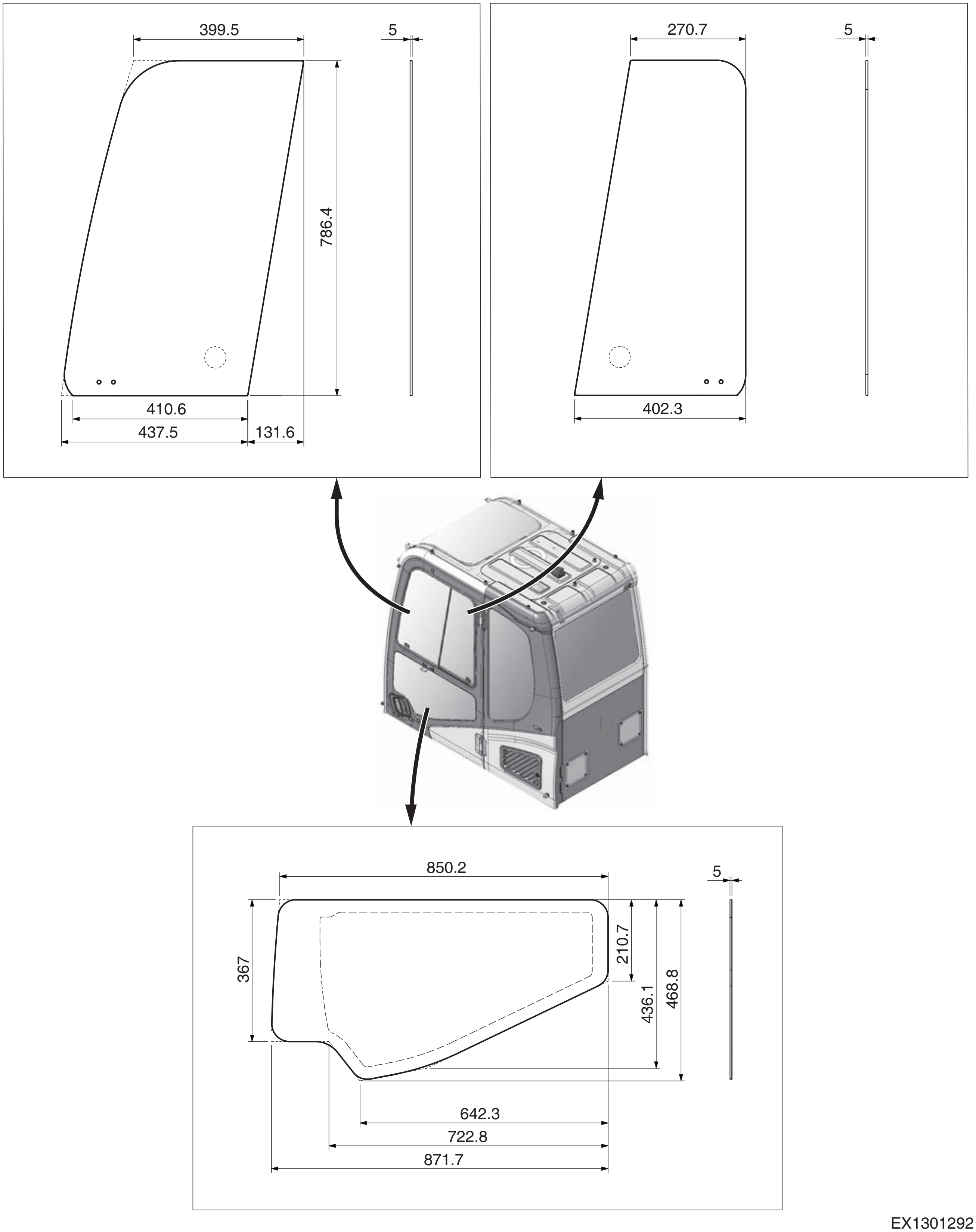


Figure 21

NOTE: *Unit: mm (1 mm = 0.039 in)*

Rear Side Glass

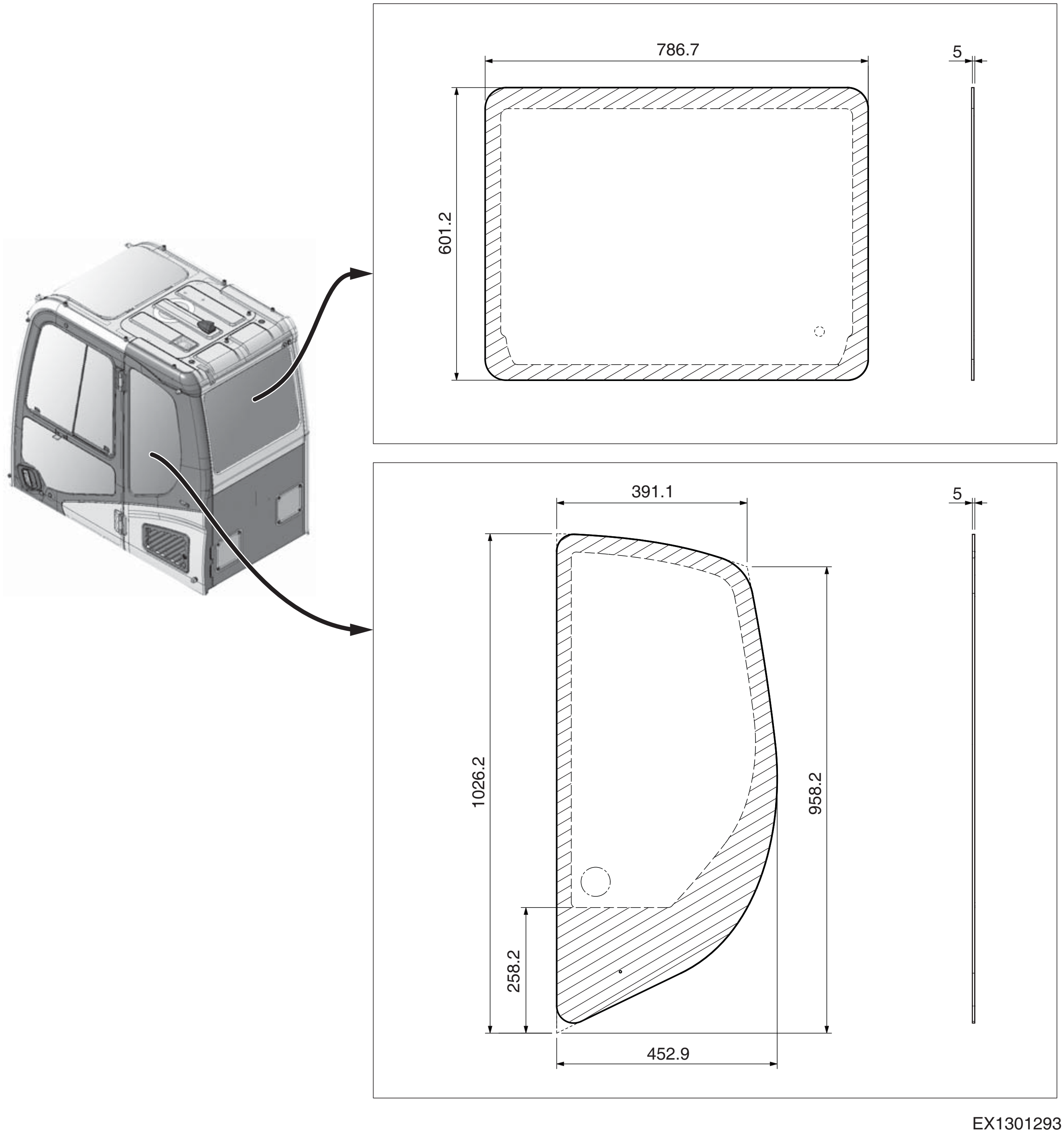


Figure 22

NOTE: *Unit: mm (1 mm = 0.039 in)*

Right Glass

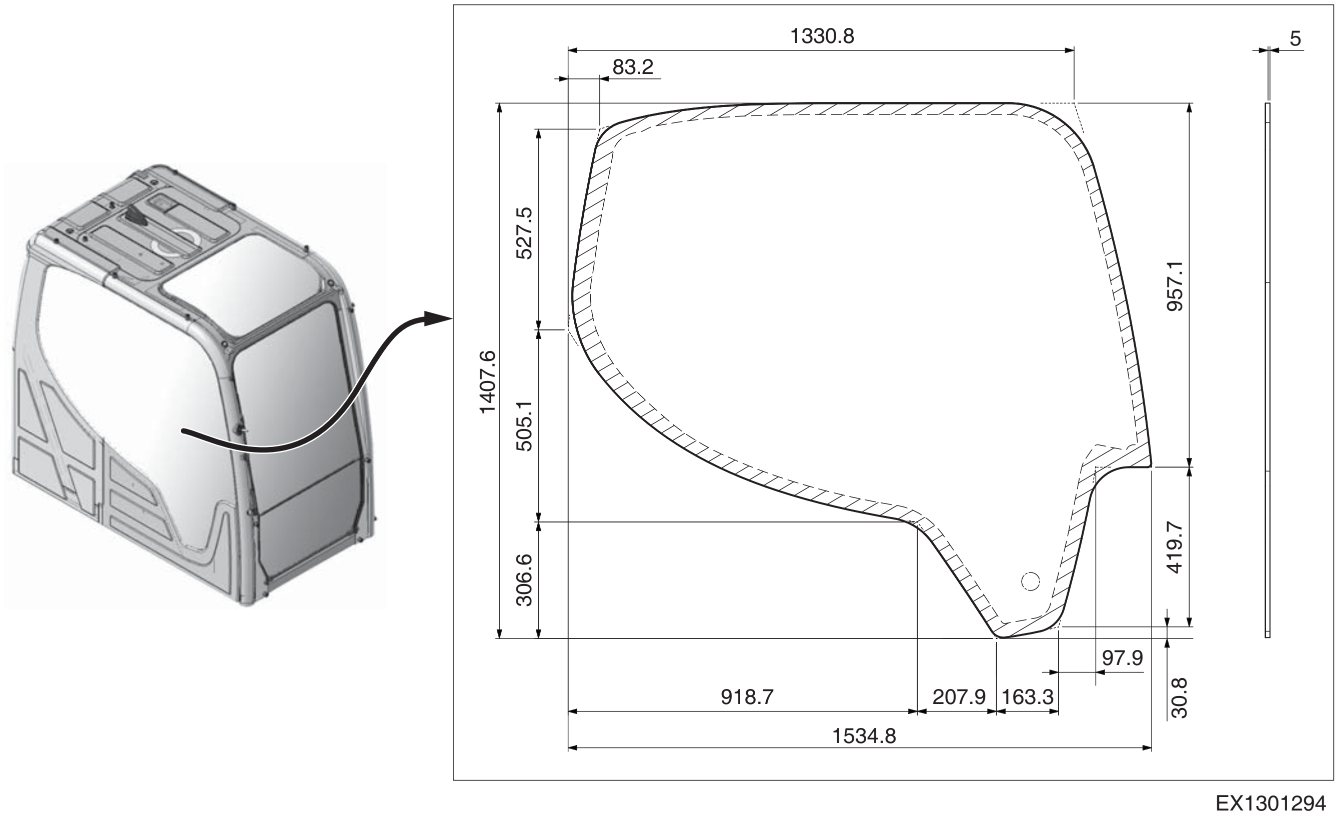


Figure 23

NOTE: *Unit: mm (1 mm = 0.039 in)*

REMOVAL AND INSTALLATION OF CABIN GLASS

Removal of Cabin Glass

Procedures to remove right-hand glass (1, Figure 24), rear left, glass, lower door glass and rear glass.

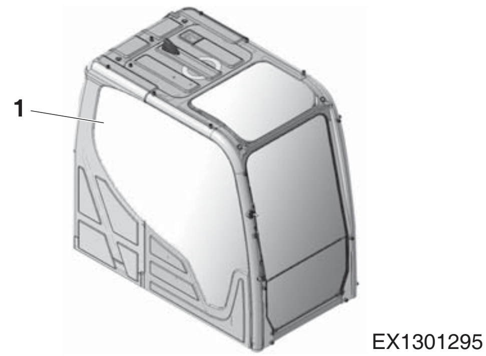


Figure 24

CAUTION

AVOID INJURY

When removing the broken or cracked glass, the glass shards can cause serious injury.

Before removing, use tape to hold the broken or cracked glass together.

1. Remove resin panel, garnish or etc. around the glass.

Reference Number	Description
1	Garnish
2	Lower Glass of Door
3	Rear Glass
4	Rear Left-hand Glass
5	Resin Panel

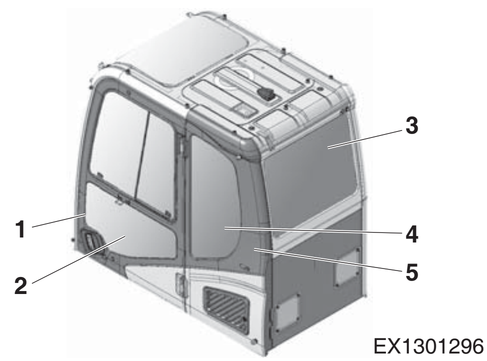


Figure 25

2. Prick a hole in the adhesive by using an awl (or cutter knife).

Reference Number	Description
1	Cabin
2	Cabin Glass
3	Awl
4	Adhesive

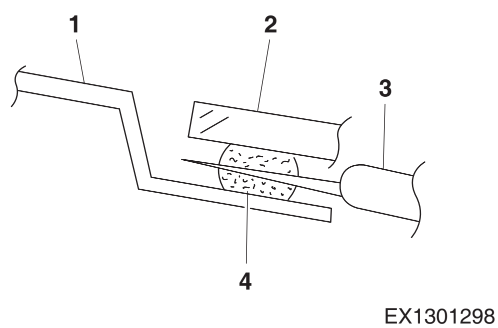


Figure 26

3. Pass a piano wire (1, Figure 27) (or a wire) through the hole.

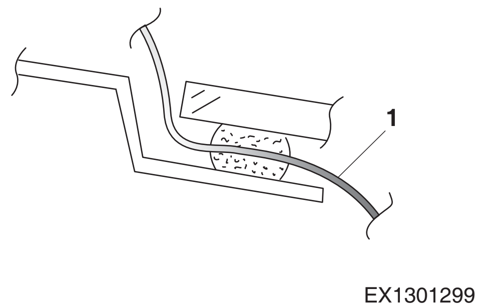


Figure 27

4. Wind both ends of the piano wire onto two screwdrivers. Draw the wire back and forth to cut the adhesive (3, Figure 28) between cabin (1) and glass (2).

   Remove glass (2, Figure 28) from the cabin (1).

   NOTE: *Piano wire is easily broken. If a part of the piano wire turns hot, change the position of the wire and continue cutting the adhesive.*

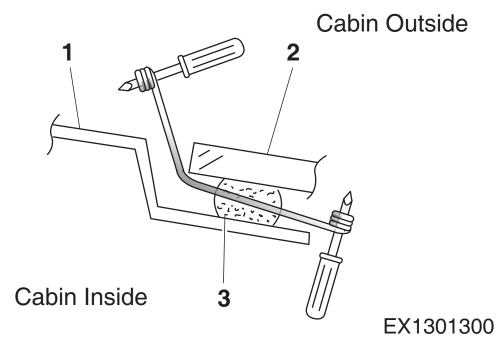


Figure 28

Installation of Cabin Glass

Procedures to install right-hand glass (1, Figure 30), rear, left-hand glass, lower door glass and rear glass.

1. Cut off the remaining adhesive leaving a layer of old adhesive 1 - 2 mm thick (Figure 29). The new adhesive will bond to the remaining adhesive.

   NOTE: *Do not damage the cabin paint.*

Reference Number	Description
1	Cabin
2	Knife

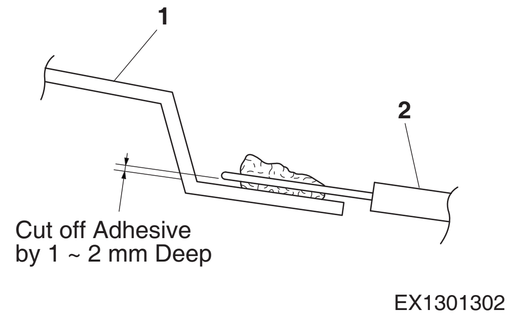


Figure 29

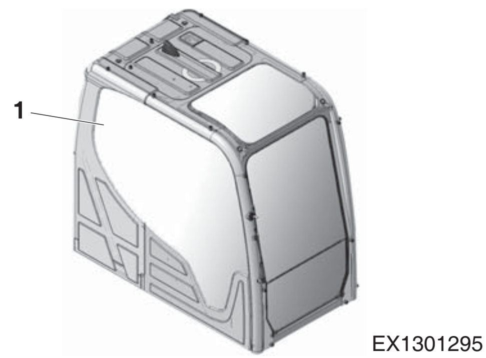


Figure 30

2. Clean the remaining adhesive and metal surfaces with a general purpose adhesive cleaner.

Reference Number	Description
1	Garnish
2	Lower Glass of Door
3	Rear Glass
4	Rear Left-hand Glass
5	Resin Panel

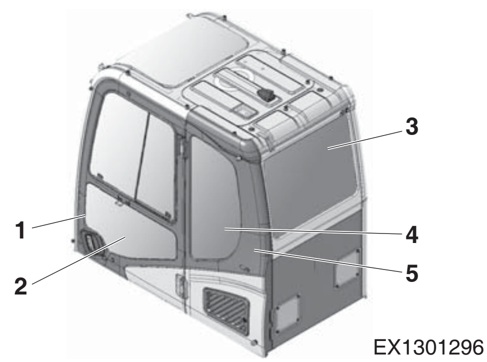


Figure 31

IMPORTANT

Primer must be shaken for about 1 minute and mix thoroughly before opening the cap.

After opening primer, apply primer as quickly as possible and replace the cap immediately after using.

After opening primer, all the contents must be used within 180 days (or 2 hours with the cap off).

3. Apply the damper on cabin body before applying adhesive.

Damper - Front Upper Glass

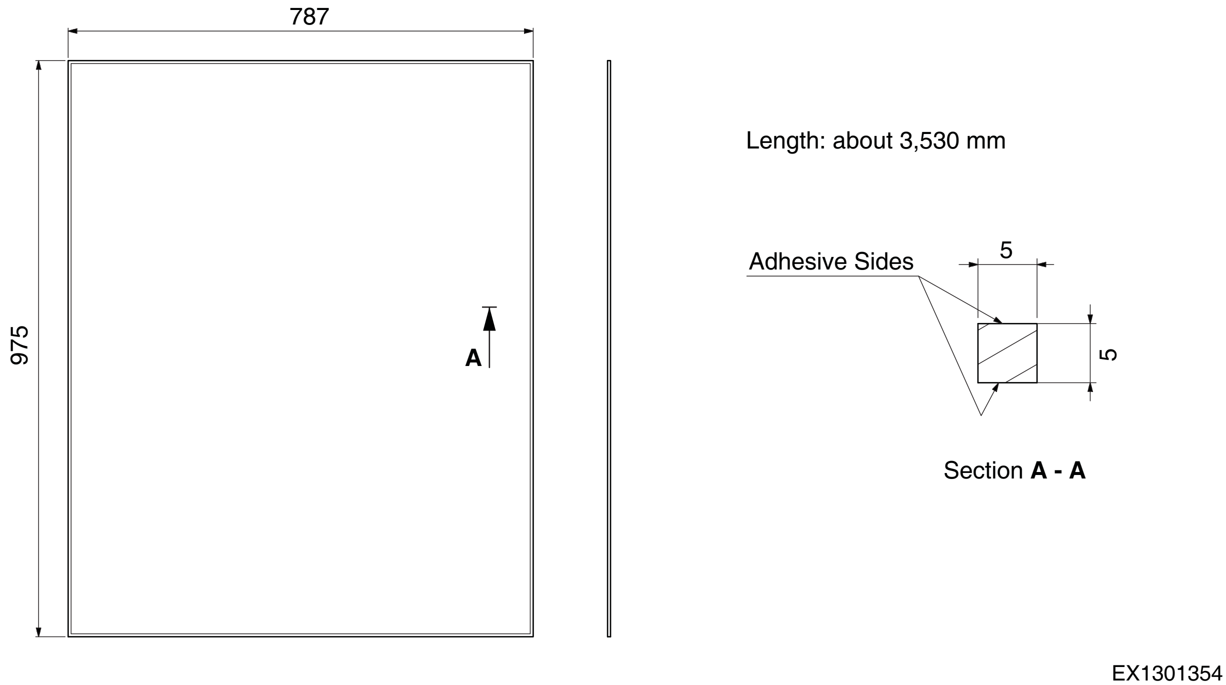


Figure 32

Damper - Rear Glass

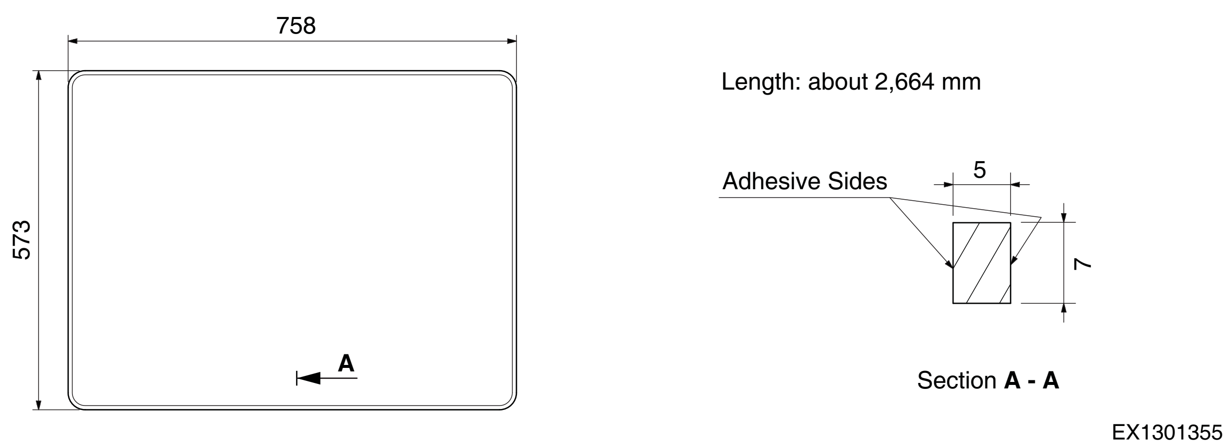


Figure 33

NOTE: *Unit: mm (1 mm = 0.039 in)*

Damper - Right-hand Glass

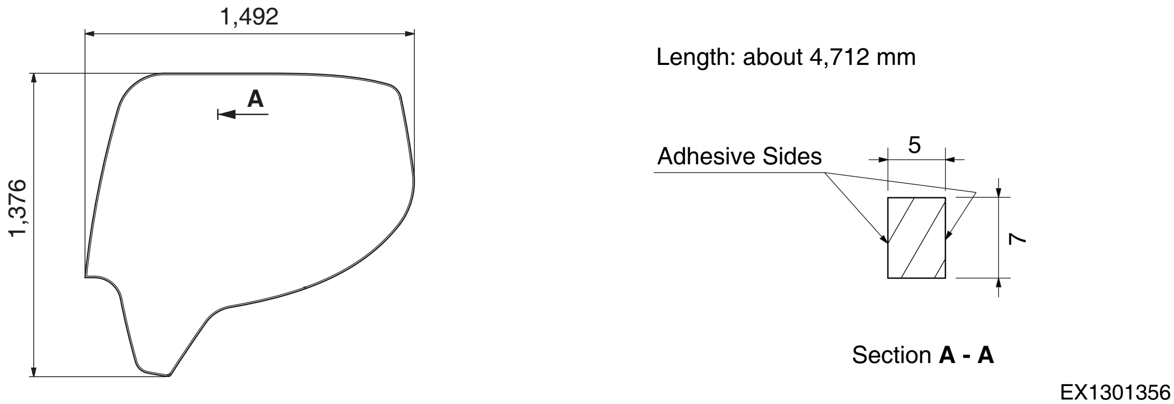


Figure 34

Damper - Lower Glass of Door

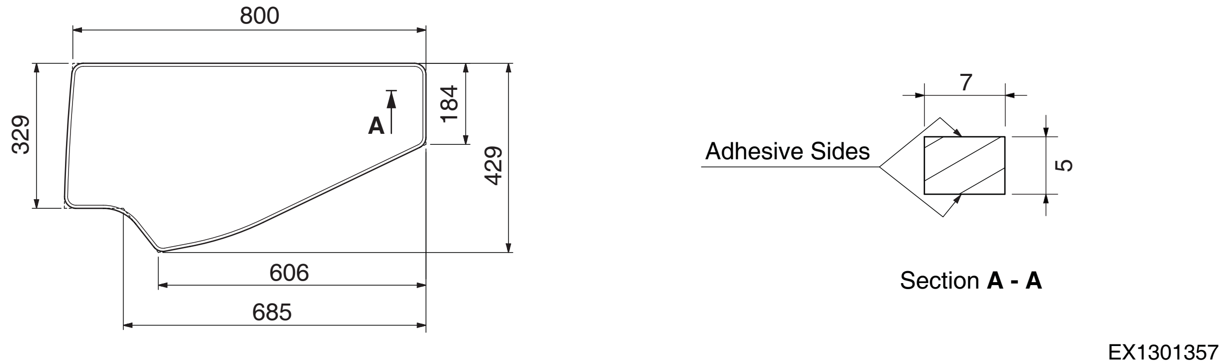


Figure 35

Damper - Rear Left-hand Glass

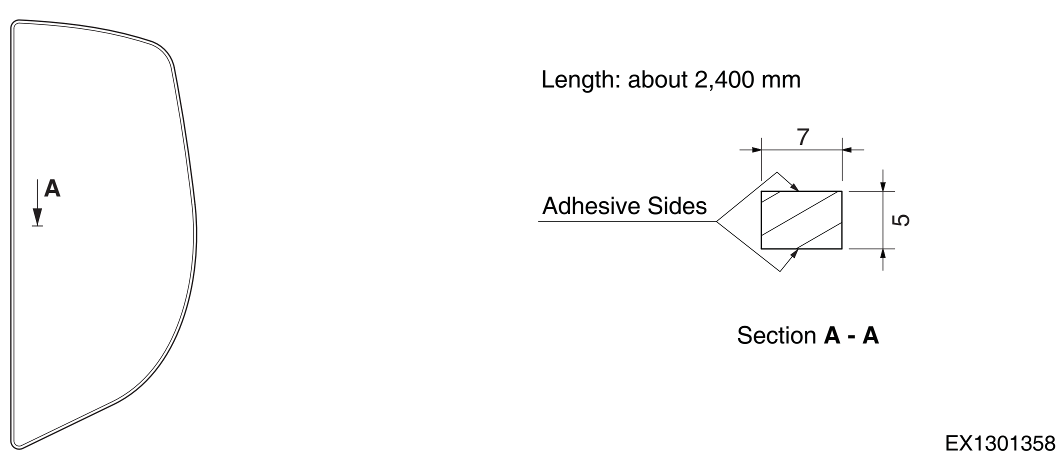


Figure 36

NOTE: *Unit: mm (1 mm = 0.039 in)*

4. Clean the mating edge of new glass by using clean rag and ethylalcohol.

IMPORTANT

Primer (Sika Primer W06G+P) must be shaken for about 1 minute and mixed thoroughly before opening the cap.

After opening primer, apply primer as quickly as possible and replace the cap immediately after using.

After opening primer, all the contents must be used within 180 days (or 2 hours with the cap off).

5. Using application brush, apply primer for glass (Sika Primer W06G+P) to the layer of old adhesive from step 1. Wait for about 15 minutes to let it dry.
(Refer to position to apply primer (2, Figure 37).)

NOTE: *The painting primer must be applied evenly to leave no blemishes.*

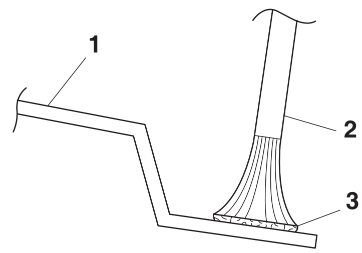


Figure 37

Reference Number	Description
1	Cabin
2	Application Brush
3	Layer of Old Adhesive on Cabin

6. Cut off the nozzle of adhesive cartridge (Sika Tack-Drive) into V-shaped by using a knife. (Refer to page -17.)
7. Remove seal of cartridge. Install the V-shaped nozzle.
8. Install the cartridge to the manual caulking gun.
9. Apply adhesive to the adhesive position at cabin side so bead triangle will be even.
(Refer to position to apply adhesive (3, Figure 37).)

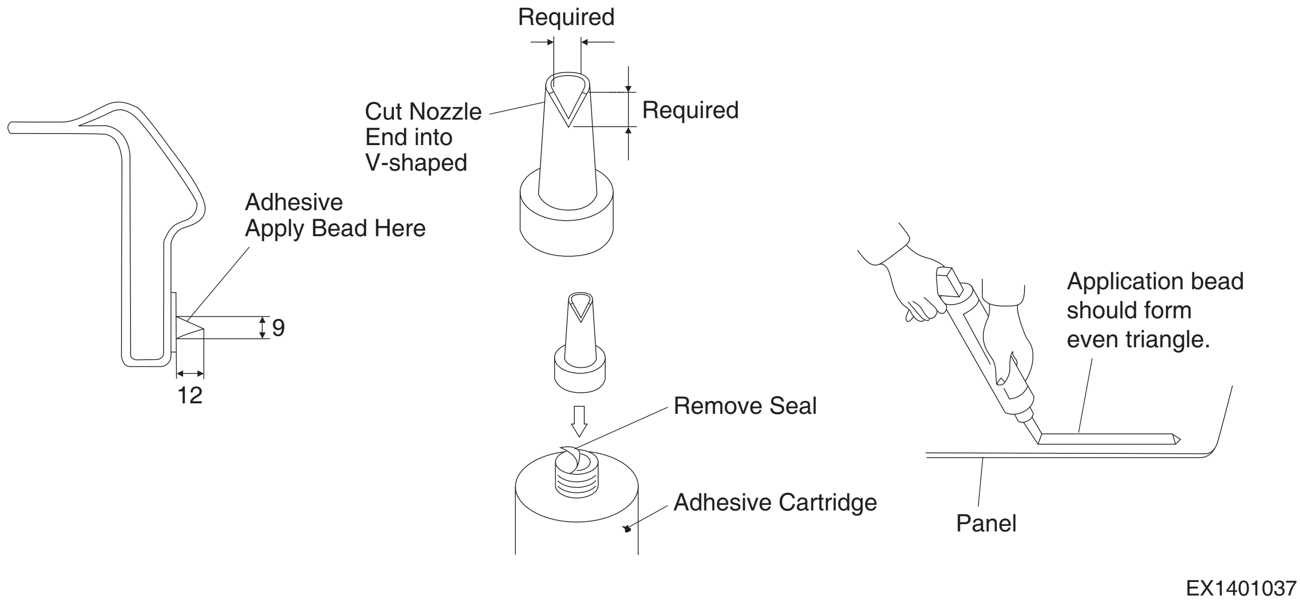


Figure 38

NOTE: *Unit: mm (1 mm = 0.039 in)*

10. The required amount (just for reference) of adhesive and primer.

		Painted Surface or Adhesive Surface	Glass Surface
	Adhesive Sika Tack-drive 310 ml Cartridge	**Primer Sika Activator DM-1 250 ml Can**	**Primer Sika Primer 206G+P 30 ml Bottle**
Upper Front Glass	310 ml	0.75 ml	0.67 ml
Lower Glass of Door	150 ml	0.50 ml	0.45 ml
Rear Left-hand Glass	250 ml	0.65 ml	0.60 ml
Rear Right-hand Glass	100 ml	1.00 ml	0.90 ml
Rear Glass	210 ml	0.50 ml	0.45 ml

Installation of Upper Door Glass

1. Before installing the glass, remove garnish (2, Figure 39) around sash assembly (1) from the cabin inside for easy removal. Push the sash assembly by hands and remove sash outside.
2. Install glass (3, Figure 39) and glass (4) into the sash grooves.
3. Install the sash assembly, which the glass is installed on, onto the door from the outside of cabin.

   Secure the sash assembly at the inside of cabin by using the garnish.

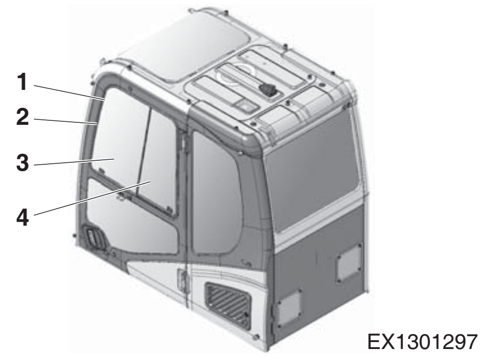


Figure 39

Installation of Upper Front Glass

1. Stick seal to the lower side of front upper glass by using Cemedine SIKAFLEX 255 ultrafast.

   Stick and secure both right and left ends (the thicker part) of seal to the glass by using Cemedine SIKAFLEX 255 ultrafast.

   Stick the mating surface of seal and the glass by using Cemedine SIKAFLEX 255 ultrafast so no visible undulation or boss can be found.

   NOTE: *Cemedine SIKAFLEX 255 ultrafast Glue-state adhesive, tubed.*

Reference Number	Description
1	Upper Glass
2	Seal
3	Lower Glass
4	Damper

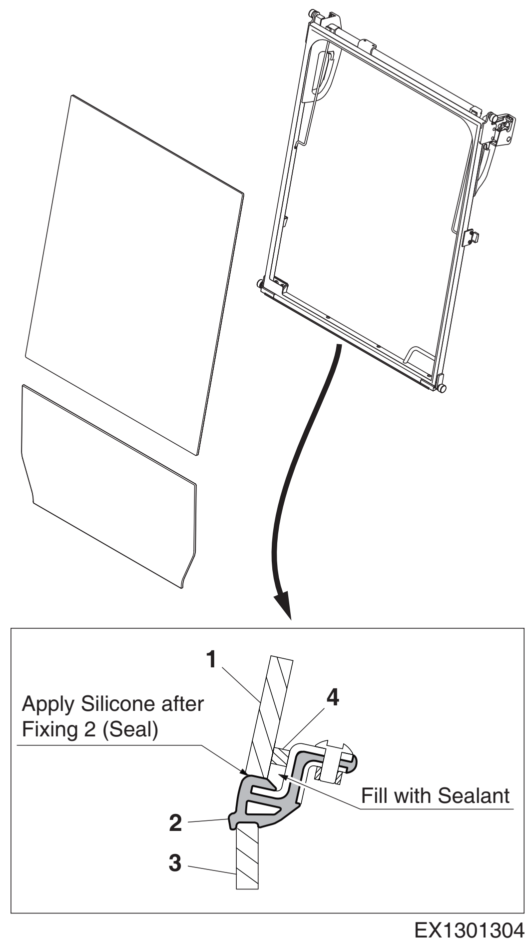


Figure 40

Counterweight

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Counterweight

GENERAL

Warning for Counterweight and Front Attachment Removal

WARNING

AVOID DEATH OR SERIOUS INJURY

DOOSAN warns any user, that removal of the counterweight from the machine, front attachment (boom and arm) or any other part, may affect the stability of the machine. This could cause unexpected movement, resulting in death or serious injuries.

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.

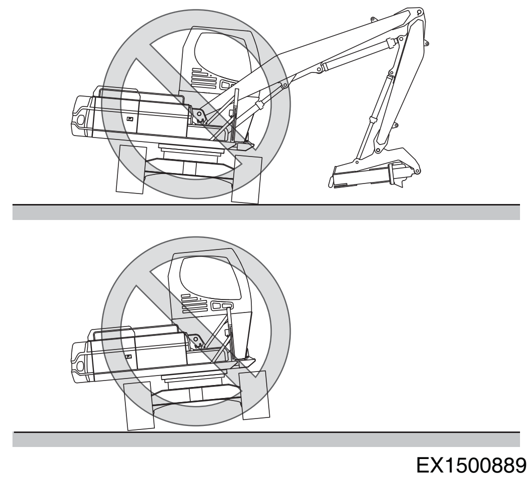


Figure 1

Before any attempt is made to begin removal or installation of the counterweight, the machine 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

AVOID DEATH OR SERIOUS INJURY

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.

- Weight of counterweight: 4,400 kg (9,700 lb)

Responsibility must 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

AVOID DEATH OR SERIOUS INJURY

If the upper structure deck has been unbalanced by removal of weight from one end only, traveling with the excavator, swinging the turntable, movement over bumps or sloping and uneven surfaces could cause loss of control resulting in tipping or rollover.

To maintain stability the counterweight must be removed only when the front attachment is taken off the machine.

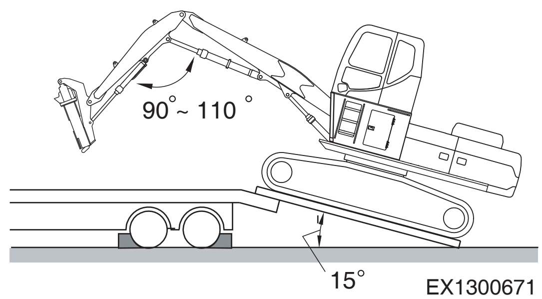


Figure 2

When loading a forestry machine on a trailer for transport after the front attachment has been removed, always go backwards up the loading ramp with the counterweight uphill (Figure 3).

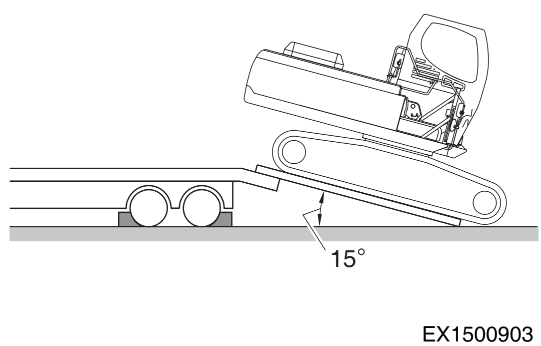


Figure 3

REMOVAL

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Death or serious injury can occur from a counterweight falling during removal or installation. Do not allow personnel under or around the counterweight during removal or installation.

Use certified cables and shackles of adequate load rating. Improper lifting can allow the load to shift and cause death or serious injury.

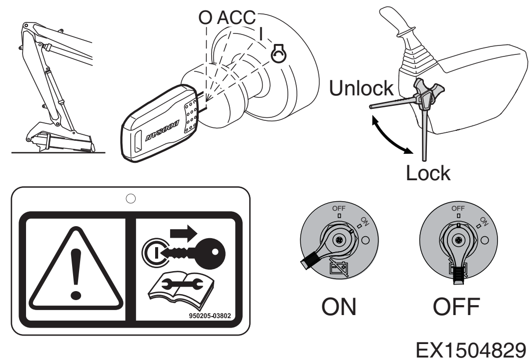


Figure 4

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

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

If engine must be running 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. Move safety lever to "LOCK" position.
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Attach maintenance warning tag on controls.
10. Turn battery disconnect switch to "OFF" position.
11. Make sure all electrical and other items are disconnected.
12. Using a suitable lifting device capable of handling a heavy load, partially support counterweight from lifting holes (5, Figure 5), counterweight (1) before loosening four bolts (2). Stop lifting with assist crane as soon as lifting slings are taut.
13. Remove four bolts (2, Figure 5) and washers (3) from counterweight (1).
    - Tool: 46 mm ( )

    NOTE: *Heat bolts, if necessary, to free them.*

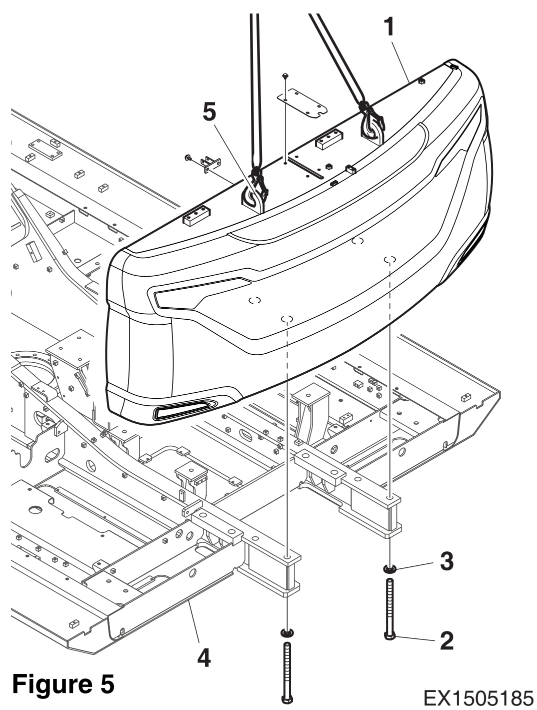


Figure 5

14. When bolts (2, Figure 5) and washers (3) have been removed, lift counterweight (1) a very short distance above support frame (4) and stop. Check slings and make sure counterweight is being supported evenly.

INSTALLATION

1. Using suitable lifting device capable of handling the weight of the counterweight, support counterweight from lifting holes (5, Figure 6). Raise counterweight (1, Figure 6) into position just above support frame (4) leaving counterweight suspended. Verify that counterweight is level and even.

   NOTE: *Leave counterweight (1, Figure 6) suspended 3 mm (0.125") above support frame (4) until all four mounting bolts (2) are started in counterweight mounting holes.*

2. Slide washers (3, Figure 6) onto bolts (2). Apply Loctite #242 to mounting bolt threads.
3. Install four bolts (2, Figure 6) with washers (3) into counterweight until washers contact support frame. Fully lower counterweight onto support frame and finish tightening bolts.
   - Tool: 46 mm ( )
   - Torque: 1,471 N.m (150 kg.m, 1,085 ft lb)
4. Remove lifting device from counterweight lifting holes (5, Figure 6)
5. Make sure all electrical and other items are connected.
6. Turn battery disconnect switch to "ON" position.

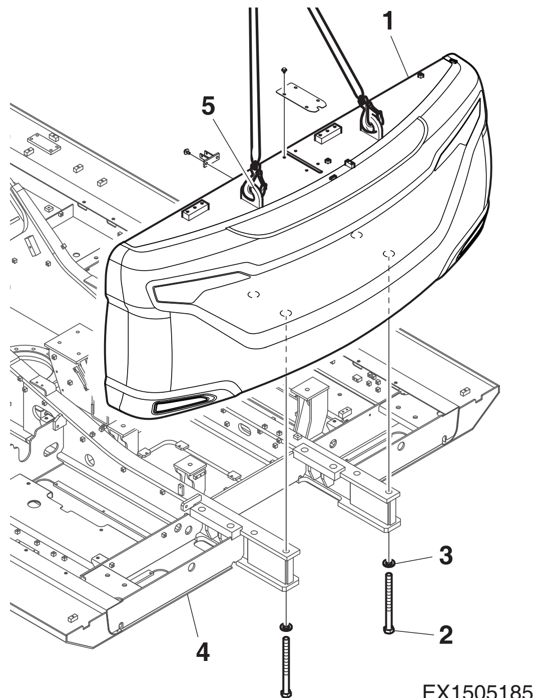


Figure 6

Hydraulic Oil Tank

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Hydraulic Oil Tank

GENERAL

Specification

Volume (Full)		195 L (52 U.S. gal)
Optimum Volume		131 L (35 U.S. gal)
Tank Size		393 x 820 x 877
Tank Weight		about 154 kg (340 lb) (Empty)
Return Filter (5, Figure 1)	Size	10 μm, 1.6 m^2 (ø150 x 415)
	Operation Pressure	0 ~ 15 bar (0 ~ 15.9 kg/cm^2, 0 ~ 217.6 psi)
	Bypass Valve Setting	1.5 bar (1.5 kg/cm^2, 21.8 psi) at 40 L/min
	Flow Rate	600 L/min (158.5 U.S. gpm)
Air Breather (14, Figure 1)	Filter	10 μm, 270 cm^2
	Cracking Pressure	0.39 ~ 0.49 bar (0.04 ~ 0.05 kg/cm^2, 0.57 ~ 0.71 psi)
Suction Filter (10, Figure 1)	Size	80 mesh, 2,958 cm^2 (ø150 x 142)
	Filtration Rating	177 μ
	Flow Rate	750 L/min (198.1 U.S. gpm)
Pressure Switch (101, Figure 1)	Actuation Pressure	1.5 bar (1.5 kg/cm^2, 21.8 psi)
	Rating	4 A Resistance at 24 V DC Max.

Parts List

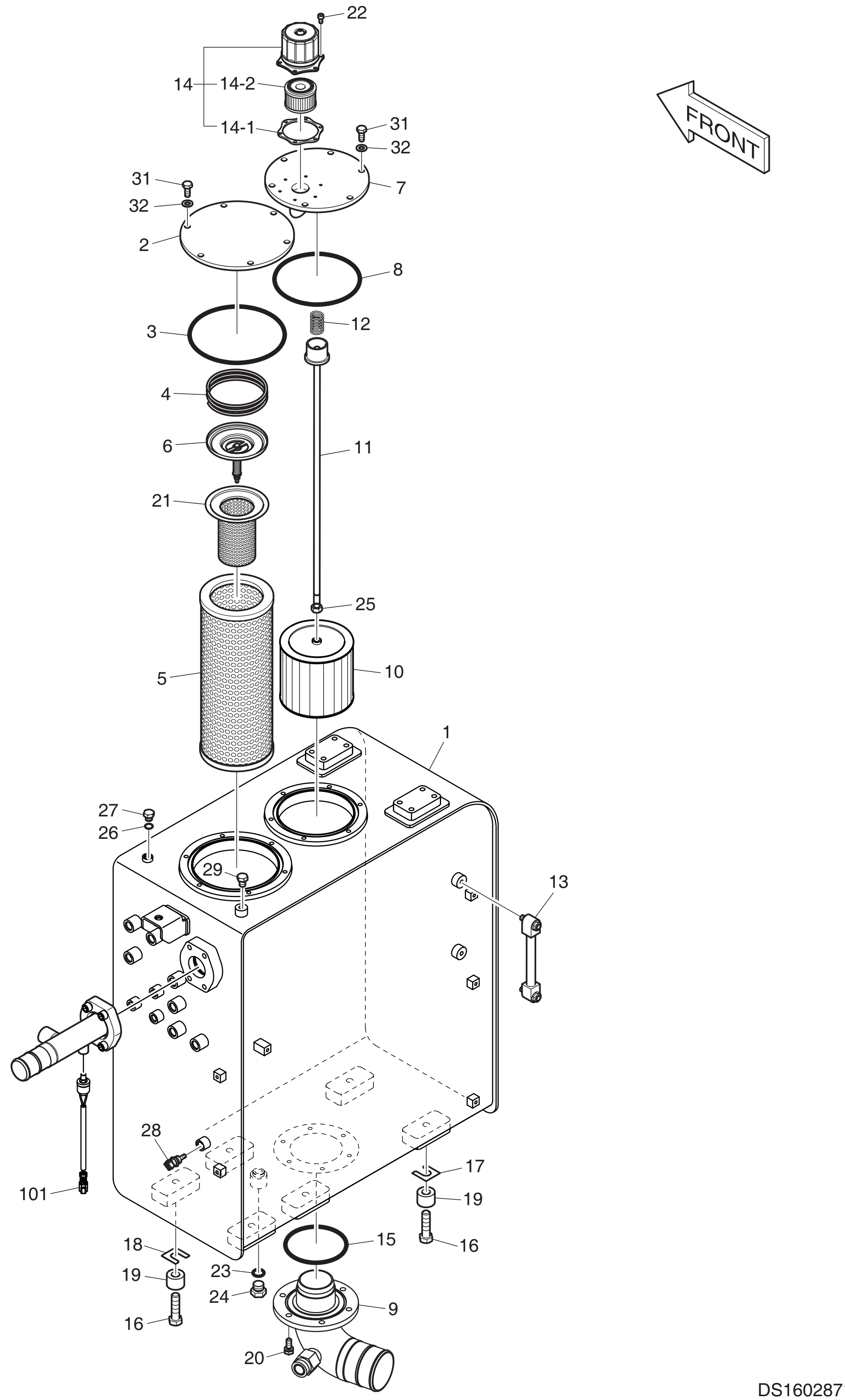


Figure 1

Reference Number	Description
1	Tank, Oil
2	Cover
3	O-ring
4	Spring
5	Element, Return Filter
6	Valve, By-pass
7	Cover, Tank
8	O-ring
9	Pipe, Suction
10	Filter, Suction
11	Rod
12	Spring, Compress
13	Gauge, Level
14	Breather, Air
14-1	Gasket
14-2	Element, Air Breather
15	O-ring

Reference Number	Description
16	Bolt
17	Shim
18	Shim
19	Spacer
20	Bolt
21	Strainer, By-pass
22	Bolt
23	O-ring
24	Plug
25	Nut
26	O-ring
27	Plug
28	Sensor, Hydraulic Oil Temp
29	Bolt
31	Bolt
32	Washer
101	Pressure Switch

Air Breather

1. Structure of air breather

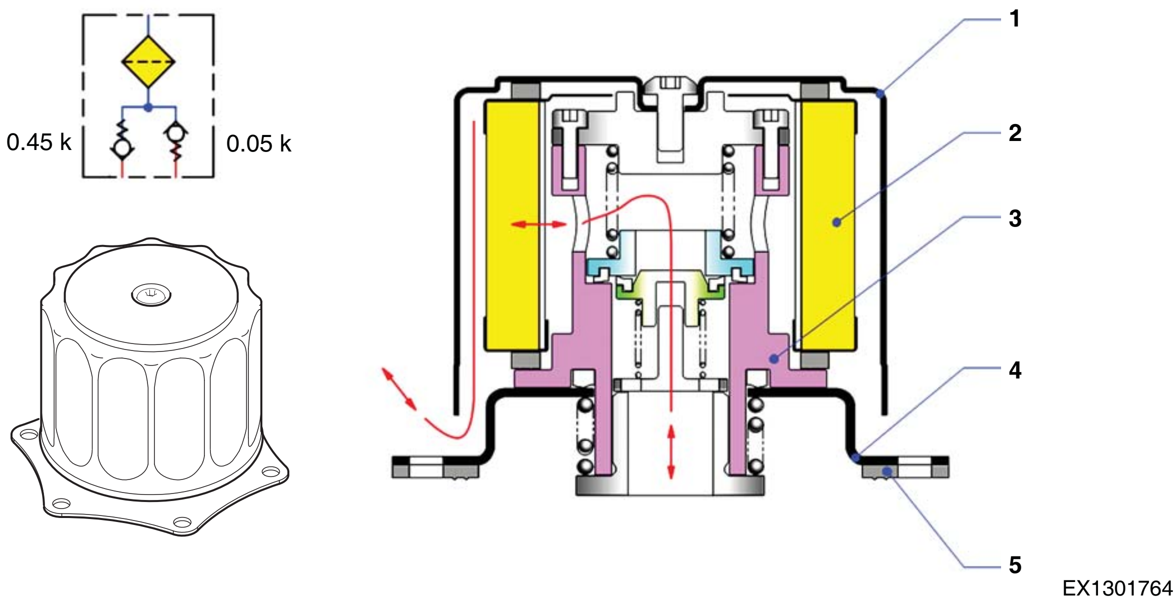


Figure 2

Reference Number	Description
1	Housing
2	Element
3	Body

Reference Number	Description
4	Flange
5	Gasket

2. Pressure release

Pulling the breather cap upward, the check valve 0.46 kg/cm^2 (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Make the machine swing about 60° rightward on the flat ground.
2. Front position: Positioned with stick cylinder fully extended and grapple and heel on ground as (Figure 3).
3. Lower all the attachments to ground.
4. Stop engine.

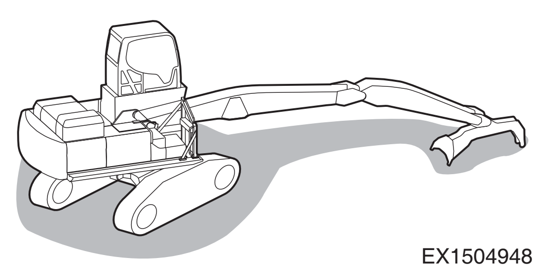


Figure 3

5. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 4)

6. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

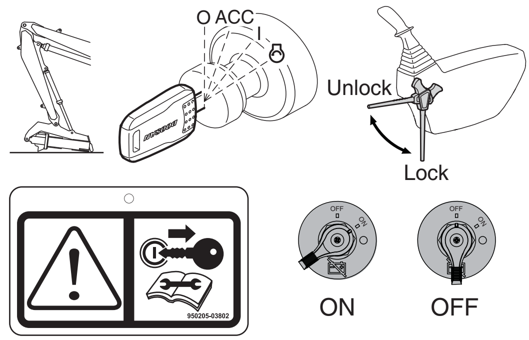
7. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.

8. Move safety lever to "LOCK" position. (Figure 4)

9. Turn key to "O" (OFF) position and remove from starter switch.

10. Attach a maintenance warning tag on controls.

11. Turn battery disconnect switch to "OFF" position. (Figure 5)



EX1504829

Figure 4

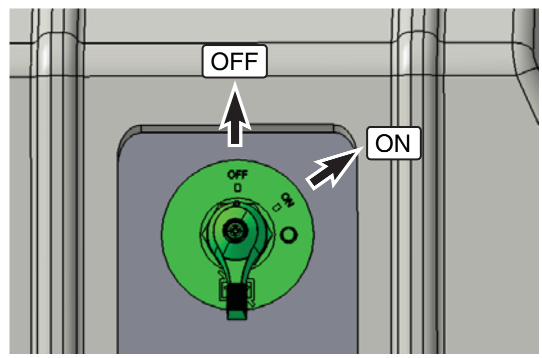
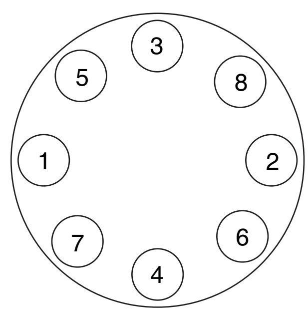


Figure 5 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 6

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

12. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.

    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

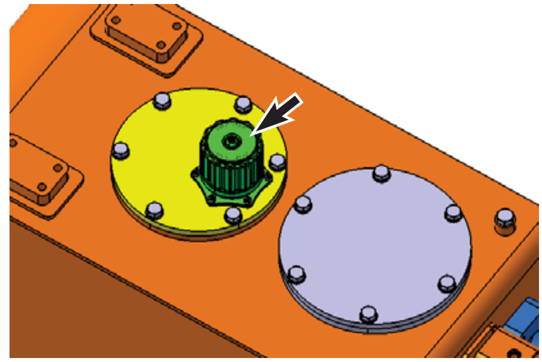
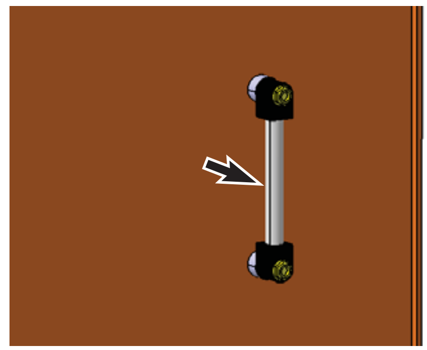


Figure 7 EX1404054

13. Oil drain method.

    NOTE: *Check the level on the oil level gauge before draining the oil.*



EX1402303

Figure 8

A. Remove cover (2 ea) on oil tank (bolt: 12 ea) and drain hydraulic oil using oil pump. (Figure 9)
Also pump oil from the suction pipe.

- Tool: 17 mm ( )
- Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

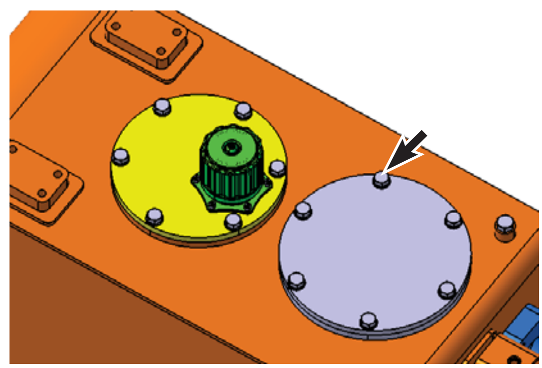
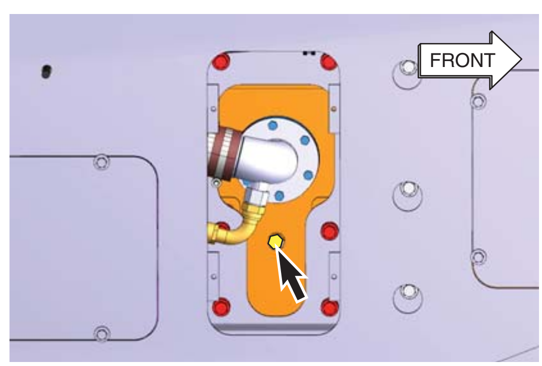


Figure 9 EX1404072

B. Drain hydraulic fluid using drain plug.
(without oil pump) (Figure 10)

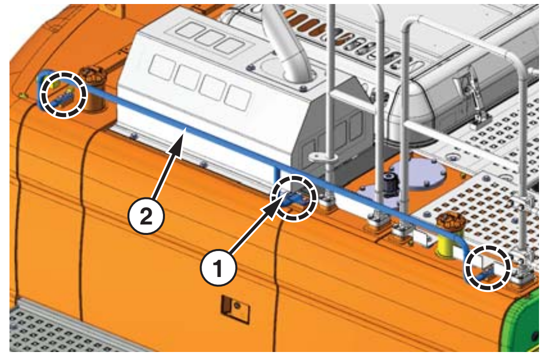
- Tool: 27 mm ( )
- Torque: 93.1 N.m (9.5 kg.m, 68.7 ft lb)
- Hydraulic oil tank volume
  - Approximately: 195 L (52 U.S. gal)
  - Effective level: 131 L (35 U.S. gal)



DS1602639

Figure 10 Bottom of Main Frame

14. Remove bolts (1, Figure 11) (6 ea) with hand rail (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)



DS1602636

Figure 11

15. Remove bolts and washers (1, Figure 12) (8 ea) with the guardrail (2) (1 ea).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Guardrail weight: 10 kg (22 lb)

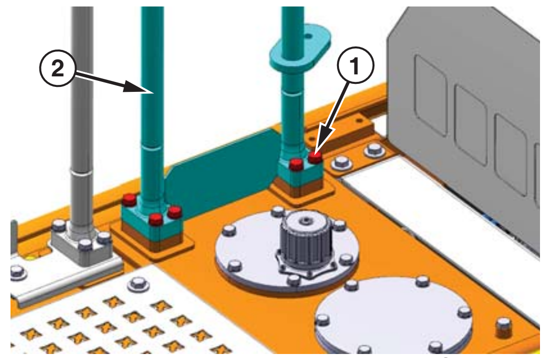


Figure 12

DS1602826

16. Open the engine cover and remove bolts and washers (1, Figure 13) (4 ea) with cover (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Cover weight: 18 kg (40 lb)

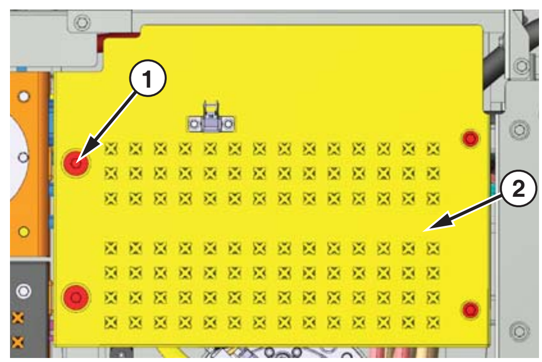
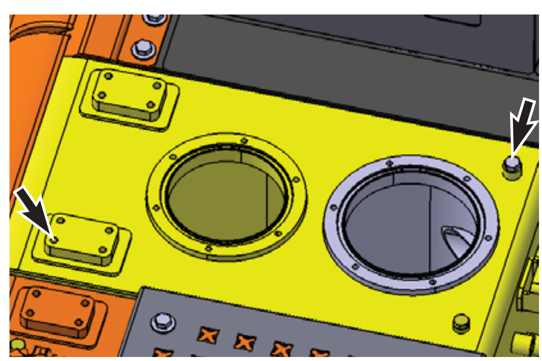


Figure 13

DS1602642

17. Install eyebolts (2 ea) on the oil tank. (Figure 14)

    And tie the rope to the bolts to lift oil tank.
    - Thread of hole: M12 x 1.75



EX1404057

Figure 14

18. Remove bolts (1, Figure 15) (4 ea) with step support (2) from storage box.

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Step support weight: about 23 kg (51 lb)

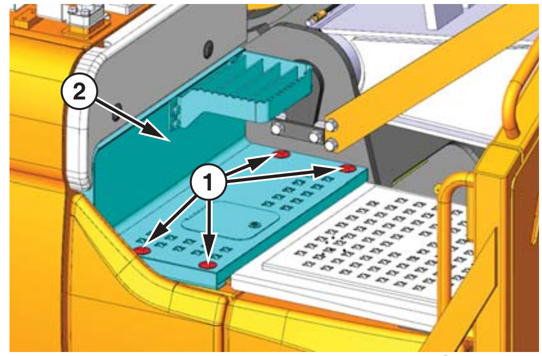


Figure 15 DS1602835

19. Remove bolts (1, Figure 16) (2 ea) from fuel tank.

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

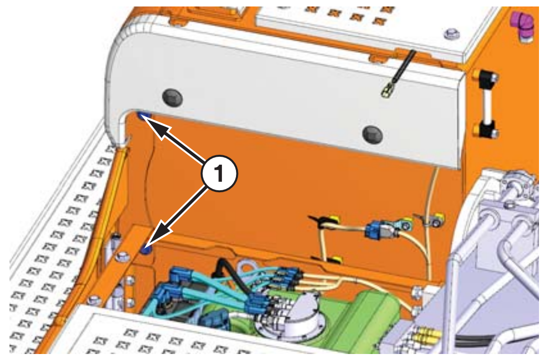
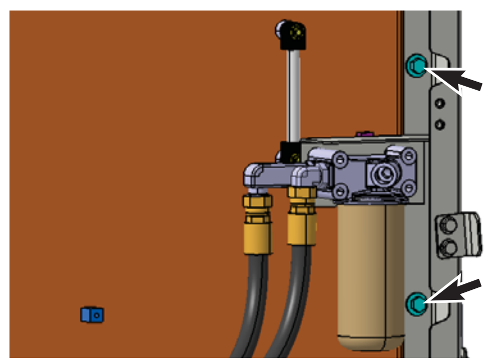


Figure 16 DS1602836

20. Remove bolts (2 ea) (Figure 17) with tank side cover.

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Tank side cover weight: 18 kg (40 lb)



EX1402308

Figure 17

21. Remove bolts and washers (1, Figure 18) (6 ea) under cover (2) on bottom of main frame.

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Under cover weight: 9 kg (20 lb)

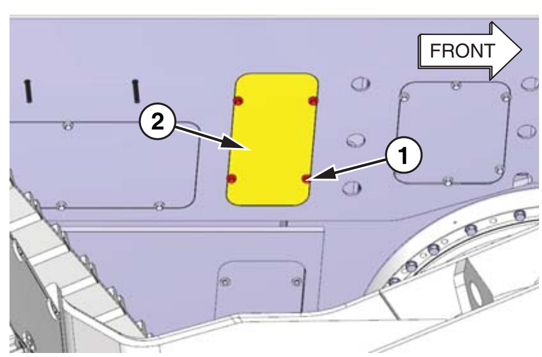


Figure 18 Bottom of Main Frame DS1602637

22. Remove oil tank mounting bolts and spacers (1, Figure 19) (6 ea) from the main frame.
    - Tool: 24 mm ( )
    - Torque: 264.6 N.m (27 kg.m, 195.2 ft lb)
23. Remove bolts (2, Figure 19) (6 ea) of suction pipe from the oil tank.
    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

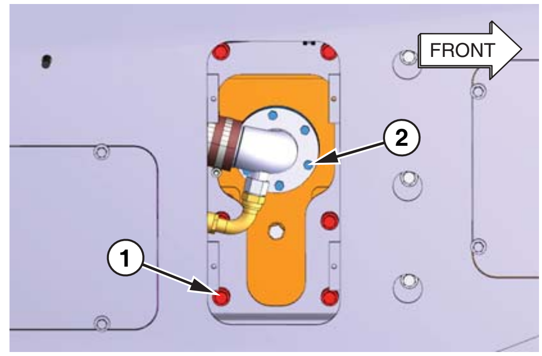


Figure 19 Bottom of Main Frame DS1602638

24. Disconnect the connector of oil temperature sensor (1, Figure 20) and pressure switch (2).

    NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
    If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

25. Remove bolts (3, Figure 20) (2 ea) and clips with harness.
    - Tool: 12 mm ( )
    - Torque: 29.4 N.m (3 kg.m, 21.7 ft lb)

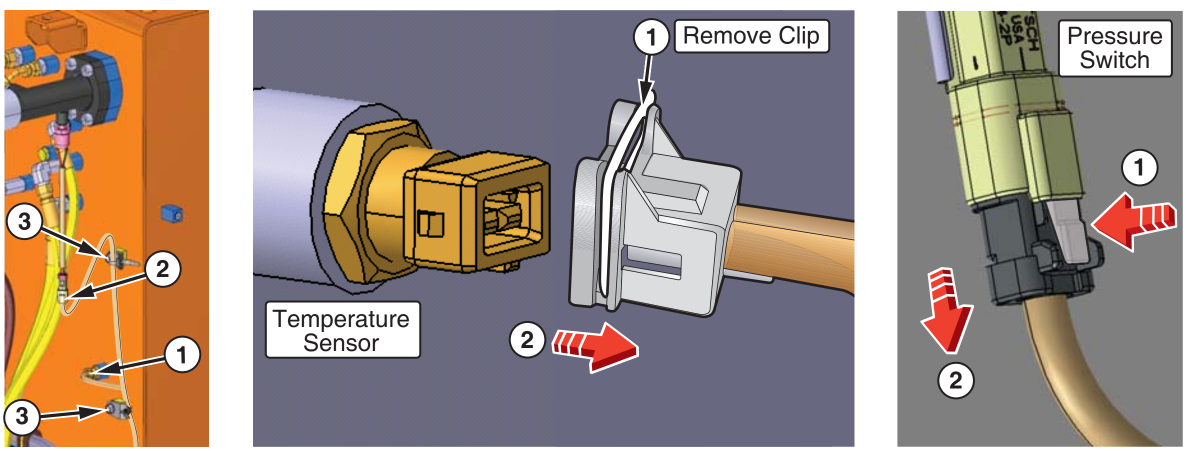


Figure 20 DS1602837

26. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 21 EX1504170

27. Remove hoses, pipes and adapters (Figure 22) from the oil tank.

NOTE: *Attach identification tags to the removed hoses for reassembling.*
After disconnecting hoses from oil tank, plug them to prevent dirt or dust from entering.
Disconnect the hoses from the bottom to top of oil tank.

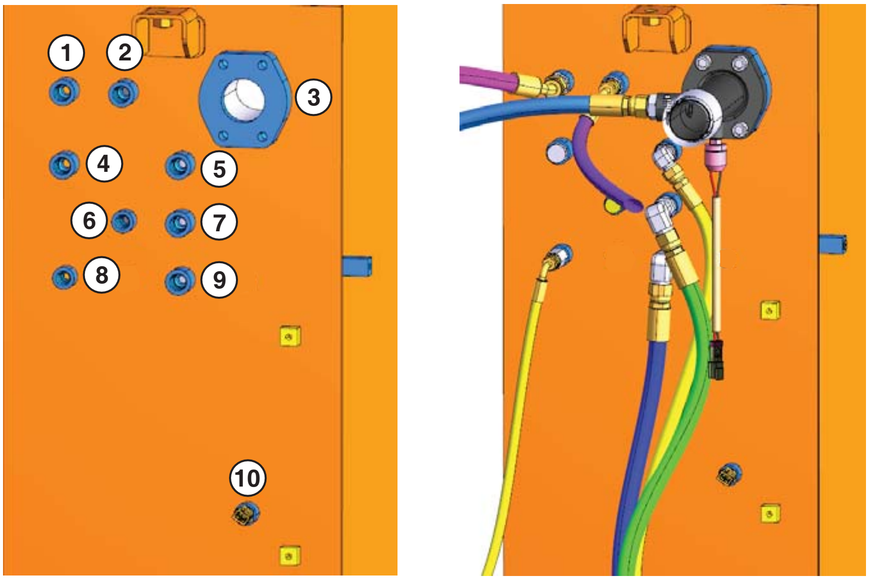


Figure 22

DS1602838

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)			Torque		
			(mm)	(mm)	N.m	kg.m	ft lb
1	from Control Valve "DR2"	UNF 13/16"-16-2B	24		55.9	5.7	41.2
2	from Control Valve "DR1"	UNF 11/16"-16-2B	22		38.2	3.9	28.2
3	from Radiator	SAE 2", D48		10	107.9	11.0	79.6
4	Plug	PF 3/8"	22		49.0	5.0	36.2
5	from Solenoid Valve "T"	UNF 11/16"-16-2B	22		38.2	3.9	28.2
6	Plug	PF 1/4"	19		39.2	4.0	28.9
7	from Joint Sub Assembly "B19"	UNF 13/16"-16-2B	24		55.9	5.7	41.2
8	from Pilot Valve "T"	UNF 9/16"-18-2B	19		25.5	2.6	18.2
9	from Joint Sub Assembly "B20"	UNF 13/16"-16-2B	24		55.9	5.7	41.2
10	Oil Temperature Sensor	M16 x 1.5	19		14.7	1.5	11.0

- Fitting

Port	Name	Size			Torque		
		A	B (C)	(mm)	N.m	kg.m	ft lb
1	Adapter	PF 1/2"	UNF 13/16"-16	27	93.2	9.5	68.7
2		PF 3/8"	UNF 11/16"-16	22	49.0	5.0	36.2
5	Elbow	PF 3/8"	UNF 11/16"-16	22	49.0	5.0	36.2
7, 9		PF 3/8"	UNF 13/16"-16	22	49.0	5.0	36.2
8	Adapter	PF 1/4"	UNF 9/16"-18	19	39.2	4.0	28.9
1	O-ring	S8000185 (4D P18)	S8030081 (1B F-08)				
2, 5		S8000145 (4D P14)	S8030061 (1B F-06)				
3		DS2856006 (2", ID:57.2, OD:64.2, 1B)					

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
4	O-ring	S8000145 (4D P14)					
6		S8000115 (4D P11)					
7, 9		S8000145 (4D P14)	S8030081 (1B F-08)				
8		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

*A: Opposite side of hose, B (C): Hose side

28. Using a crane, lift the hydraulic oil tank slowly.
    - Oil tank weight: about 154 kg (340 lb)

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

NOTE: *First, assemble the bolts and spacers (6 ea) of oil tank mounting to main frame. (Figure 23)*

1. Install the oil tank with bolts and spacers (1, Figure 23) (6 ea) to the main frame.
    - Tool: 24 mm ( )
    - Torque: 264.6 N.m (27 kg.m, 195.2 ft lb)
2. Install the bolts (2, Figure 23) (6 ea) through suction pipe to the oil tank.
    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)
3. Perform installation in the reverse order to remove.
4. If removed the level gauge, install level gauge as the following torque.
    - Torque: 12.7 N.m (1.3 kg.m, 9.4 ft lb)

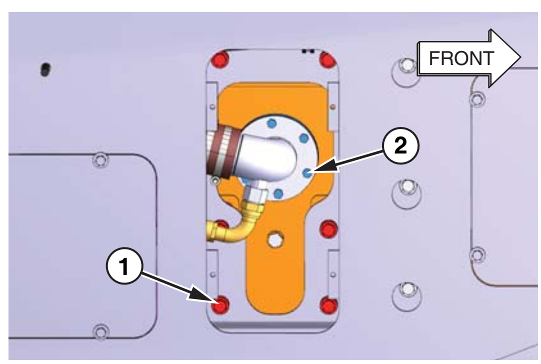


Figure 23 Bottom of Main Frame DS1602638

5. When assembling rod to suction filter, adjust the assembling length as Figure 24.

Reference Number	Description
1	Suction Filter
2	Nut
3	Rod

- Length (A): 650 mm
- Torque (2 nut): 49 N.m (5 kg.m, 36.2 ft lb)

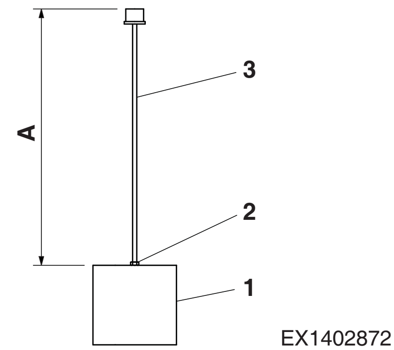
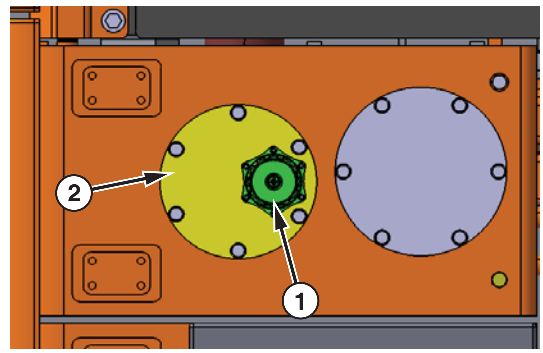


Figure 24

6. Location of air breather (1) must be as Figure 25 when assembling cover (2).



EX1404060

Figure 25

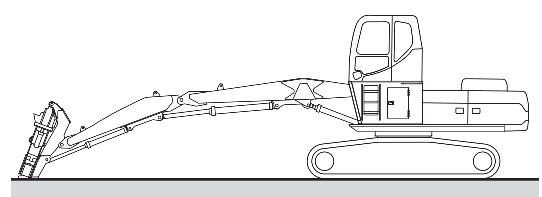
COMPLETING WORK

1. Hydraulic oil tank volume:
   - Approximately: 195 L (52 U.S. gal)
   - Effective level: 131 L (35 U.S. gal)
2. Adjusting standard for hydraulic oil level
   A. Front position: Positioned with stick cylinder fully extended and grapple and heel on ground as Figure 26.

   B. Engine condition: Low idle

   C. Fill hydraulic oil until fluid in level gauge is positioned between low and high marks.

   D. If hydraulic oil level is too high, drain excess hydraulic oil from tank by removing drain plug located on bottom of tank.



EX1300555

Figure 26

Fuel Tank

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Fuel Tank

GENERAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Diesel fuel is highly flammable and can be potentially explosive. To prevent fires or explosion, keep arcs, sparks or other ignition sources away from diesel fuel or fuel containers.

Specification

Fuel Tank 1

Volume (Full)	400 L (106 U.S. gal)		
Tank Size (mm)	772 x 820 x 979		
Tank Weight	about 189 kg (416 lb) (Empty)		
Fuel Strainer Filter (4, Figure 1)	Filtration Ratio		24 mesh
	Working Oil Temp.		-40 ~ 80°C
Fuel Cap (5, Figure 1)	Check Valve	Positive Pressure	0.25 ~ 0.05 bar (0.25 ~ 0.05 kg/cm^2, 3.63 ~ 0.73 psi)
		Negative Pressure	below 0.035 bar (0.035 kg/cm^2, 0.51 psi)
Fuel Sensor (18, Figure 1)	Working Voltage		V max. 48 V
	Working Current		I max. 300 mA
	Rating Power		125 mW

Fuel Tank 2

Volume (Full)	606 L (160 U.S. gal)		
Tank Size (mm)	2,710 x 330 x 979		
Tank Weight	about 439 kg (968 lb) (Empty)		
Fuel Strainer Filter (4, Figure 2)	Filtration Ratio		24 mesh
	Working Oil Temp.		-40 ~ 80°C
Fuel Cap (5, Figure 2)	Check Valve	Positive Pressure	0.25 ~ 0.05 bar (0.25 ~ 0.05 kg/cm^2, 3.63 ~ 0.73 psi)
		Negative Pressure	below 0.035 bar (0.035 kg/cm^2, 0.51 psi)

Parts List

Fuel Tank 1

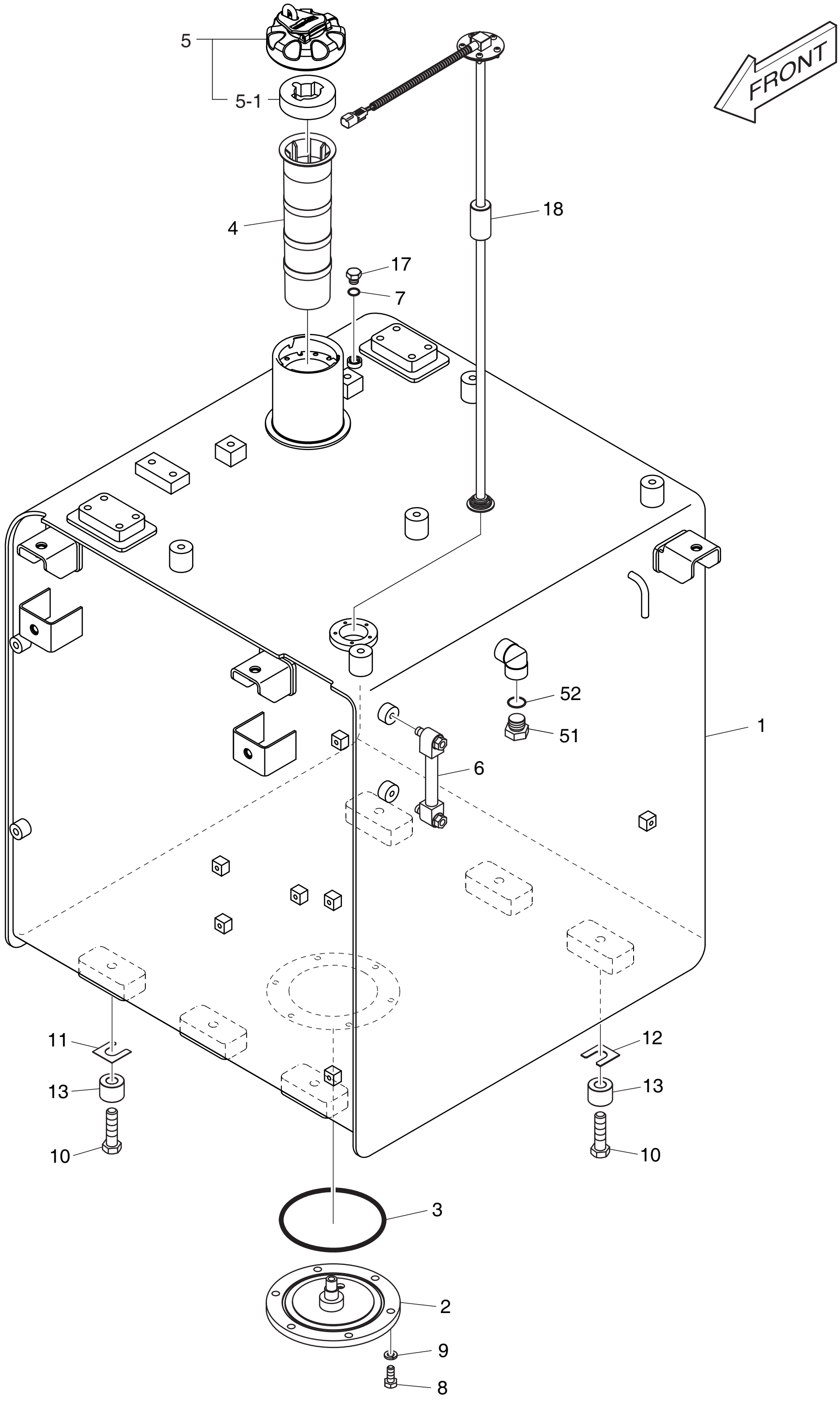


Figure 1

DS1602736

Reference Number	Description
1	Tank, Fuel
2	Cover, Tank
3	O-ring
4	Filter, Fuel Strainer
5	Cap, Fuel
5-1	Element, Fuel Cap
6	Gauge, Level
7	O-ring
8	Bolt

Reference Number	Description
9	Washer, Spring
10	Bolt
11	Shim
12	Shim
13	Spacer
17	Plug
18	Sensor, Fuel
51	Plug
52	O-ring

Fuel Tank 2

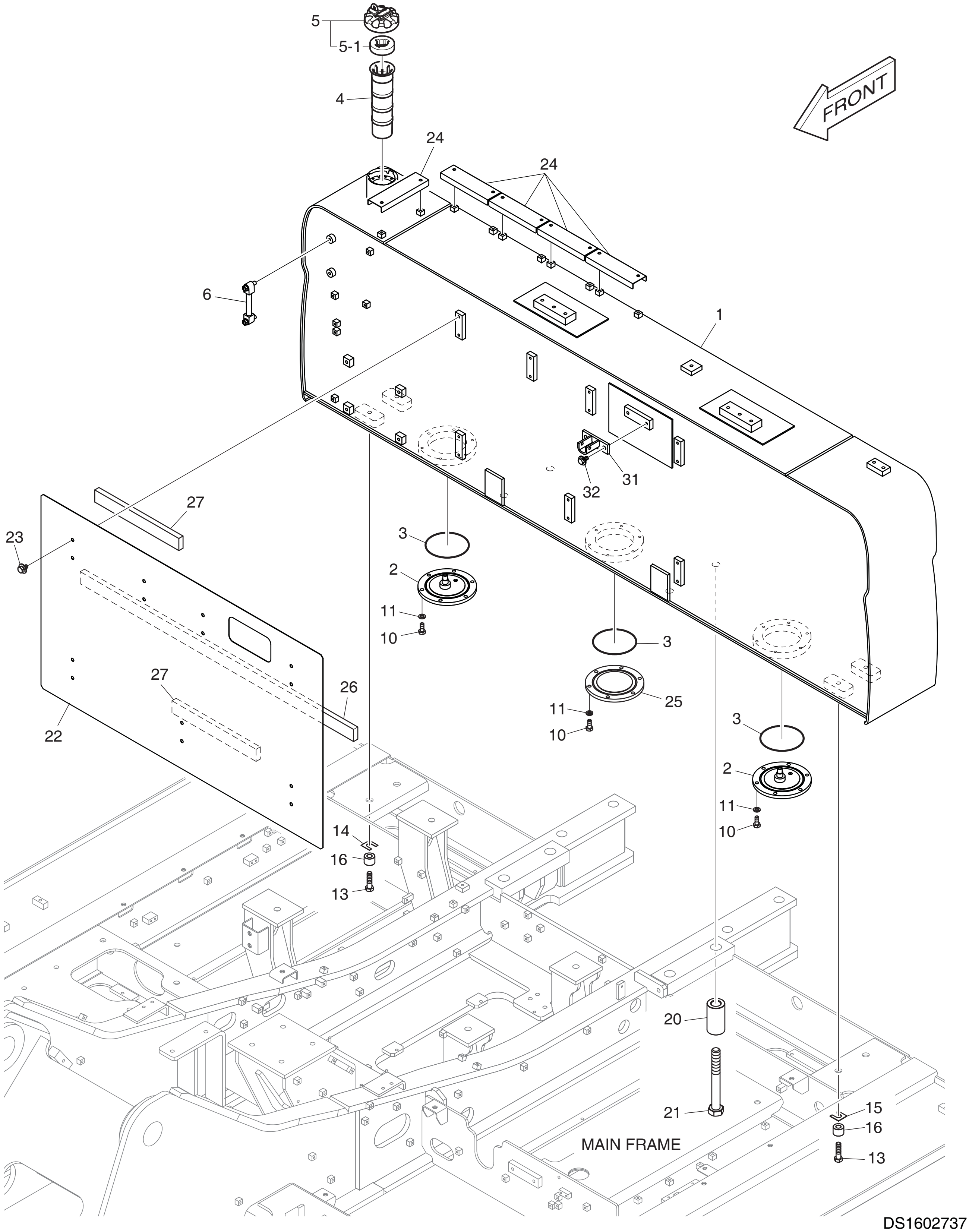


Figure 2

Reference Number	Description
1	Tank, Fuel
2	Cover, Tank
3	O-ring
4	Filter, Fuel Strainer
5	Cap, Fuel
5-1	Element, Fuel Cap
6	Gauge, Level
10	Bolt
11	Washer
13	Bolt
14	Shim
15	Shim

Reference Number	Description
16	Spacer
20	Spacer
21	Bolt
22	Plate, Front
23	Bolt
24	Plate
25	Cover
26	Foam
27	Foam
31	Bracket
32	Bolt

REMOVAL (FUEL TANK 1)

WARNING

AVOID DEATH OR SERIOUS INJURY

Fire hazard!

Fuel is easily flammable.

- **Keep open flames and ignition sources away from the workplace.**

1. Look at fuel level display (Figure 3) on instrument panel in operator's cabin to see what it displays. The display is divided into seven separated segments. 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.*

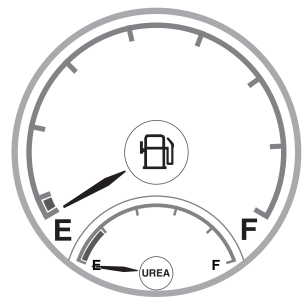


Figure 3

2. Make the machine swing about 60° rightward on the flat ground as shown in (Figure 4) before lowering all the attachments on the ground.

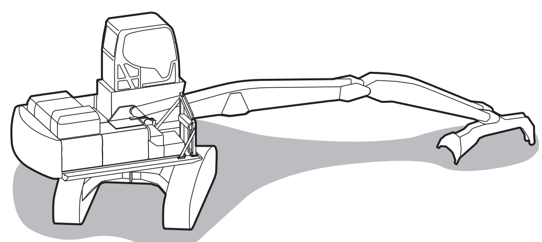


Figure 4

3. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 5)
4. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

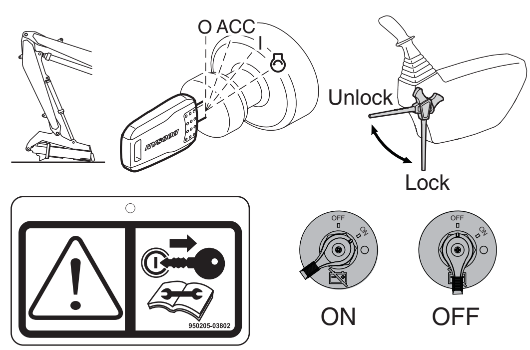


Figure 5

5. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
6. Move safety lever to "LOCK" position. (Figure 5)
7. Turn key to "O" (OFF) position and remove from starter switch.

8. Attach a maintenance warning tag on controls.

9. Turn battery disconnect switch to "OFF" position. (Figure 6)

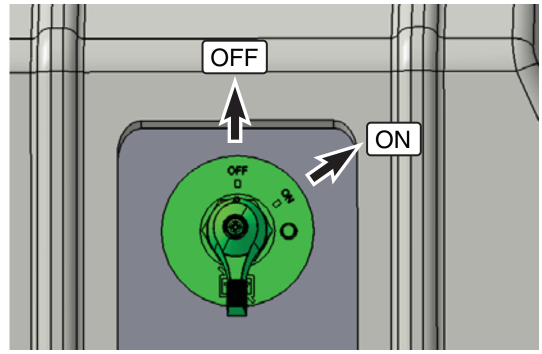
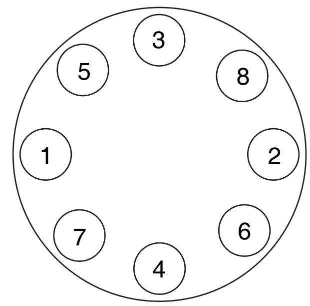


Figure 6 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 7

10. Clean area around fuel tank fill cap. Open fuel cap.

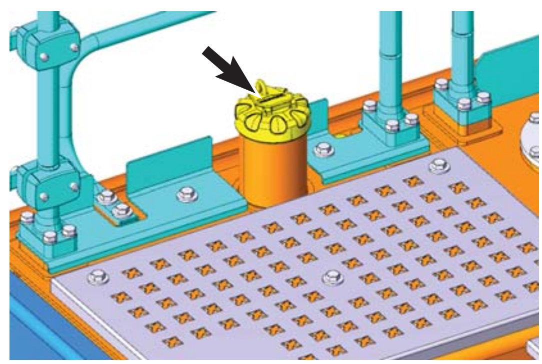


Figure 8 DS1602802

11. Open drain valve (Figure 9) right side door and carefully drain.

    - Fuel tank capacity: 400 L (106 U.S. gal)

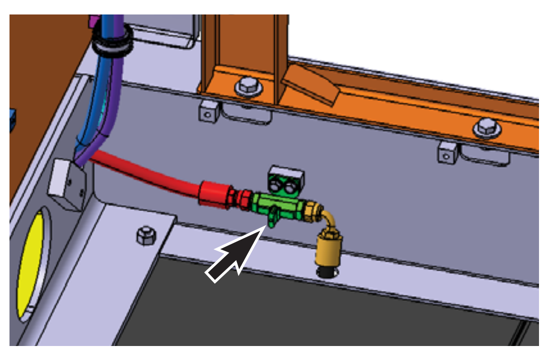
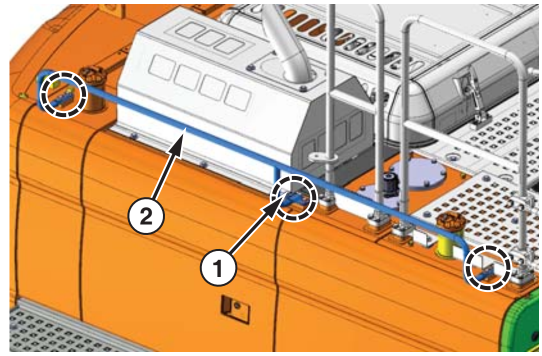


Figure 9 Pump Room EX1402322

12. Remove bolts (1, Figure 10) (6 ea) with hand rail (2).

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)



DS1602636

Figure 10

13. Remove bolts and washers (1, Figure 11) (10 ea) with the guardrail (2) (1 ea).
14. Remove bolts (3, Figure 11) (5 ea) and cover (4) from fuel tank.

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Tank cover weight: 6.4 kg (14.1 lb)
    - Guardrail weight: 12.5 kg (27.6 lb)

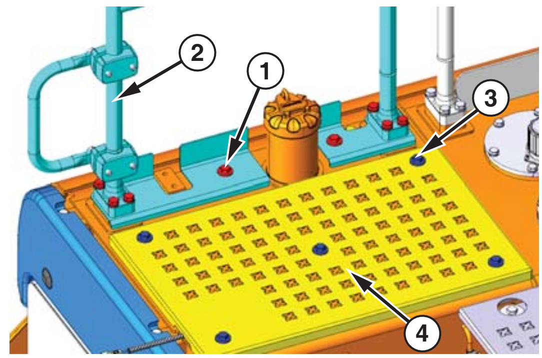


Figure 11

DS1602803

15. Open the engine cover and remove bolts and washers (1, Figure 12) (4 ea) with cover (2).

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Cover weight: 18 kg (40 lb)

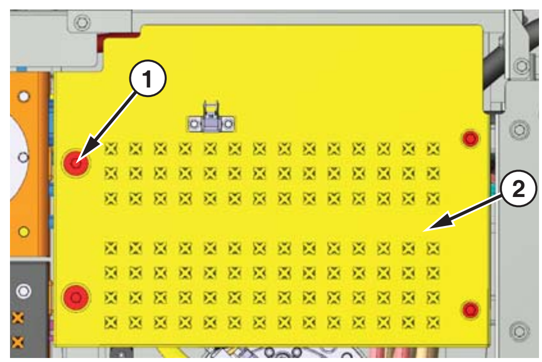


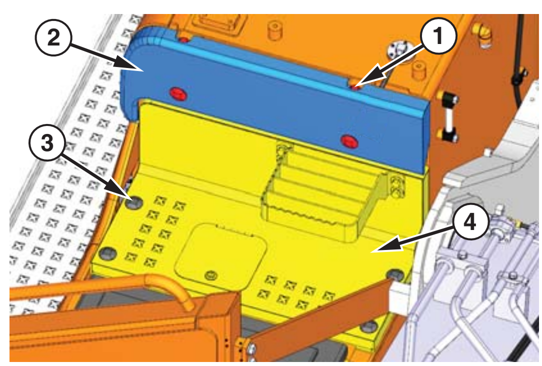
Figure 12

DS1602642

16. Remove bolts (1, Figure 13) (4 ea) with the tank front cover (2) from fuel tank.
17. Remove bolts (3, Figure 13) (4 ea) with step support (4) from storage box.

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Weight

Reference Number	Description	kg (lb)
2	Tank Front Cover	5 (11)
4	Step Support	23 (50.7)



DS1602804

Figure 13

18. Disconnect the connector of fuel sensor (A) and urea tank harness (B).

NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

19. Remove bolts (1, Figure 14) (4 ea) and clips with harness.

- Tool: 12 mm ( )
- Torque: 29.4 N.m (3 kg.m, 21.7 ft lb)

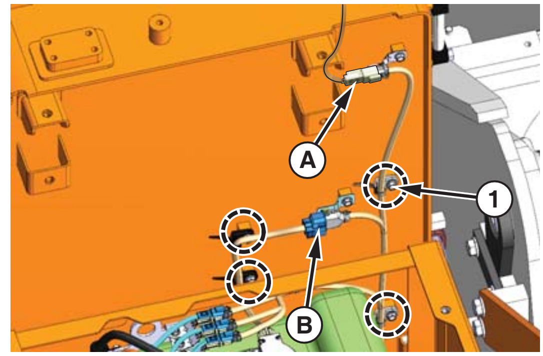


Figure 14 DS1602805

How to disconnect the harness connector.

A. Fuel sensor

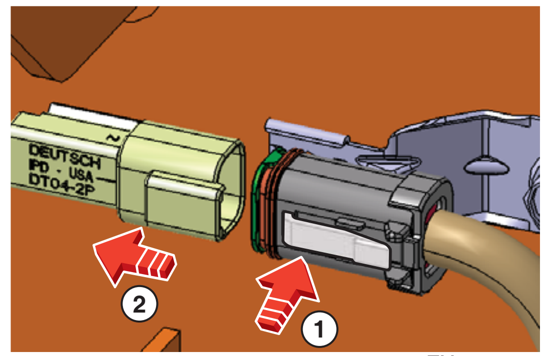


Figure 15 EX1402326

B. Urea tank

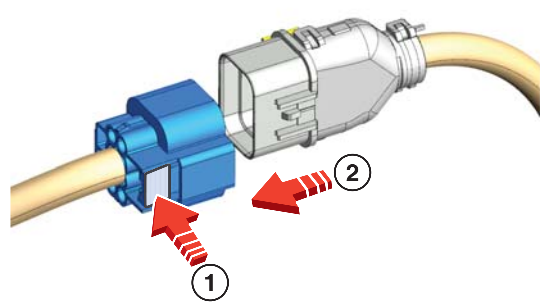


Figure 16 DS1602806

20. Remove hose from fuel tank.
    - Tool for clip (1): ⊖ Driver
21. Remove bolt (3, Figure 12) (1 ea) and clip.
    - Tool: 12 mm ( )
    - Torque: 29.4 N.m (3 kg.m, 21.7 ft lb)

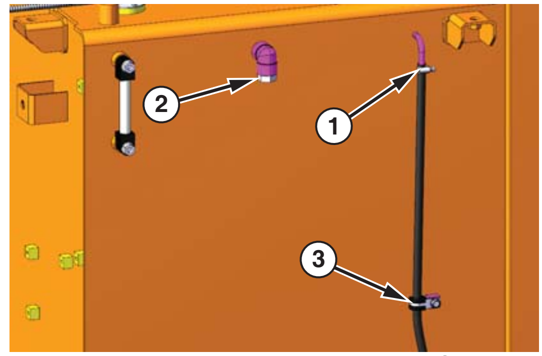


Figure 17

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
2	Plug	PF 1/2"	27	93.1	9.5	68.7

- Fittings

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
2	O-ring	S8000185 (4D P18)					

* A: Opposite side of hose, B (C): Hose side

22. Install eyebolts (2 ea) on the fuel tank.

    And tie the rope to the bolts to lift tank.
    - Thread of hole: M12 x 1.75 and PF1/4"
    - Fuel tank weight: 189 kg (416 lb)

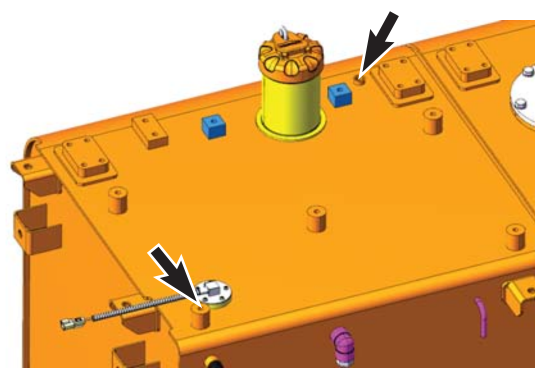


Figure 18

23. Remove bolts (1, Figure 19) (2 ea) from fuel tank.
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

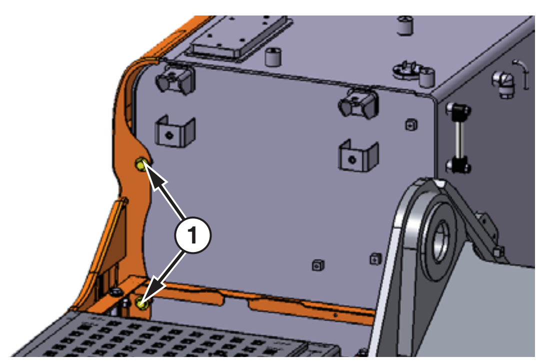


Figure 19

24. Open the right side door, remove bolts (2 ea) with tank side cover (Figure 20).

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Tank cover weight: 57 kg (126 lb)

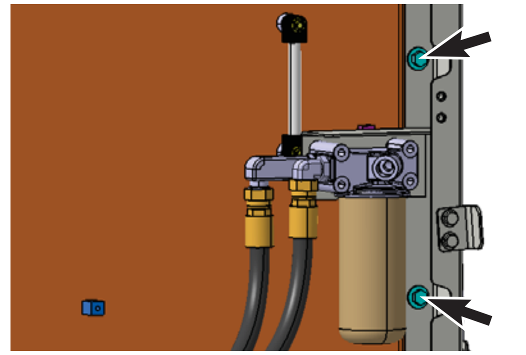
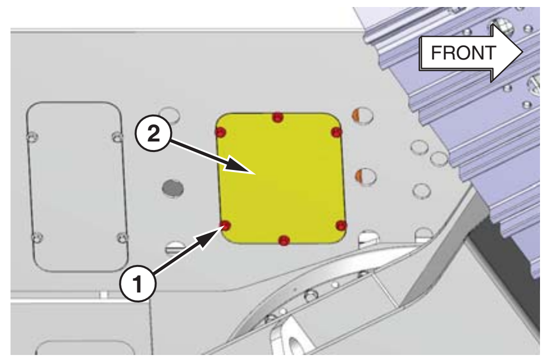


Figure 20 EX1402330

25. Remove bolts and washers (1, Figure 21) (6 ea) with under covers (2) on bottom of main frame.

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Weight: 10 kg (22 lb)



DS1602809

Figure 21 Bottom of Main Frame

26. When disconnecting the hose, fuel left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 22 EX1504170

27. Remove hoses and adapter from fuel tank

NOTE: *Cap the open ends of hose with plug.*

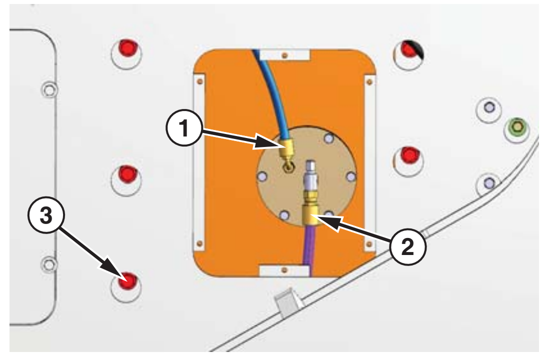


Figure 23 Bottom of Main Frame DS1602810

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
1	to Drain Valve	UNF 11/16"-16-2B	21	38.2	3.9	28.2
2	Supply Line	UNF 13/16"-16-2B	24	55.9	5.7	41.2

- Fittings

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
2	Tee	UNF 13/16"-16	UNF 13/16"-16, UNF 9/16"-18	24	55.9	5.7	42.2
1	O-ring	S8030061 (1B F-06)					
2	O-ring	S8030081 (1B F-08)	S8030081 (1B F-08), 2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

28. Remove fuel tank mounting bolts and spacers (3, Figure 23) (6 ea) from the main frame.

- Tool: 24 mm ( )

29. Lift tank 25 mm and make sure it is balanced.
30. Make sure there are no other electrical wires or hoses connected to tank.
31. Completely remove tank after inspection

- Fuel tank weight: 189 kg (416 lb)

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

INSTALLATION (FUEL TANK 1)

NOTE: *First, assemble the bolts and spacers (6 ea) of fuel tank mounting to main frame. (Figure 24)*

1. Install the fuel tank with bolts and spacers (3, Figure 24) (6 ea) to the main frame.
   - Tool: 24 mm ()
   - Torque: 264.6 N.m (27 kg.m, 195.2 ft lb)

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

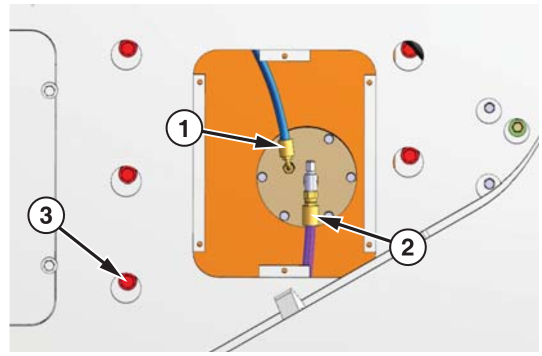


Figure 24 Bottom of Main Frame DS1602810

2. Connect fuel supply line (2, Figure 24) and drain valve line (1) to fuel tank.
3. Perform installation in the reverse order to remove.
4. Make sure fuel tank drain valve (Figure 25) right side door is closed.
5. Fill fuel tank and check for signs of leaks. Correct any problems found.
6. Fuel tank capacity: 400 L (106 U.S. gal)

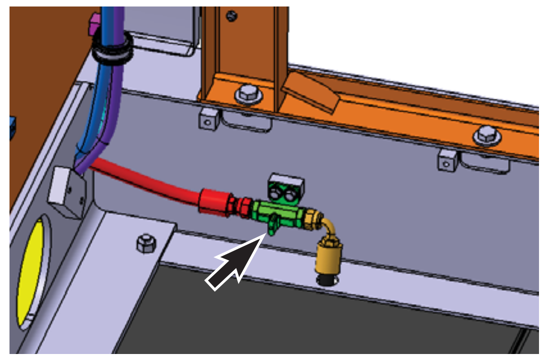


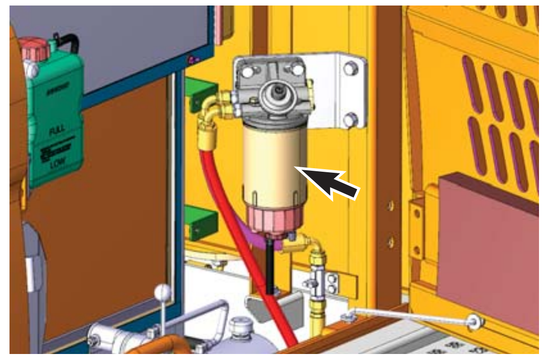
Figure 25 Pump Room EX1402322

COMPLETING WORK (FUEL TANK 1)

If air remains in the fuel inlet line to the engine, it can cause the engine to run in an abnormal condition. Air may impact the starting capability of the engine, and may also result in surging engine speeds.

If the machine happens to have run out of fuel, or if the fuel filter has been replaced, bleed the air out using the following procedure:

1. Stop engine.
2. Open left side door and then there is fuel filter.



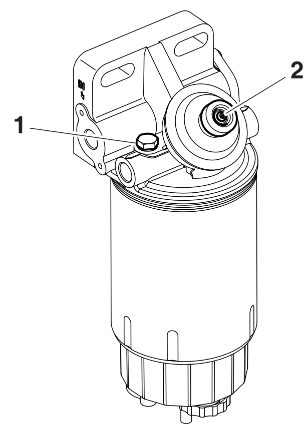
DS1602824

Figure 26

3. Check that fuel valve is open.
4. Open fuel drain valve.
5. Loosen plug (1, Figure 27) on the fuel prefilter head.
6. Pump the hand-operated primer pump (2, Figure 27) on the fuel prefilter. Pump primer until fuel is present at plug hole in fuel prefilter head.
7. Tighten plug (1, Figure 27) in fuel prefilter head.

   NOTE: *Plug tightening torque: 6.5 N.m (0.66 kg.m, 4.8 ft lb)*

8. Continue to pump primer pump until a strong resistance is felt.
9. Start engine and look for signs of leaks.
10. Repeat procedure if necessary.



EX1401866

Figure 27

REMOVAL (FUEL TANK 2)

WARNING

AVOID DEATH OR SERIOUS INJURY

Fire hazard!

Fuel is easily flammable.

- **Keep open flames and ignition sources away from the workplace.**

1. Look at fuel level display (Figure 28) on instrument panel in operator's cabin to see what it displays. The display is divided into seven separated segments. 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.*

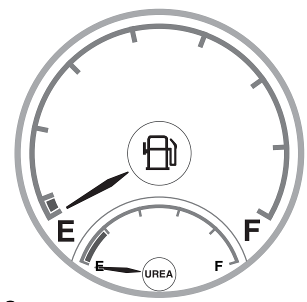


Figure 28 EX1300964

2. Park on firm and level ground.
3. Lower front attachment (bucket) to ground. (Figure 29).
4. Stop engine.

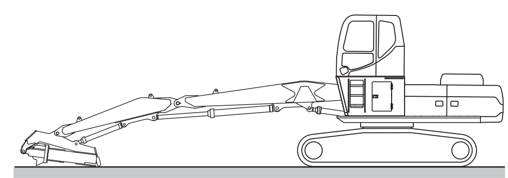


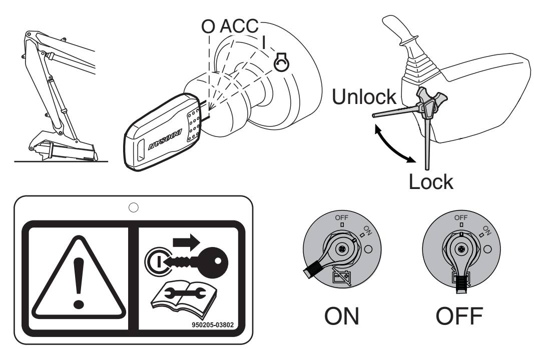
Figure 29 EX1300554

5. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 30)
6. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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



EX1504829

Figure 30

7. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
8. Move safety lever to "LOCK" position. (Figure 30)
9. Turn key to "O" (OFF) position and remove from starter switch.
10. Attach a maintenance warning tag on controls.

11. Turn battery disconnect switch to "OFF" position. (Figure 31)

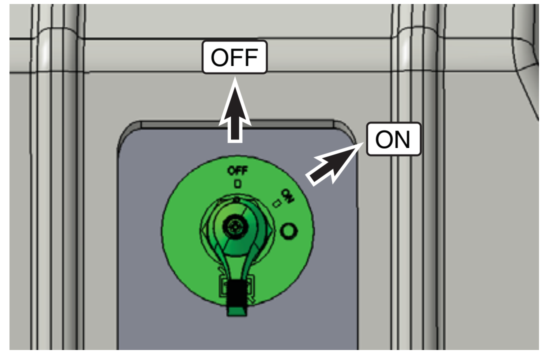
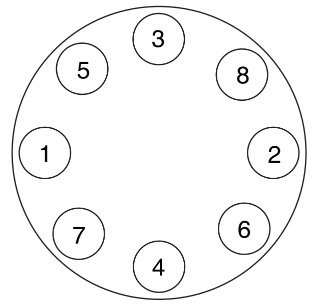


Figure 31 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 32

12. Clean area around fuel tank fill cap. Open fuel cap.

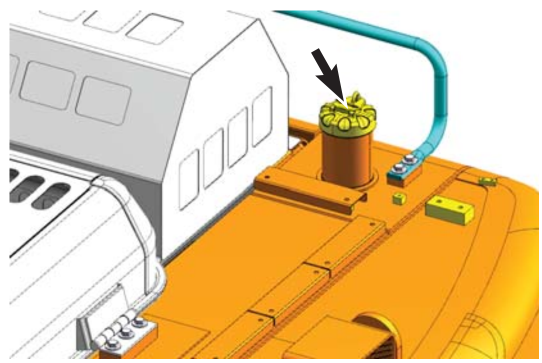
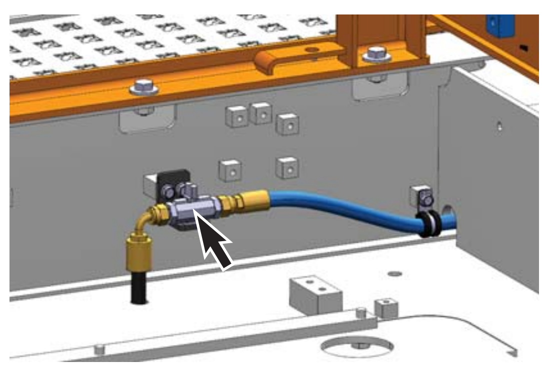


Figure 33 DS1602817

13. Open drain valve (Figure 34) right side door and carefully drain.

    - Fuel tank capacity: 606 L (160 U.S. gal)



DS1602818

Figure 34 Pump Room

14. Remove bolts (1, Figure 35) (6 ea) with right side hand rail (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

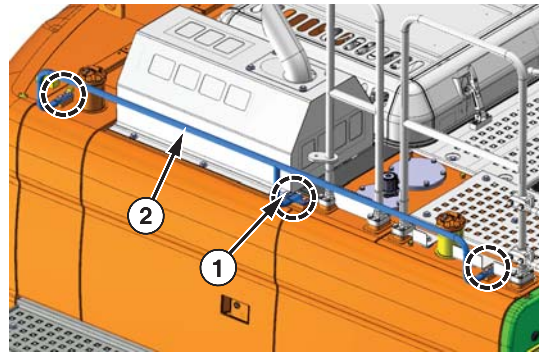


Figure 35

15. Remove bolts (1, Figure 36) (6 ea) with left side hand rail (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

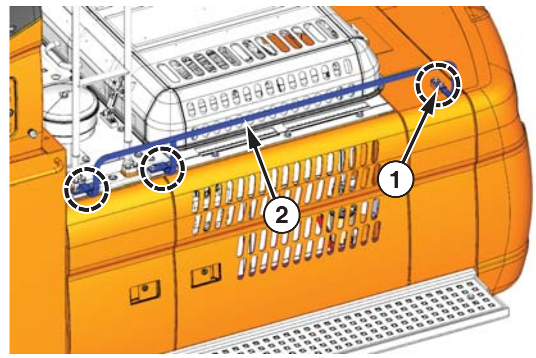


Figure 36

16. Remove bolts and nuts (1, Figure 37) (2 ea) with gas springs (2 ea) from engine cover.
    - Tool: 13 mm ( )
17. Remove lock pin (2, Figure 37) with stay from support.

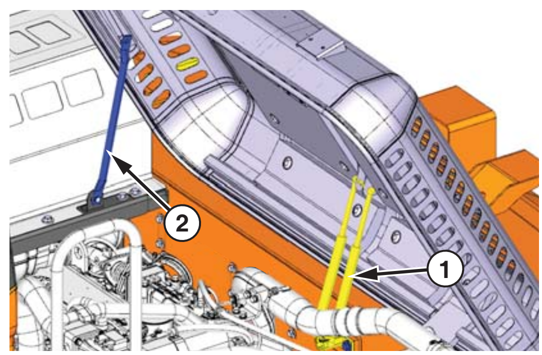


Figure 37

18. Remove bolts (1, Figure 38) (6 ea) with engine cover (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Engine cover weight: 54 kg (119 lb)

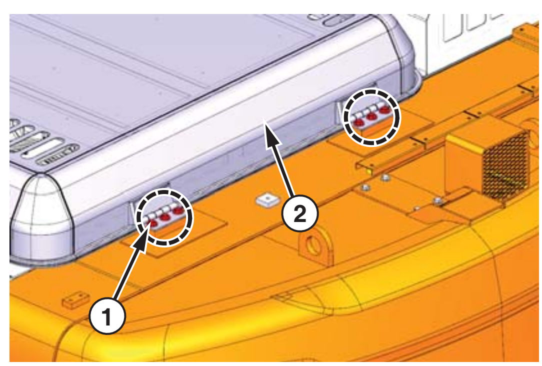


Figure 38

19. Install eyebolts (2 ea) on the fuel tank.

    And tie the rope to the bolts to lift tank.

    - Thread of hole: M12 x 1.75
    - Fuel tank weight: 439 kg (968 lb)

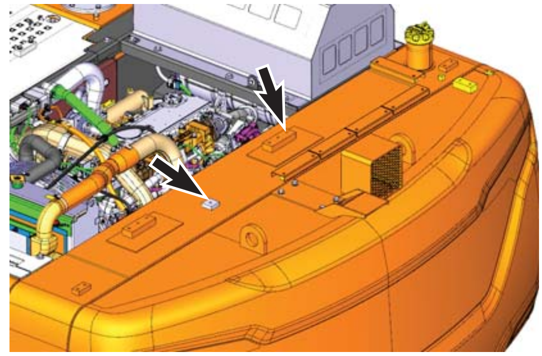


Figure 39

20. Remove bolts and washers (1, Figure 40) (8 ea) with under covers (2) (2 ea) on bottom of main frame.

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Weight: 6 kg (13 lb) (1 ea)

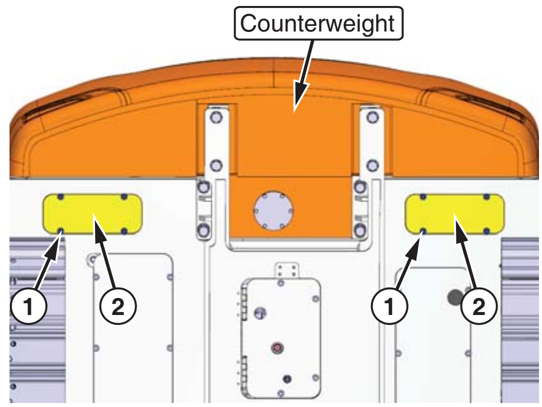


Figure 40

21. When disconnecting the hose, fuel left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 41

22. Remove hoses and adapter from fuel tank

NOTE: *Cap the open ends of hose with plug.*

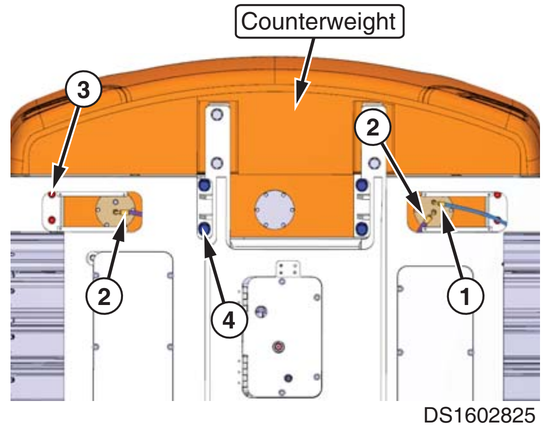


Figure 42 Bottom of Main Frame

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
1	to Drain Valve	UNF 11/16"-16-2B	21	38.2	3.9	28.2
2	Supply Line	UNF 13/16"-16-2B	24	55.9	5.7	41.2

- O-ring

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
1	O-ring	S8030061 (1B F-06)					
2		S8030081 (1B F-08)					

* A: Opposite side of hose, B (C): Hose side

23. Remove fuel tank mounting bolts and spacers (3 and 4, Figure 42) (8 ea) from the main frame.
    - Bolt (3) (4 ea):
      - Tool: 24 mm ( )
    - Bolt (4) (4 ea):
      - Tool: 46 mm ( )
24. Make sure there are no other electrical wires or hoses connected to tank.
25. Completely remove tank after inspection.
    - Fuel tank weight: 439 kg (968 lb)

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

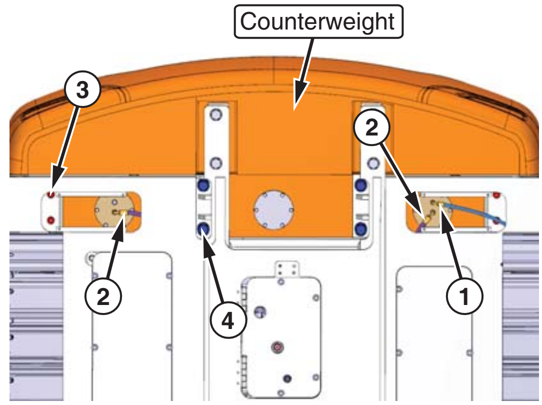
INSTALLATION (FUEL TANK 2)

NOTE: *First, assemble the bolts and spacers (8 ea) of fuel tank mounting to main frame. (Figure 43)*

1. Install the fuel tank with bolts and spacers (3 and 4, Figure 43) (8 ea) to the main frame.
   - Bolt (3):
     - Tool: 24 mm ( )
     - Torque: 264.6 N.m (27 kg.m, 195.2 ft lb)
   - Bolt (4):
     - Tool: 46 mm ( )
     - Torque: 1,471 N.m (150 kg.m, 1,085 ft lb)

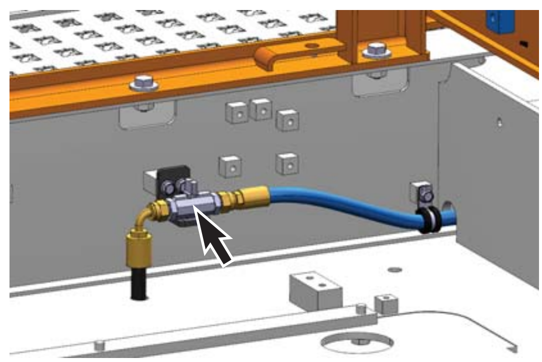
   NOTE: *The clear level gauge on the front side of the tank is easily damaged. Be careful of obstacles and wind gusts.*

2. Connect fuel supply line (2, Figure 43) and drain valve line (1) to fuel tank.
3. Perform installation in the reverse order to remove.
4. Make sure fuel tank drain valve (Figure 44) of right side door is closed.
5. Fill fuel tank and check for signs of leaks. Correct any problems found.
6. Fuel tank capacity: 606 L (160 U.S. gal)



DS1602825

Figure 43 Bottom of Main Frame



DS1602818

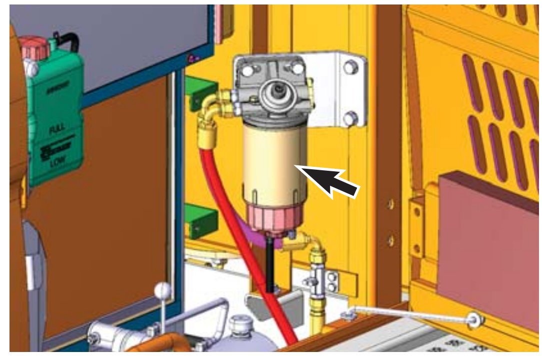
Figure 44 Pump Room

COMPLETING WORK (FUEL TANK 2)

If air remains in the fuel inlet line to the engine, it can cause the engine to run in an abnormal condition. Air may impact the starting capability of the engine, and may also result in surging engine speeds.

If the machine happens to have run out of fuel, or if the fuel filter has been replaced, bleed the air out using the following procedure:

1. Stop engine.
2. Open left side door and then there is fuel filter.



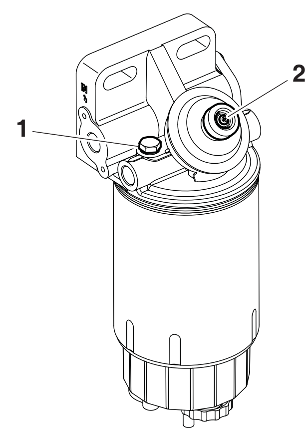
DS1602824

Figure 45

3. Check that fuel valve is open.
4. Open fuel drain valve.
5. Loosen plug (1, Figure 46) on the fuel prefilter head.
6. Pump the hand-operated primer pump (2, Figure 46) on the fuel prefilter. Pump primer until fuel is present at plug hole in fuel prefilter head.
7. Tighten plug (1, Figure 46) in fuel prefilter head.

   NOTE: *Plug tightening torque: 6.5 N.m (0.66 kg.m, 4.8 ft lb)*

8. Continue to pump primer pump until a strong resistance is felt.
9. Start engine and look for signs of leaks.
10. Repeat procedure if necessary.



EX1401866

Figure 46

Main Pump

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Main Pump

GENERAL

Specifications

Input Power	(P)	126 kW (171 PS) @ 1,800 rpm
Rated Speed	(N)	1,800 rpm
High Idle	(N)	2,200 rpm
Max. Flow	(Q max.)	2 x 214 L/min @ 1,800 rpm & 350 bar (356.9 kg/cm^2, 5,076.3 psi)
Min. Flow	(Q min.)	104 L/min @ 1,800 rpm
Max. Displacement	(V g max.)	120 cc/rev x 2
Weight		120 kg (265 lb)

Control Pressure

Beginning of Regulation	(P)	10 bar (10 kg/cm^2, 145 psi)
End of Regulation	(P)	24.3 bar (24.7 kg/cm^2, 352 psi) @ 50 L/min

Pilot Pressure Pump Relief Valve

Pilot Pressure	(P)	39 ±2 bar (40 ±2 kg/cm^2, 569 ±28 psi) @ 1,800 rpm

Performance Curves

1. P - Q Curve

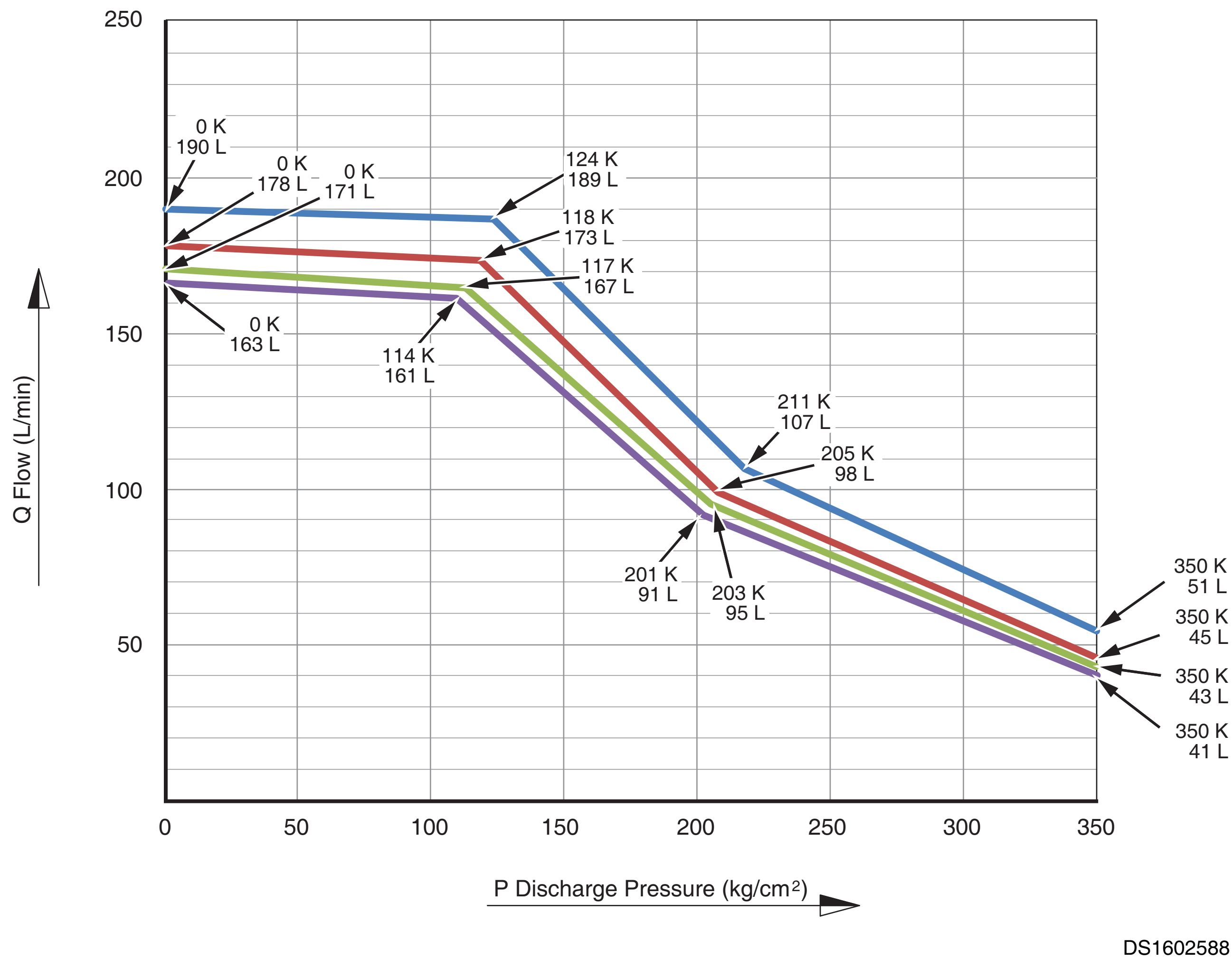
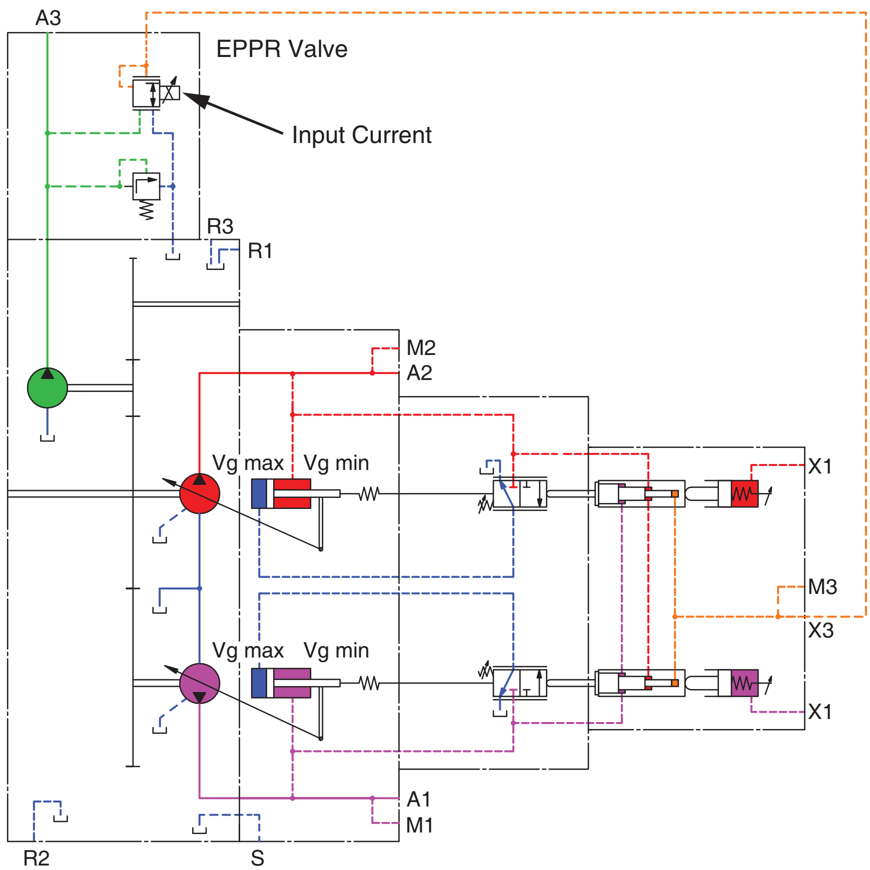
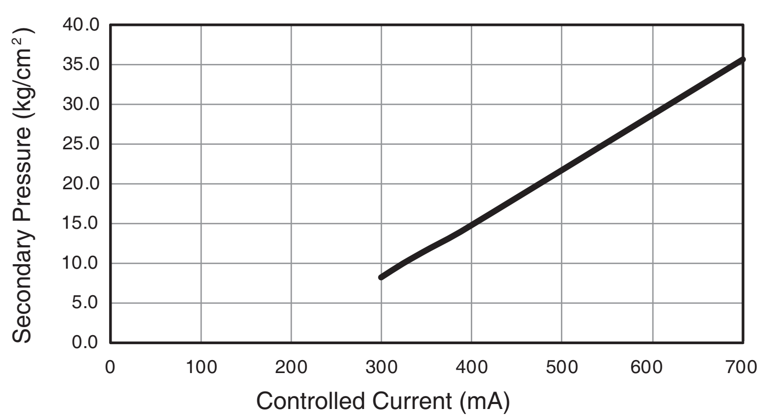


Figure 1

Mode	Input (rpm)	Input Current (mA)	Secondary Pressure (bar (kg/cm²))	Remarks
Power Plus	1,800	300	8.0 (8.2)	Variable
Power	1,700	325	9.8 (10.0)	
Standard	1,650	355	11.7 (12.0)	
Economy	1,600	395	14.2 (14.5)	

2. P - I Curve





DS1602561

Figure 2

Overview

This pump is a pressure control type which has an axial piston variable double pump structure equipped with two axial piston rotary groups in a joint shaft design for hydraulic drive. It consists of the EPPR valve to control the pump's pressure, regulator to control the swivel angle of the pump, pilot sensor to convert the pump displacement flow into an electric signal, gear pump for pilot pressure, PTO for an optional pump, and pump cover to be engaged with the engine to fix the pump.

Port

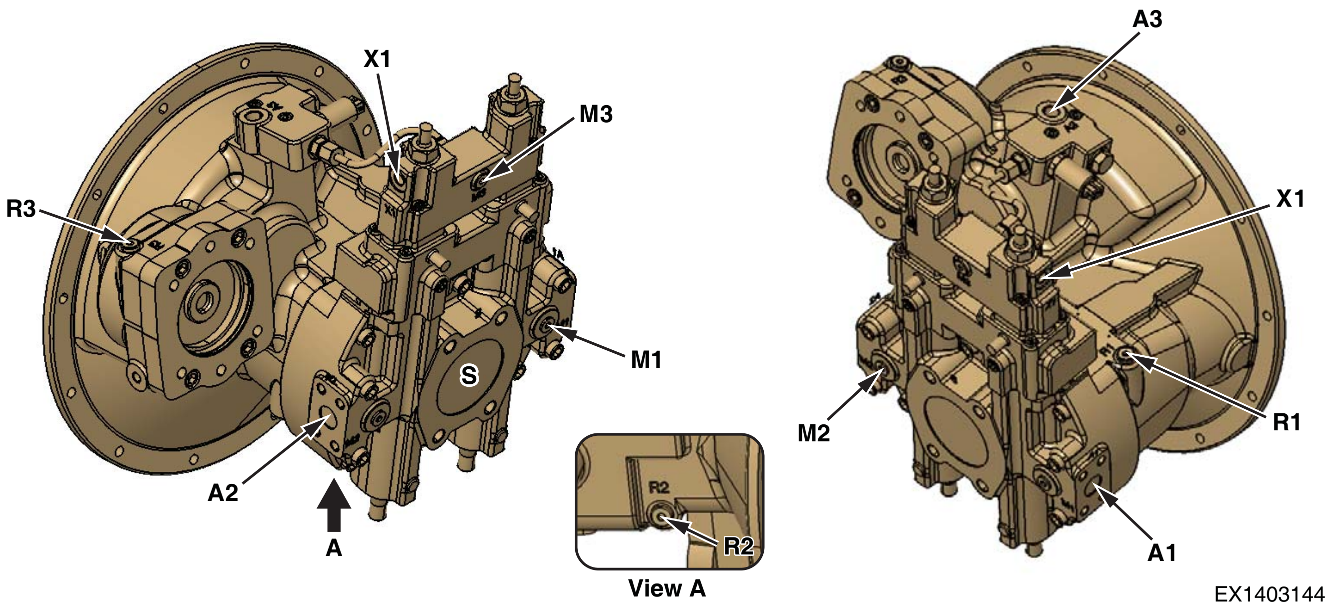


Figure 3

Port	Description	Size
S	Suction Port	SAE 3 1/2"
A1	Piston Pump Delivery Port	SAE 1"
A2	Piston Pump Delivery Port	
A3	Gear Pump Delivery Port (39 bar (40 kg/cm^2))	M18 x 1.5
X1	Control Pressure Ports for Negative Control (ps1 and ps2)	M14 x 1.5
M1	Measurement Port A1	UNF 9/16"-18-2B
M2	Measurement Port A2	
M3	Measurement Port for Power Override	M14 x 1.5
R1	Air Bleed Port	
R2	Drain port	
R3	Air Bleed Port	

Hydraulic Circuit

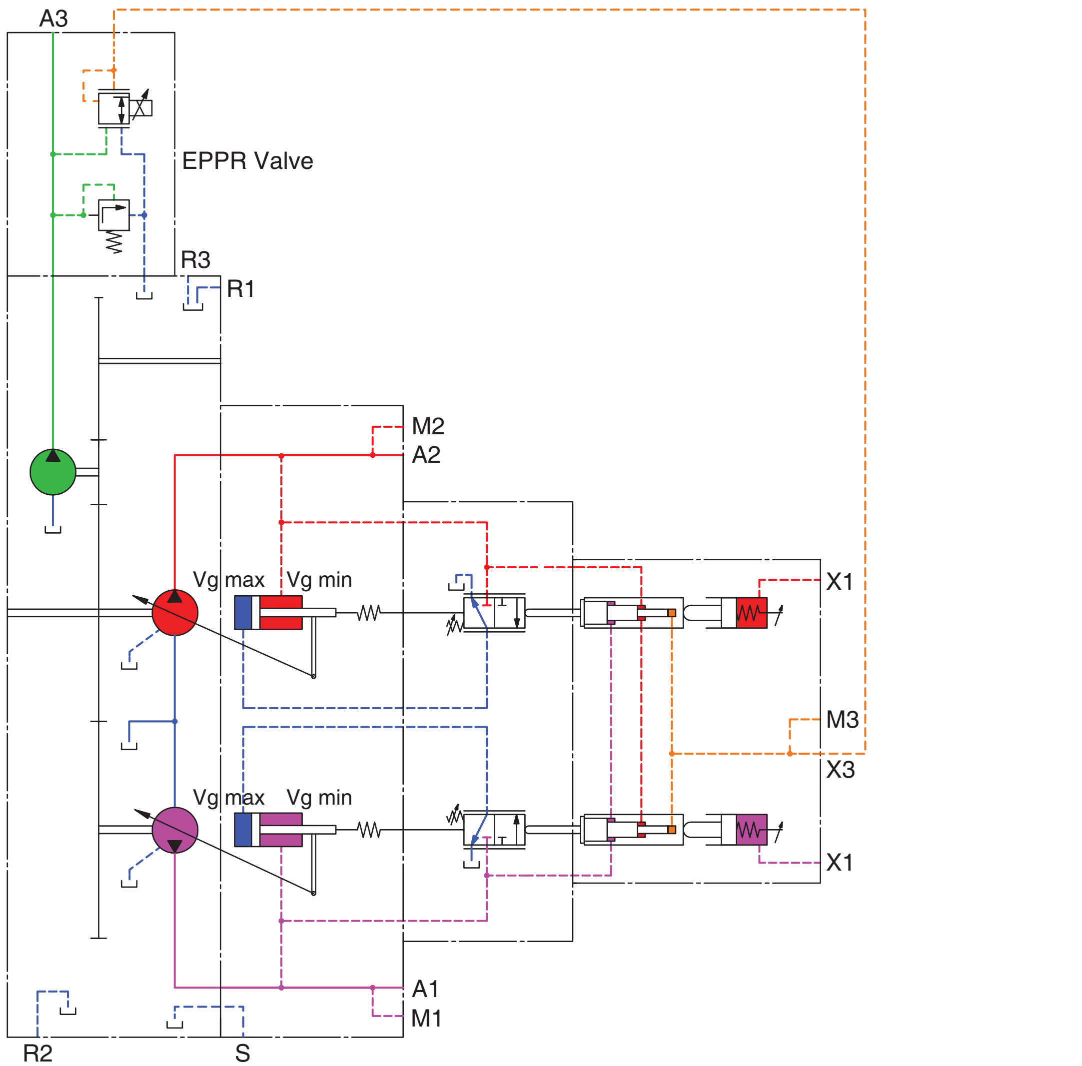


Figure 4

Parts List

The exploded view of the pump shows the parts necessary for internal repair and assembling and the parts available when required.

Rotary Group

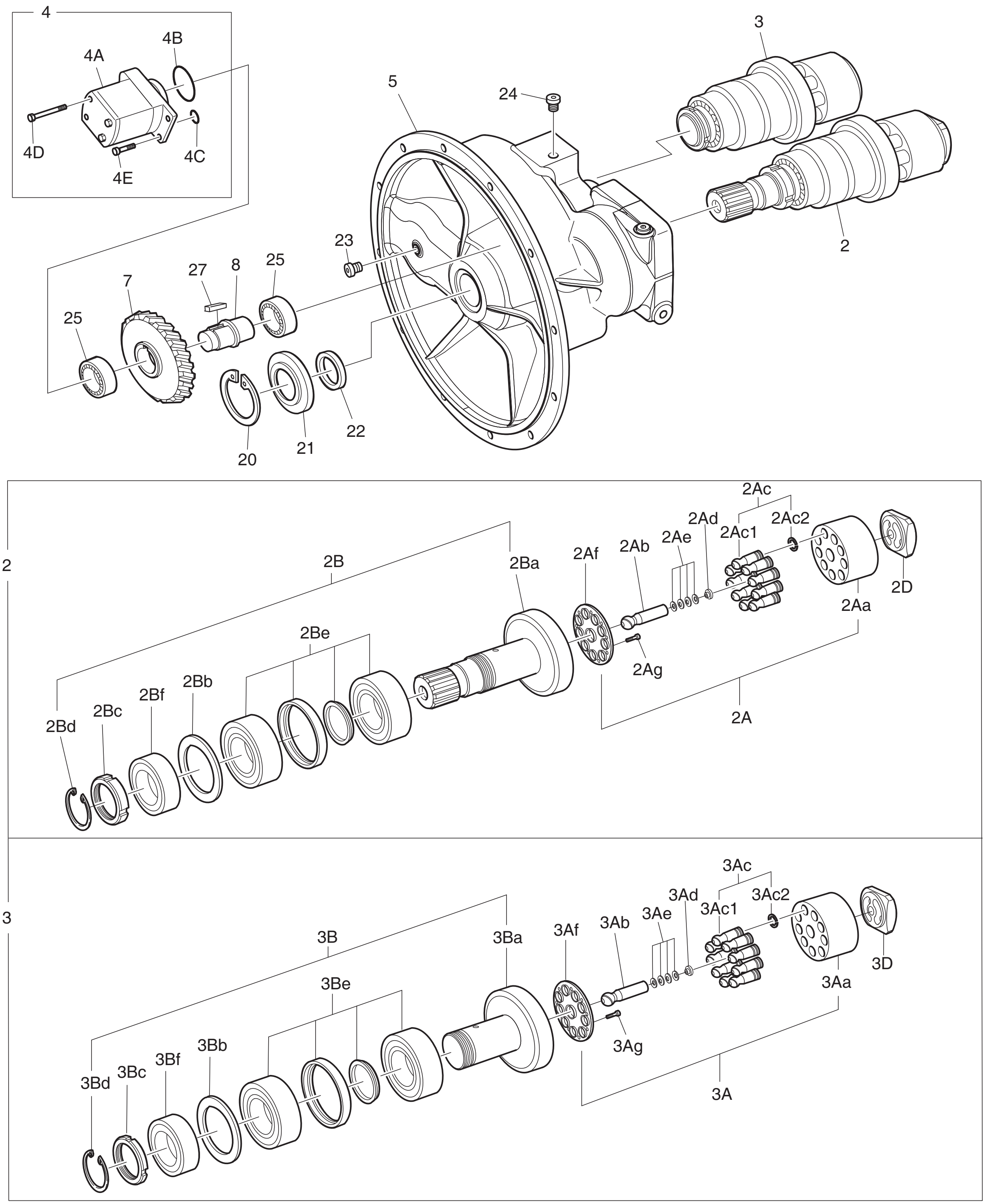


Figure 5 EX1403163

Reference Number	Description
2	Rotary Group
2A	Rotary Group. Hydraulic Section
2Aa	Cylinder
2Ab	Pin; Center
2Ac	Piston & Piston Rings
2Ac1	Piston
2Ac2	Ring; Steel Sealing
2Ad	Collar, Spring
2Ae	Cup Spring
2Af	Plate; Retaining
2Ag	Bolt
2B	Shaft with Bearing Assembly
2Ba	Shaft; Drive
2Bb	Shim
2Bc	Plate, Backup
2Bd	Ring; Retaining
2Be	Bearing; Unit Tapered-roller
2Bf	Bearing; Tapered-roller
2D	Lens; Control Right-hand
3	Rotary Group
3A	Rotary Group. Hydraulic Section
3Aa	Cylinder
3Ab	Pin; Center
3Ac	Piston & Piston Rings
3Ac1	Piston
3Ac2	Ring; Steel Sealing
3Ad	Collar, Spring

Reference Number	Description
3Ae	Cup Spring
3Af	Plate; Retaining
3Ag	Bolt
3B	Shaft With Bearing Assembly
3Ba	Shaft; Drive
3Bb	Shim
3Bc	Plate, Backup
3Bd	Ring; Retaining
3Be	Bearing; Unit Tapered-roller
3Bf	Bearing; Tapered-roller
3D	Lens; Control Left-hand
4	Gear Pump Assembly
4A	Pump; Gear
4B	O-ring
4C	O-ring
4D	Bolt; Socket
4E	Bolt; Socket M8 x 25
5	Housing; Pump
7	Gear
8	Shaft; Stub
20	Ring; Retaining
21	Ring; Shaft Seal
22	Shim
23	Screw; Locking
24	Screw; Locking
25	Bearing; Plain Roller
27	Key; Shaft

Control Part

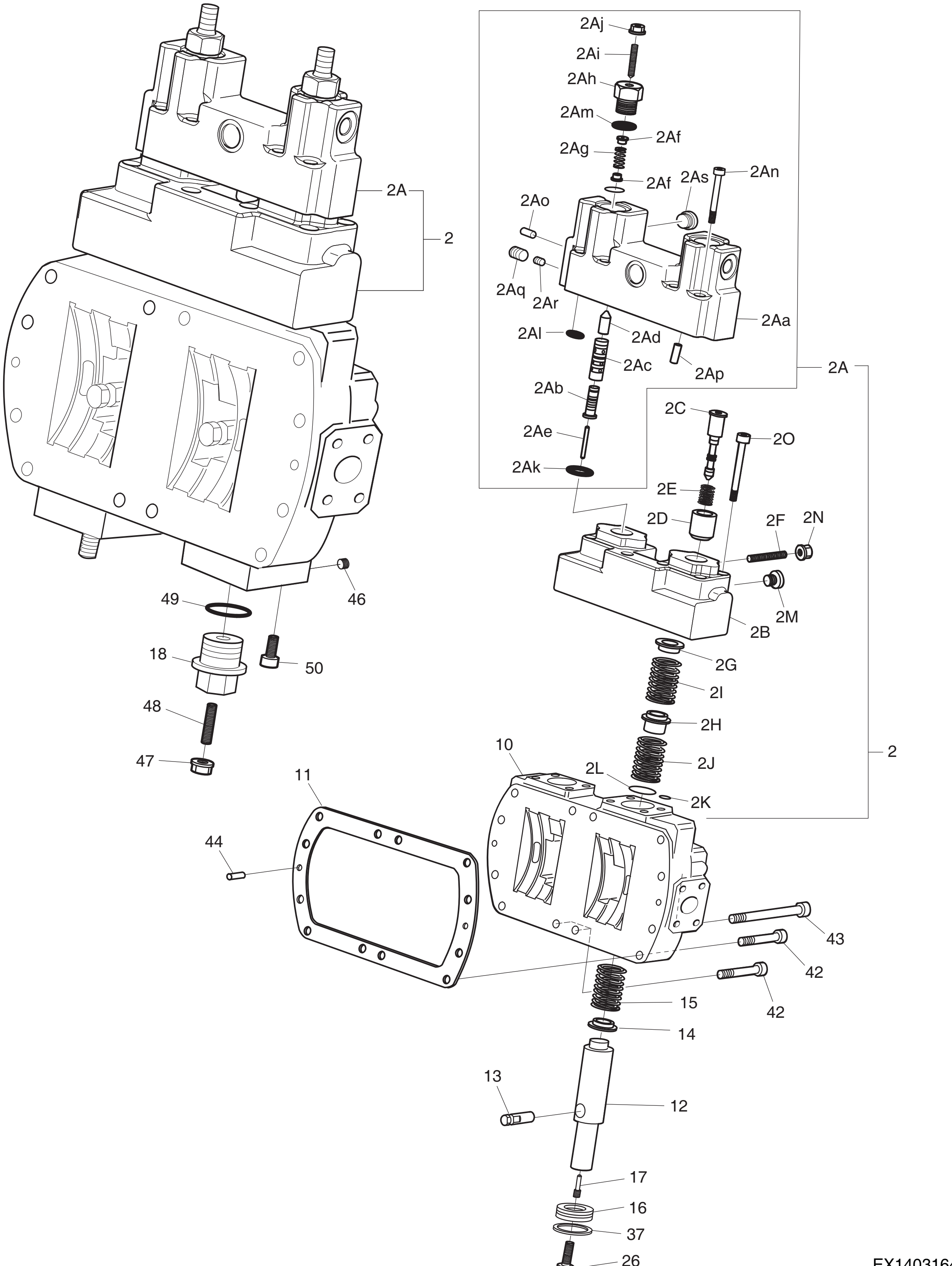


Figure 6

Reference Number	Description
2	Control Module
2A	Control Module
2Aa	Housing; Control
2Ab	Piston; Control
2Ac	Bush; Control
2Ad	Piston; Positioning
2Ae	Pin
2Af	Collar; Spring
2Ag	Spring; Pressure
2Ah	Screw; Locking
2Ai	Pin; Threaded
2Aj	Nut; Seal Lock
2Ak	O-ring
2Al	O-ring
2Am	O-ring
2An	Screw; Socket-head
2Ao	Plug
2Ap	Pin; Cylinder
2Aq	Plug
2Ar	Plug
2As	Screw; Locking
2B	Housing; Control
2C	Piston; Control
2D	Bush; Spring
2E	Spring; Pressure
2F	Pin; Threaded
2G	Collar; Spring

Reference Number	Description
2H	Collar; Spring
2I	Spring
2J	Spring
2K	O-ring
2L	O-ring
2M	Screw; Locking
2N	Nut; Seal Lock
2O	Bolt
10	Plate; Port
11	Gasket
12	Piston; Positioning
13	Trunnion; Positioning
14	Collar; Spring
15	Spring
16	Piston
17	Pin; Threaded
18	Plug
26	Screw; Hex
37	Ring; Steel Sealing
42	Bolt; Socket
43	Bolt; Socket M12 X 1.75 X 80
44	Pin; Cylinder
46	Plug
47	Nut; Seal Lock
48	Pin; Threaded
49	O-ring
50	Screw

Theory of Operation

The axial piston variable double pump with two axial tapered piston rotary groups with bent-axis design for open-circuit hydrostatic drives. The axial piston variable double pump has a common suction port (S) for both circuits and the auxiliary pump. It generates two flows for supplying two separate circuits.
Flow is proportional to drive speed and displacement.
By adjusting the bent-axis rotary groups, the two flows can be steplessly changed independent of one another. For axial piston units with bent-axis design, the pistons (3) are arranged at an angle to the driveshaft (1). When the driveshaft is turned, the cylinder (4) is picked-up and set into motion cardan free by the pistons, which are arranged in a ring on and flexibly connected to the driveshaft flange. The cylinder then rotates over the spherical control lens (5), in which two kidney-shaped control slots have been incorporated. As they turn, each of the pistons moves from top to bottom dead center and back, executing a stroke that depends on the swivel angle. The driveshaft flange of both rotary groups, which lie parallel next to one another, are interlocked. The rotary group with the long driveshaft drives the second rotary group by way of the interlocked drive-shaft flange. On the low-pressure side, fluid flows into the enlarging piston chamber. At the same time, on the pressure side the fluid is pushed out of the cylinder chamber into the hydraulic system by the pistons. The pistons are braced against the driveshaft flange by the load of the hydraulic pressure.

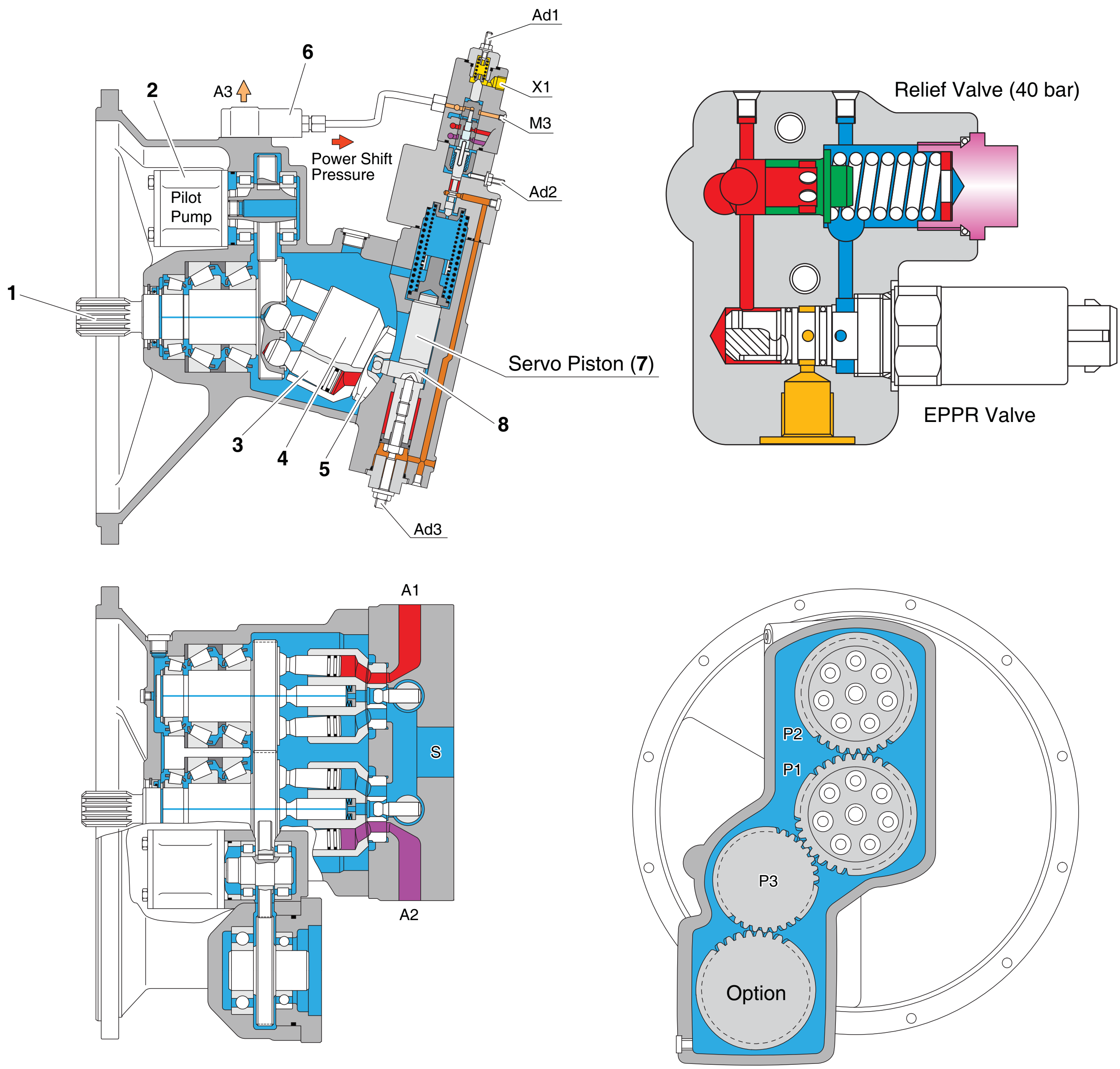


Figure 7

Reference Number	Description
1	Drive Shaft
2	Gear Pump (Pilot)
3	Piston
4	Cylinder
5	Control Lens
6	EPPR Valve

Reference Number	Description
7	Positioning Piston
8	Positioning Trunnion
S	Suction Port
A1, A2	High-pressure Delivery Port
A3	Pilot Port

Engine torque is transferred to the shaft and the seven plungers, causes the cylinder block to rotate while sliding along the valve plate surface.

The plunger oscillates in the cylinder block bores and alternately hydraulic oil is drawn and delivered.

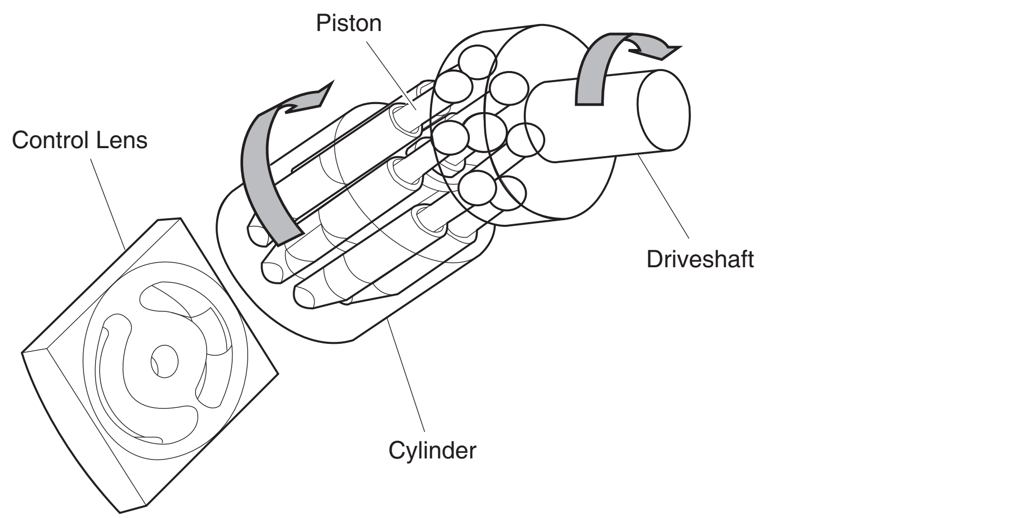


Figure 8

Increasing and Decreasing Flow Rate

Changing inclination of cylinder (4, Figure 7) causes the piston (3, Figure 7) stroke to increase or decrease depending on the slant angle in order to control the main pump flow rate.
Up-down movement of positioning piston (7, Figure 7) changes inclination of cylinder (4, Figure 7). Positioning piston (7, Figure 7) is interlocked with control lens (5, Figure 7) positioning trunnion (8, Figure 7).
The one end of cylinder (4, Figure 7) is kept in contact with the surface of control lens (5, Figure 7) and slides along it.

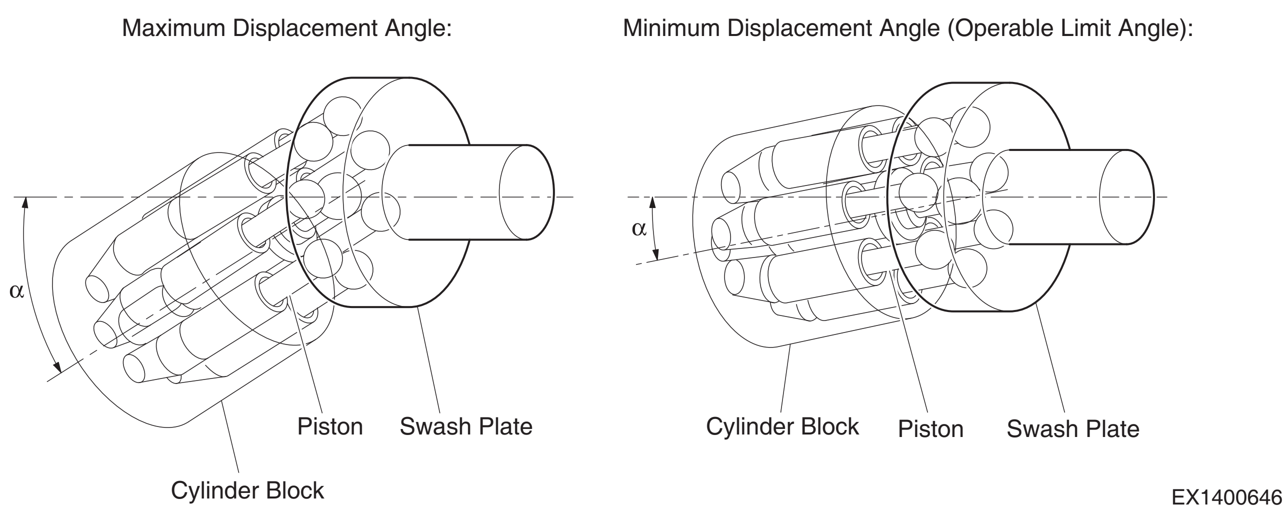


Figure 9

Pressure Control

As the magnetic pump discharge pressure A1 and the relative pump pressure A2 rise, the pump's swivel angle (discharge flow rate) is automatically decreased to limit the input torque under a certain level. (While the RPM is constant, the input power (HP) is constant as well.)

As the system is operated with the combined load pressure of double pumps in parallel, the regulator for each pump is controlled with the same swivel angle (discharge flow rate) during power control.

This mechanism prevents overload of the motor regardless of load application on two pumps.

- Pump Input Pressure (PS) = (P x Q)/450

  P: External System or Load Pressure, (P1 + P2)/2

  Q: Pump Discharge Flow Rate

Decrease of Pump Pressure

1. Decrease input pressure signal to EPPRV.
2. Regulator spool moves upward and connect the pump pressure to head side of control piston.
3. Control piston moves right and decrease swash plate.
4. Decreasing flow rate decreases pump pressure.

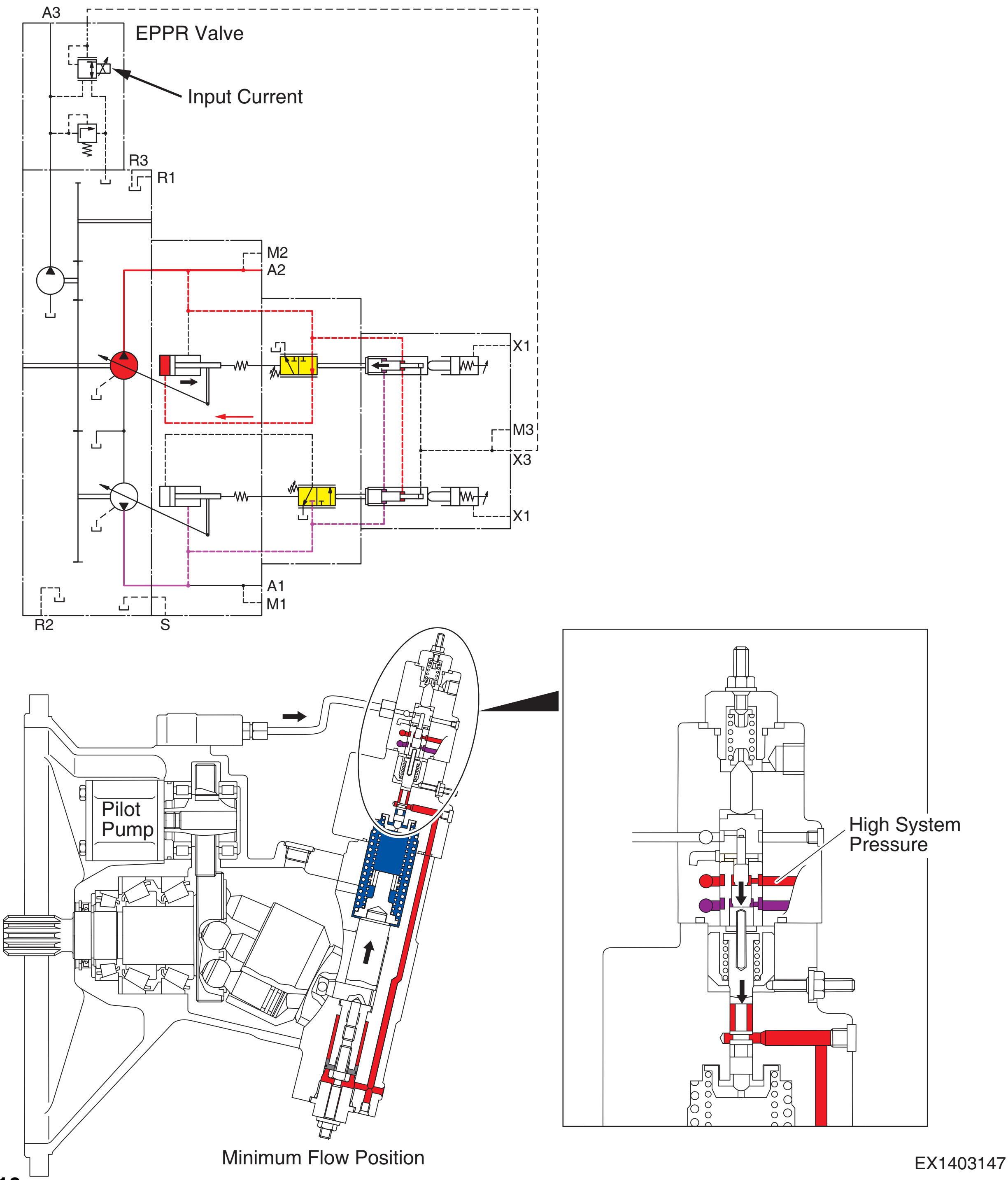


Figure 10

Increase of Pump Pressure

1. Increase input pressure signal to EPPRV.
2. Regulator spool moves downward and connect head side of control piston to drain.
3. Control piston moves left and increase swash plate.
4. Increasing flow rate increases pump pressure.

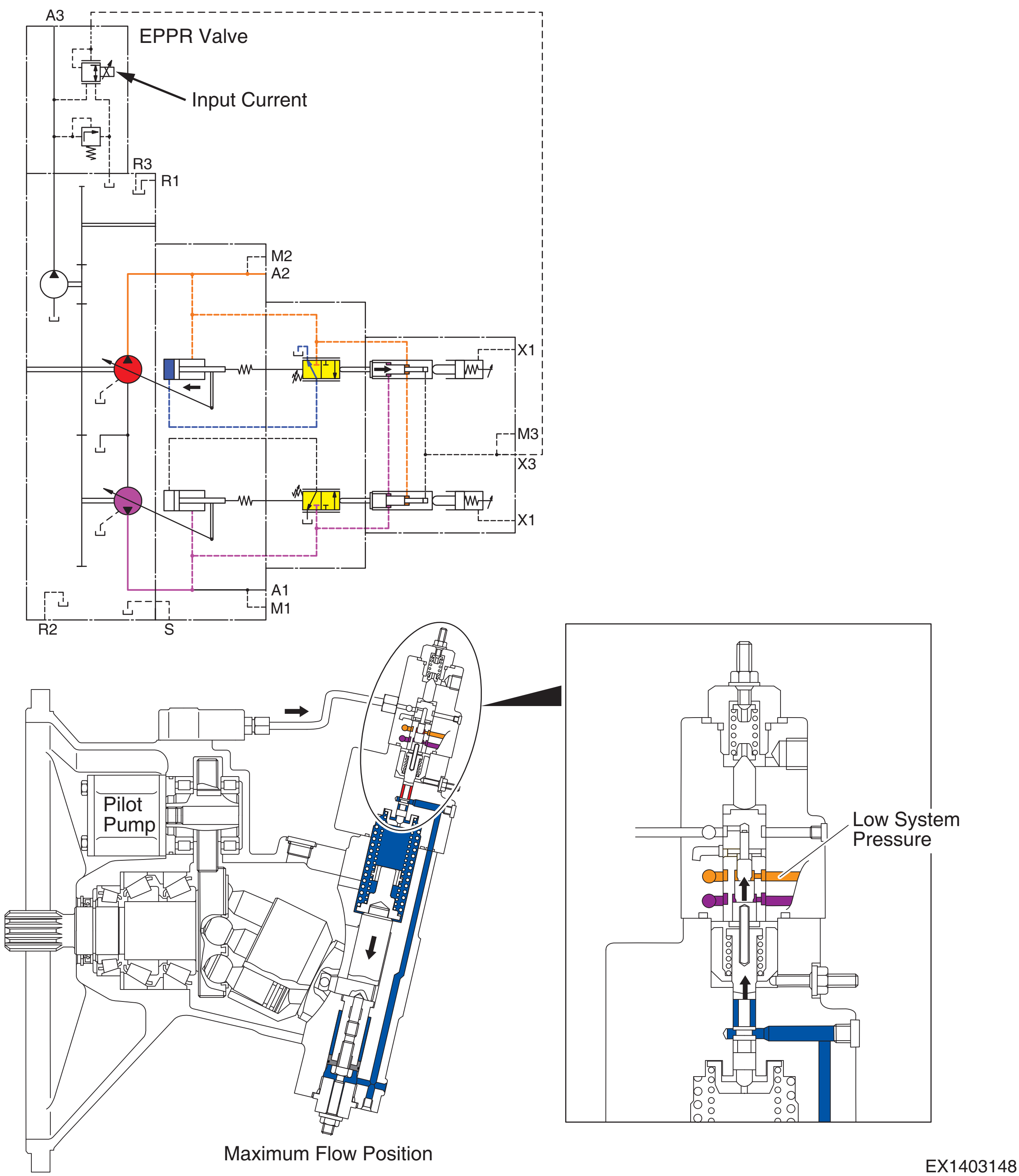


Figure 11

Flow Control

As shown in the figure below, the pump's discharge flow rate is arbitrarily controlled according to change in the pilot pressure.

The servo valve is a negative flow control type to decrease the main pump's discharge flow rate according to increase of the pilot pressure.

Therefore, fuel consumption can be decreased during operation by discharging only the required amount of oil with pilot pressure.

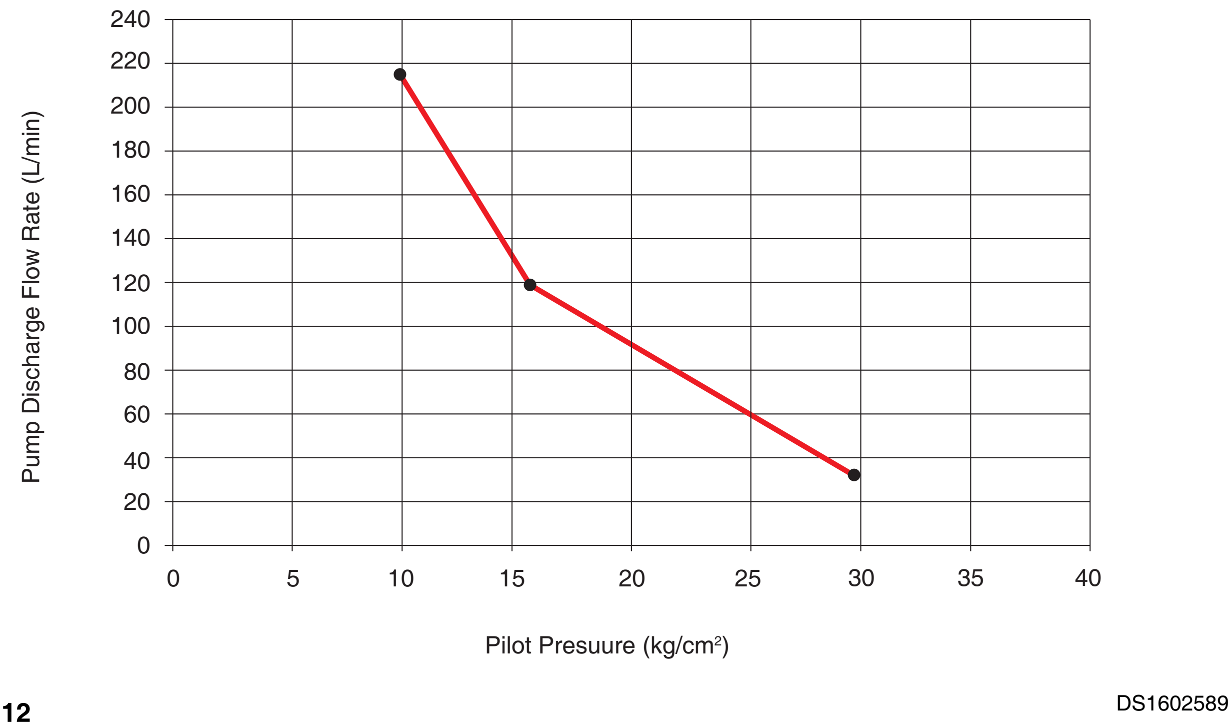


Figure 12

Decrease Oil Flow

When receiving high negacon pressure through the port ps1 or ps2 from the control valve by the operating signal (neutral position), pressure in the large-diameter chamber is increased. Even though pressure is always built in the small-diameter chamber, their volumetric difference pushes the servo piston, decreasing the angle of the swash plate and reducing the discharge flow rate of the pump. As the pump's discharge flow rate is minimized, power loss and heat by excessive oil flow from cut-out valve are prevented.

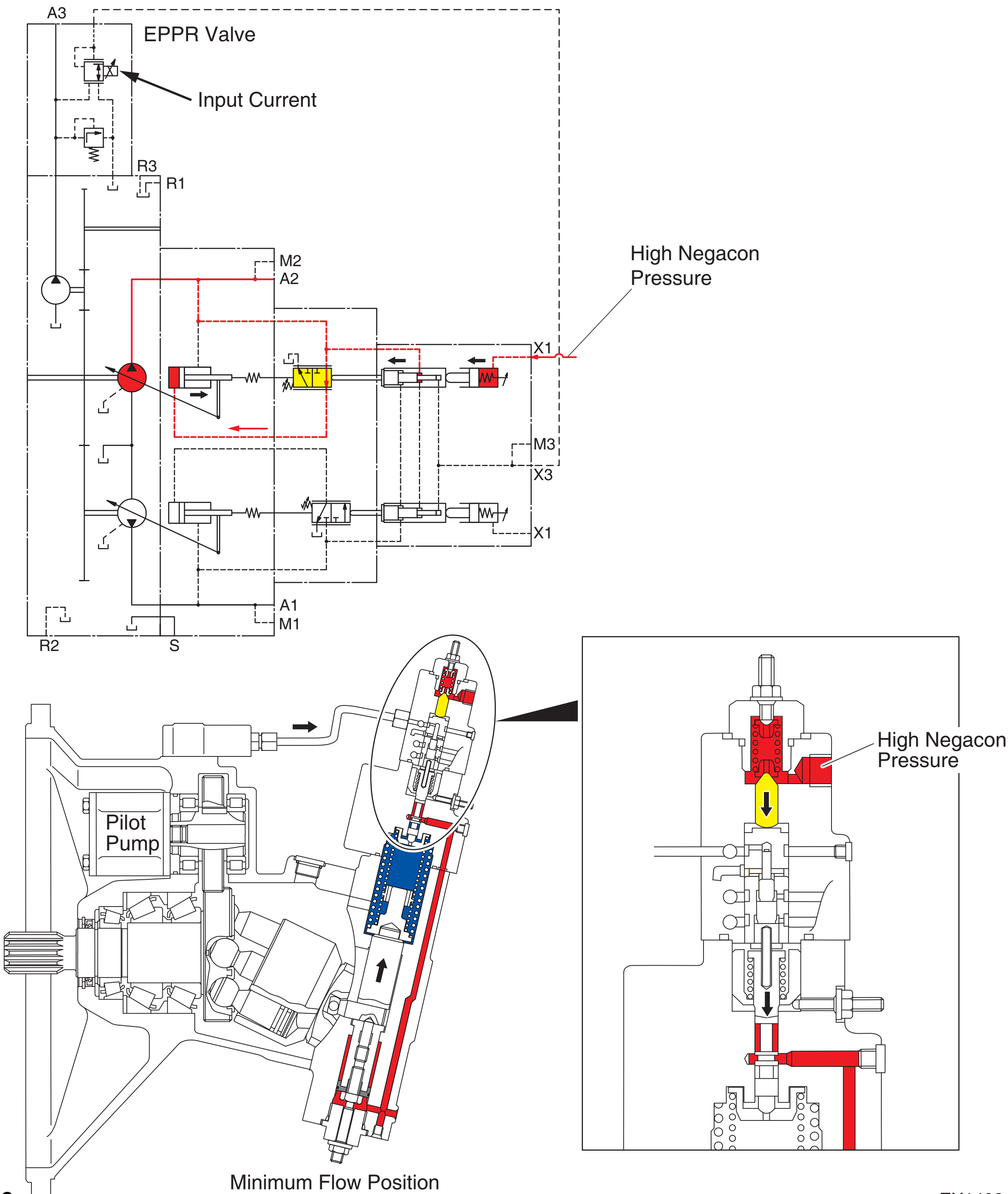


Figure 13

EX1403149

Increase Oil Flow

When receiving low negacon pressure through the port ps1/ps2 by operation of each spool of the control valve through the pilot line, oil flows to the large-diameter chamber, control piston and drain port, so pressure in the large-diameter chamber is decreased. As the small-diameter chamber is always applied with discharge pressure, the swivel angle is increased to push the servo piston. Then, the angle of the swash plate is increased to maximize the pump's discharge flow rate, making an efficient operating condition.

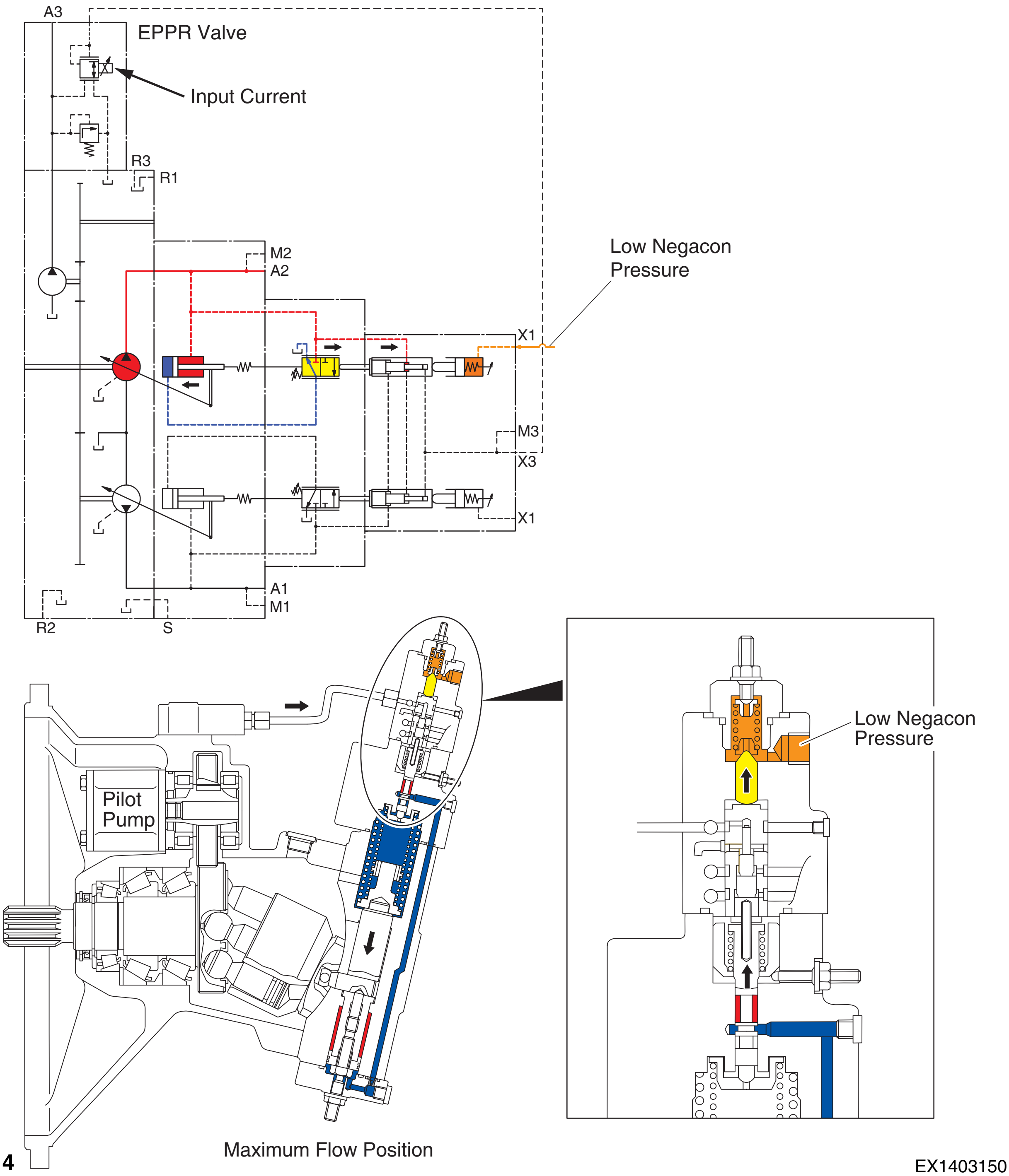
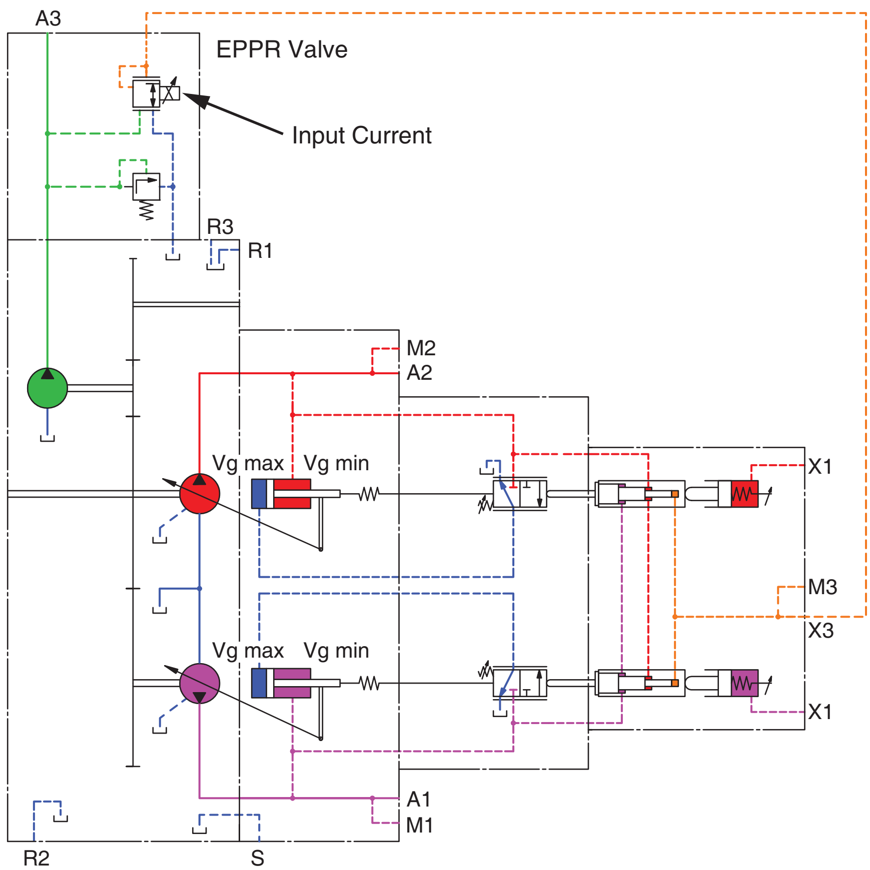


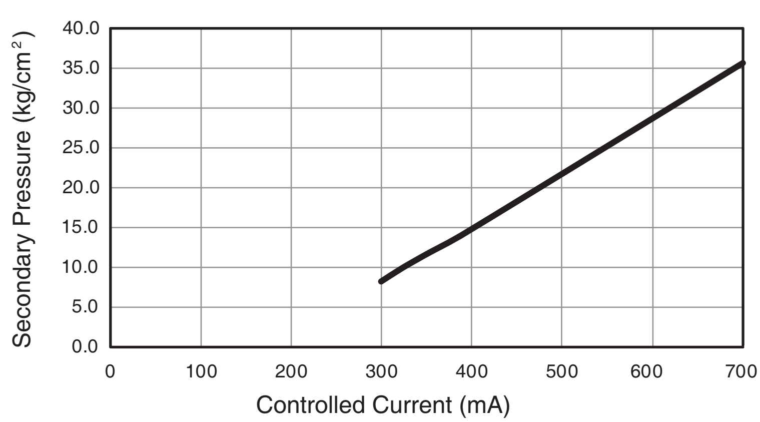
Figure 14

Power Shift

The power shift function controls the setting power of the pump by changing current of the EPPR (Electronic Proportional Pressure Reducing) valve which is attached to the pump.

The power shift EPPR valve sends its secondary pressure to the power control section of each pump regulator through the internal passage of the pump to change power to the same level. With this mechanism, power of the pump can be arbitrarily adjusted in order to obtain optimum level of power suitable for various operating conditions.





DS1602561

Figure 15

Power Shift (STD Mode/Economy Mode: 11.7 ~ 14.2 bar

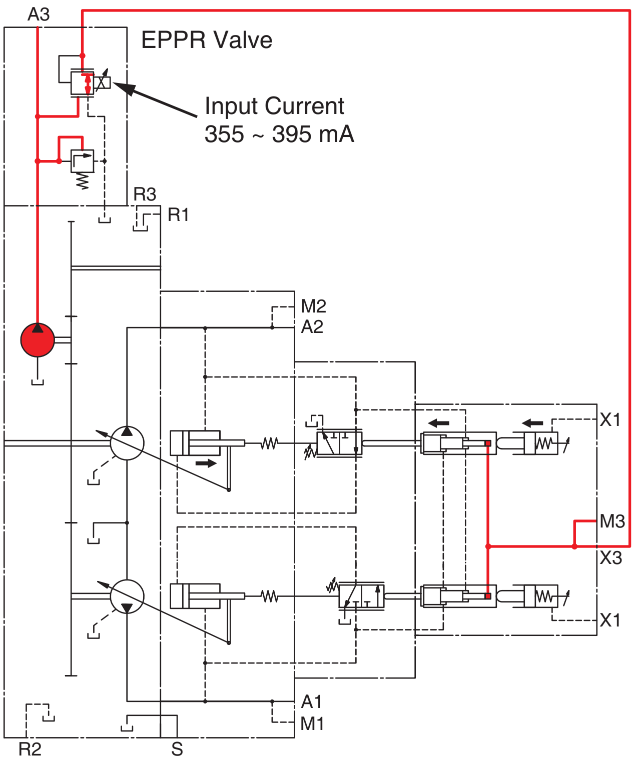


Figure 16

Power shift pressure helps moving power control spool easily with low system pressure.

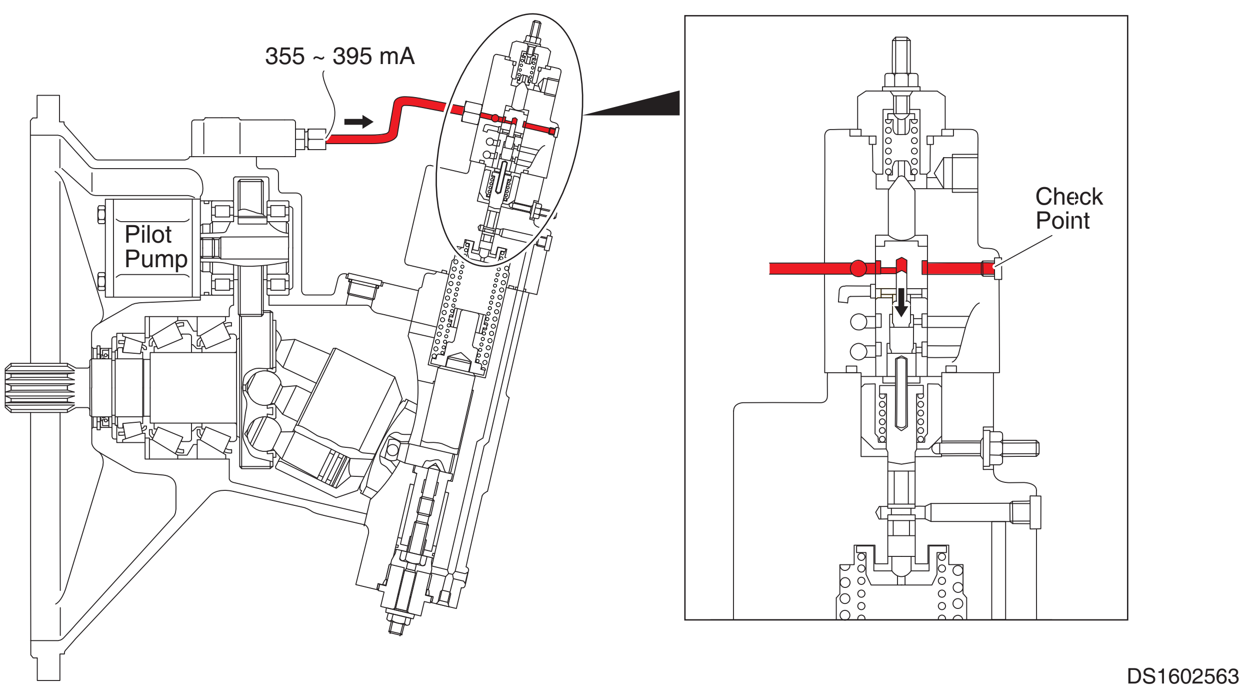


Figure 17

Power Shift (Power Plus Mode/Power Mode: 8 ~ 9.8 bar)

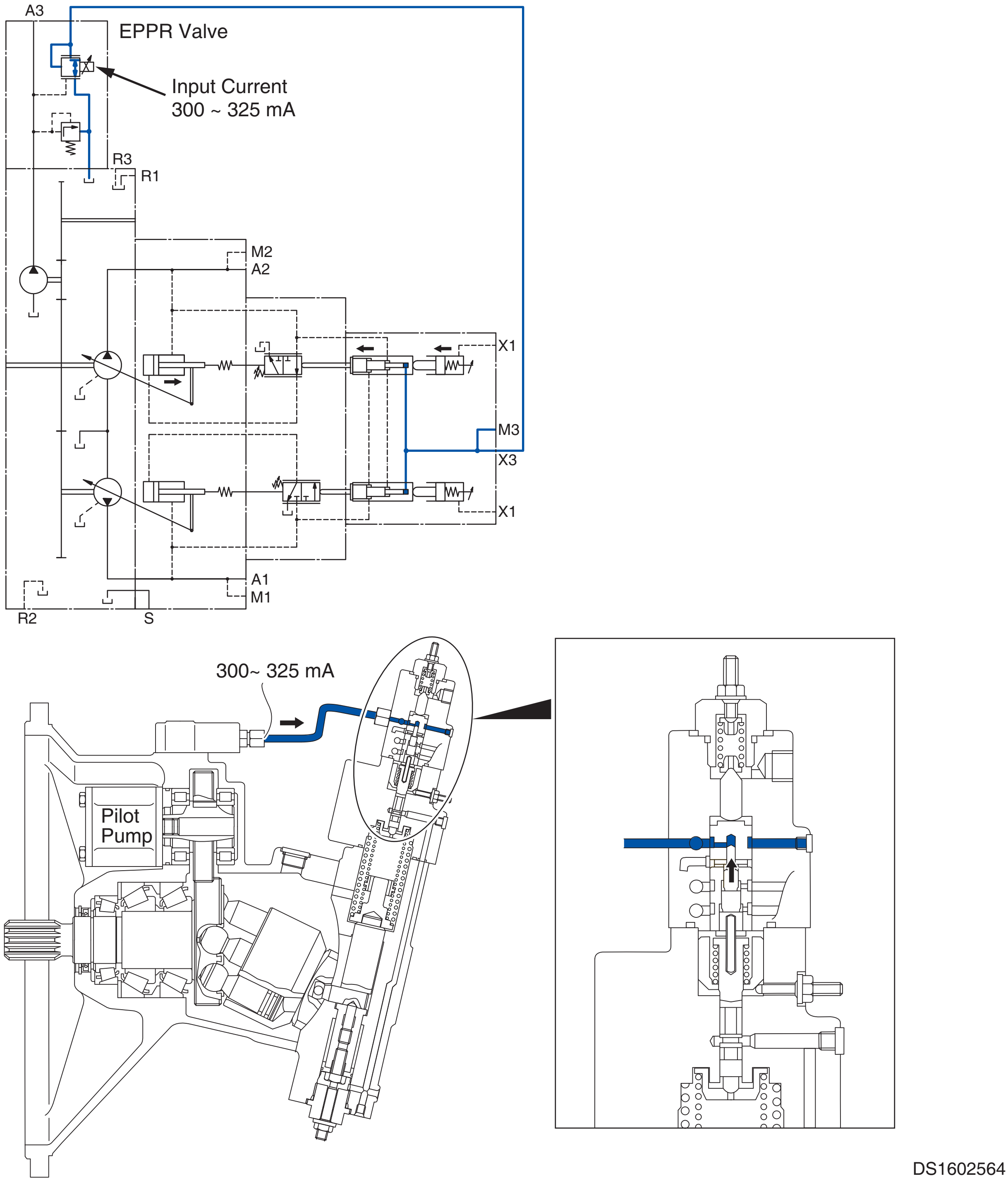


Figure 18

To control flow, it needs more system pressure then standard mode pressure.

Adjusting and Measuring Point

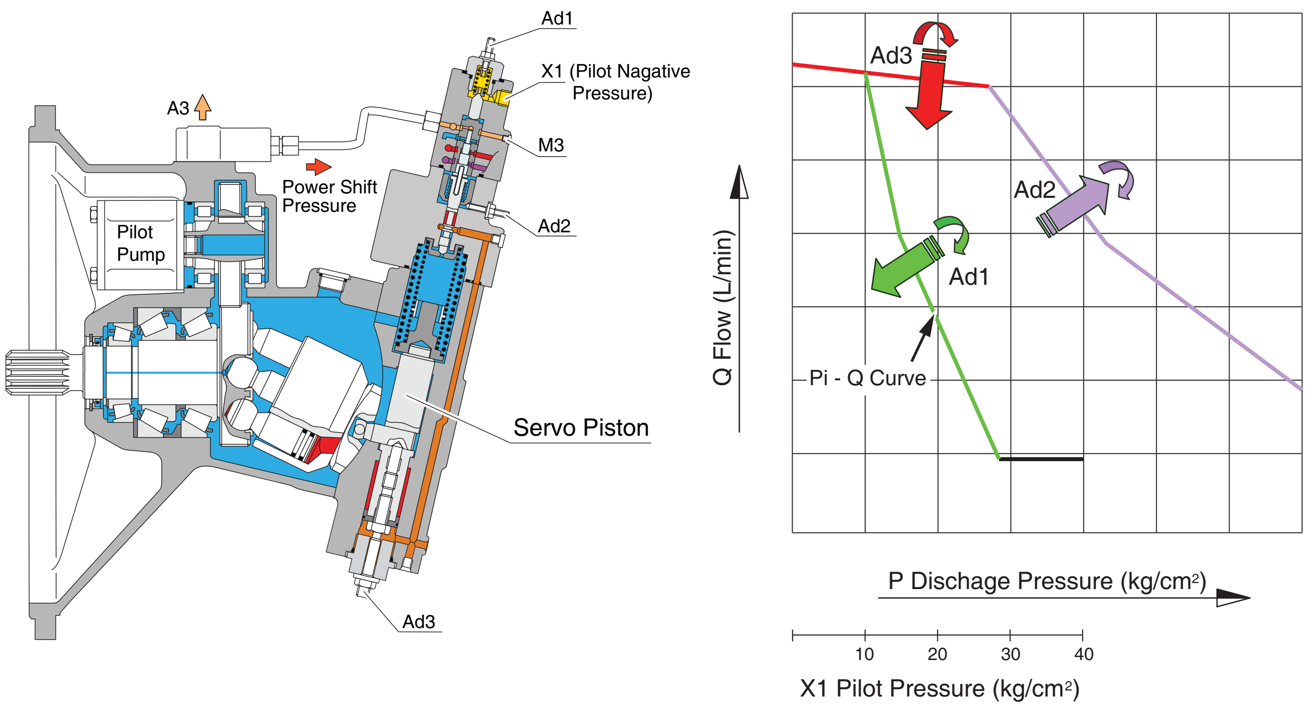


Figure 19

EX1403155

- Flow adjusting
  - Ad1: Flow control adjust screw (The flow rate by pilot pressure adjusted)
  - Ad2: Pressure control adjust screw (Pump input pressure adjust)
  - Ad3: Max. flow adjust screw (Servo Piston Stroke Limitation)
- Measuring point
  - M3: Power shift pressure check point (EPPR Valve 2nd pressure)

SECTION VIEW

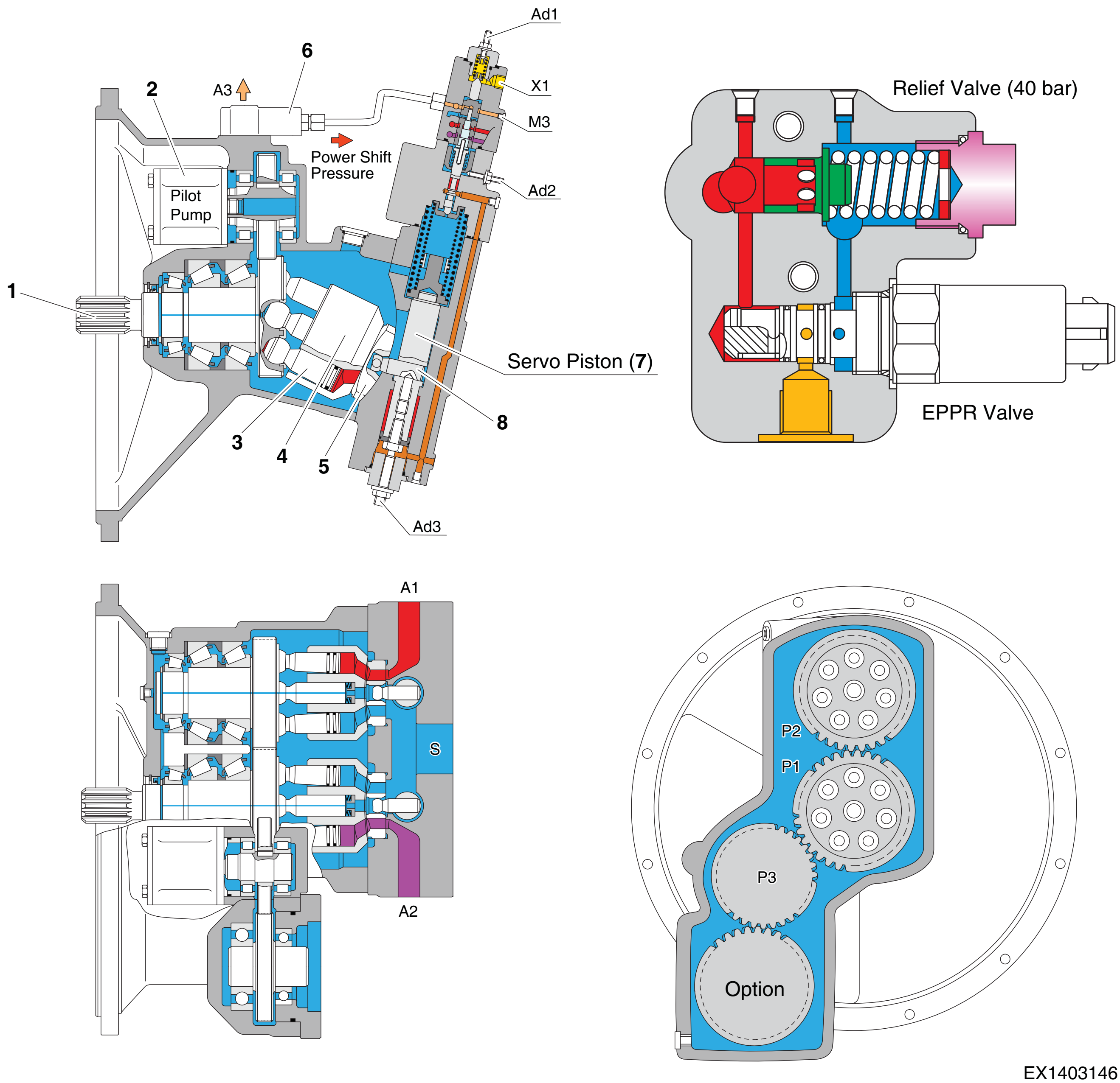


Figure 20

Reference Number	Description
1	Drive Shaft
2	Gear Pump (Pilot)
3	Piston
4	Cylinder

Reference Number	Description
5	Control Lens
6	EPPR Valve
7	Positioning Piston
8	Positioning Trunnion

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Make the machine swing about 30° rightward on the flat ground as shown in (Figure 21) before lowering the all the attachments on the ground and then stop engine.

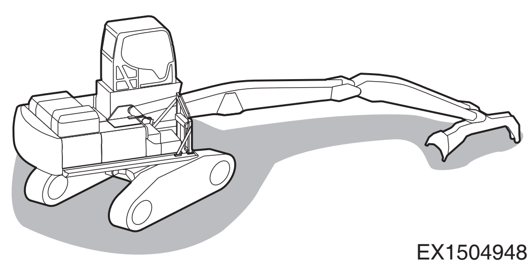


Figure 21

2. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 22)
3. Turn starter switch to "I" (ON) position.

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

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

4. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
5. Move safety lever to "LOCK" position. (Figure 22)
6. Turn key to "O" (OFF) position and remove from starter switch.
7. Attach a maintenance warning tag on controls.
8. Turn battery disconnect switch to "OFF" position. (Figure 23)

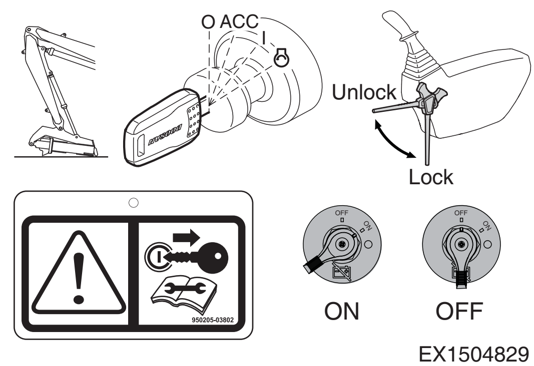


Figure 22

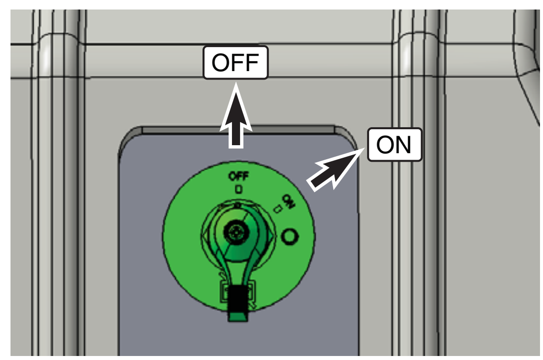


Figure 23 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*

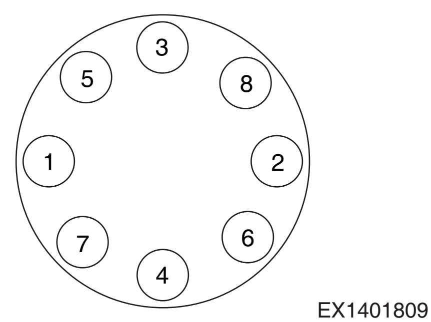


Figure 24

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

9. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.

   Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

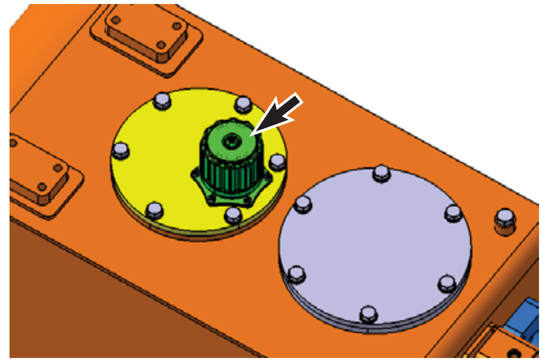
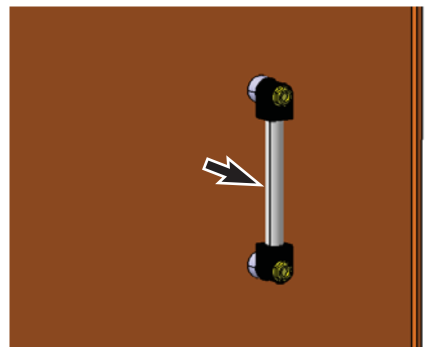


Figure 25 EX1404054

10. Oil drain method.

   NOTE: *Check the level on the oil level gauge before draining the oil.*



EX1402303

Figure 26

A. Remove cover (2 ea) on oil tank (bolt: 12 ea) and drain hydraulic oil using oil pump. (Figure 27)
Also pump oil from the suction pipe.

- Tool: 17 mm ( )
- Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

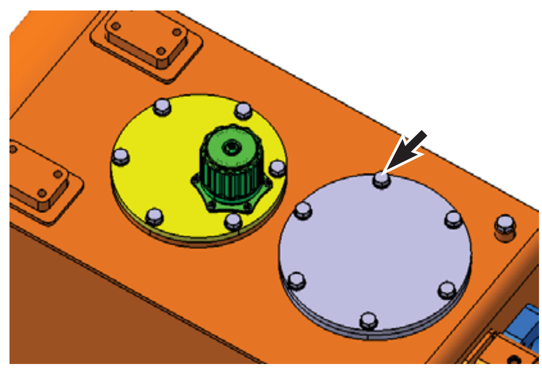
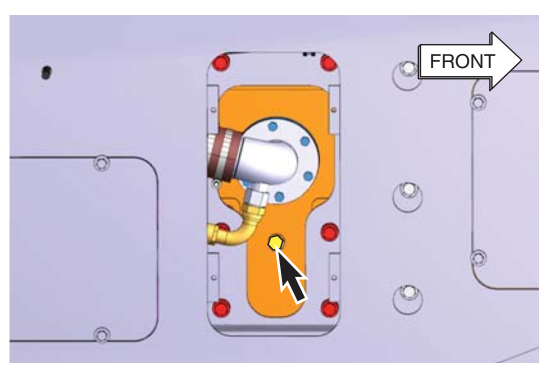


Figure 27 EX1404072

B. Drain hydraulic fluid using drain plug.
(without oil pump) (Figure 28)

- Tool: 27 mm ( )
- Torque: 93.1 N.m (9.5 kg.m, 68.7 ft lb)
- Hydraulic oil tank volume
  – Approximately: 195 L (52 U.S. gal)
  – Effective level: 131 L (35 U.S. gal)



DS1602639

Figure 28 Bottom of Main Frame

C. Plug the filter cap to location of suction filter.

Item	Part Number
Filter Cap	2188-1008

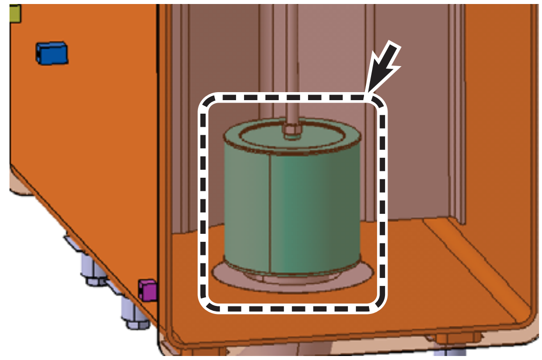
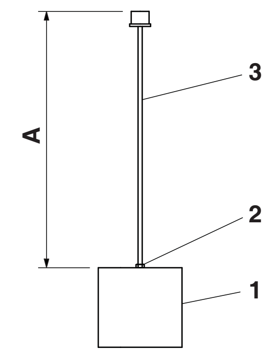

EX1402349

Figure 29



EX1402872

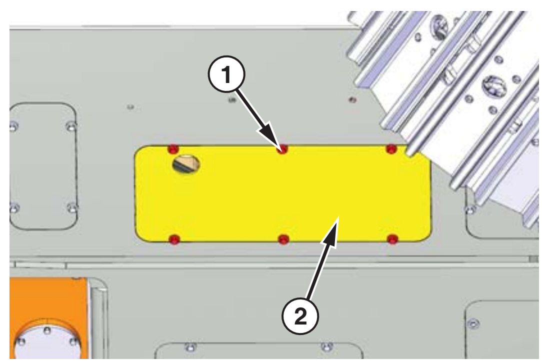
Figure 30

Reference Number	Description
1	Suction Filter
2	Nut
3	Rod

When installing

- Length (A): 650 mm
- Torque (2 nut): 49 N.m (5 kg.m, 36.2 ft lb)

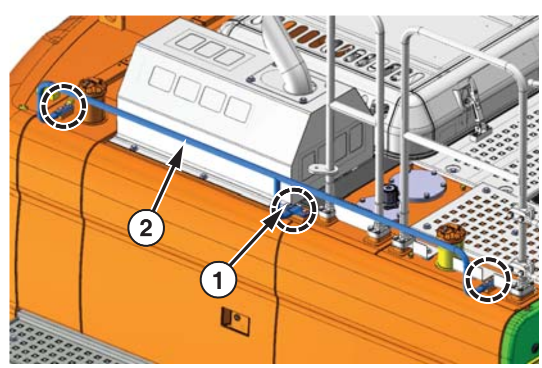
11. Remove bolt (1, Figure 31) (6 ea) and remove under cover (2) under pump side.
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Cover weight: 20 kg (44 lb)



DS1602768

Figure 31 Bottom of Main Frame

12. Remove bolts (1, Figure 32) (6 ea) with hand rail (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)



DS1602636

Figure 32

13. Open the right side door.

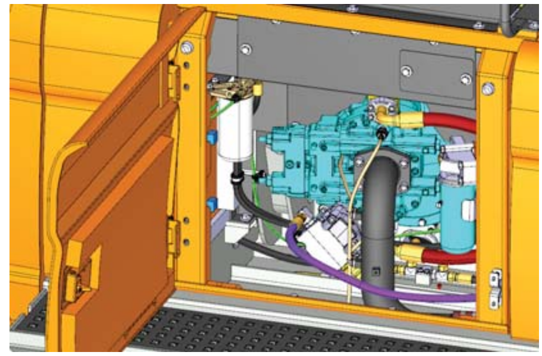


Figure 33 DS1602769

14. Remove bolts and washers (1, Figure 34) (4 ea) with oil filter assembly (2).
Do not remove hoses (3).

- Tool: 17 mm ( )
- Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

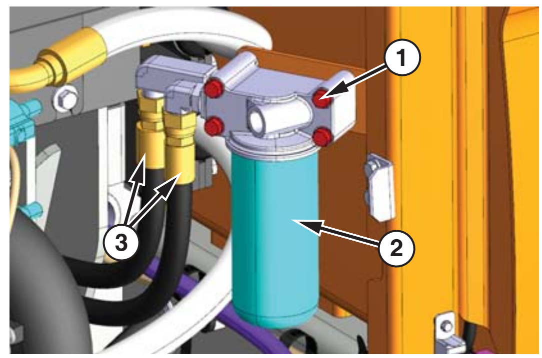


Figure 34 DS1602770

15. Remove bolts (1, Figure 35) (11 ea) and remove baffle cover (2) from pump room.

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Cover weight: 7 kg (15.4 lb)

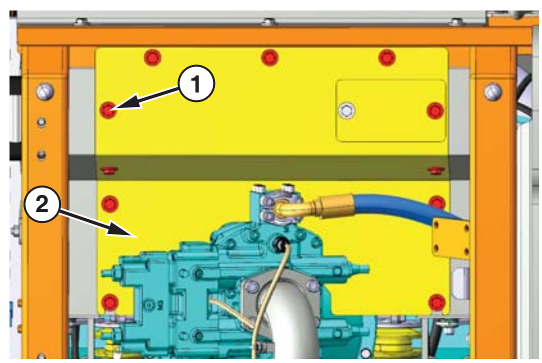


Figure 35 DS1602771

16. Open the engine cover. Remove bolts (1, Figure 36) (10 ea) with muffler cover (2) and tail pipe cover (3).

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Cover weight: about 20 kg (44 lb)

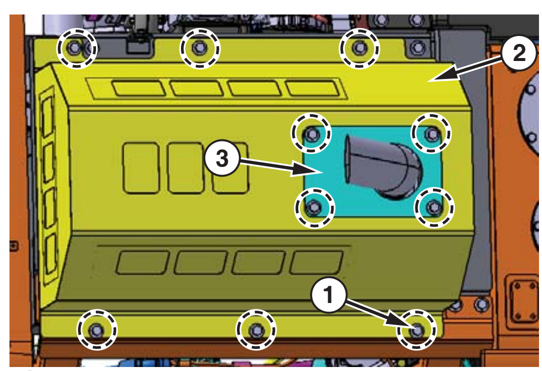


Figure 36 EX1404076

17. Remove bolts and clip (1, Figure 37) from support.

    - Tool: 12 mm ( )
    - Torque: 29.4 N.m (3 kg.m, 21.7 ft lb)

18. Remove clamp (2, Figure 37) from exhaust pipe.

    - Tool: 10 mm ( )

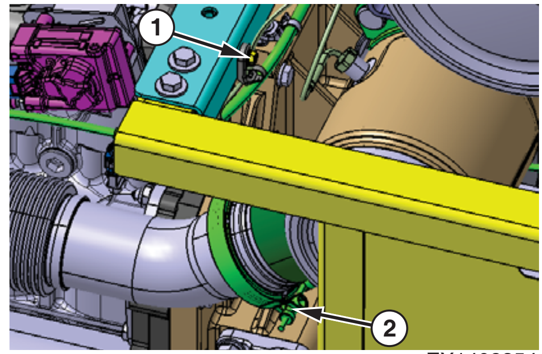


Figure 37 EX1402354

19. Disconnect the harness connector (Figure 38).

    NOTE: *Be careful not to let water get into electrical components (sensor, connectors). If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.*

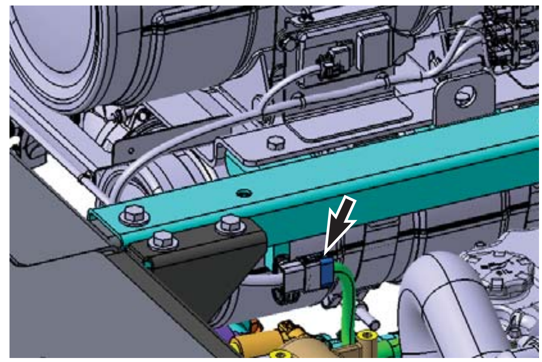


Figure 38 EX1404082

20. Remove water hoses (1, Figure 39) (2 ea) and urea hose (2) from Dosing module.

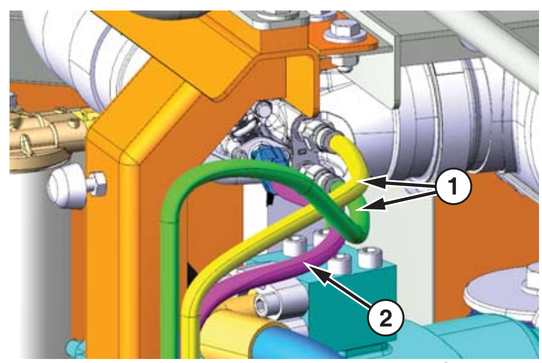


Figure 39 DS1602772

21. Attach a lifting device onto lifting hole to support it.

    - SCR-DOC assembly: about 90 kg (198 lb)

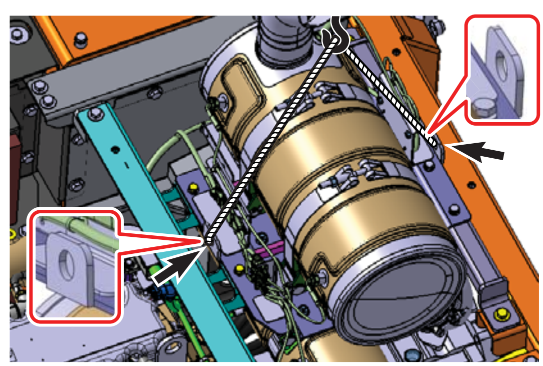


Figure 40 EX1402357

22. Remove bolts and washers (1, Figure 41) (2 ea).
    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)
23. Remove bolt (2, Figure 41) (2 ea).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

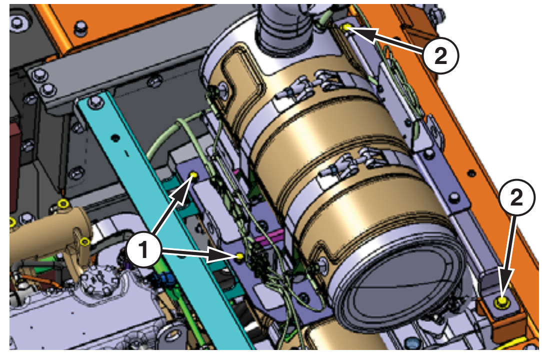


Figure 41 EX1402358

24. Lift the SCR-DOC assembly from support slowly and carefully.

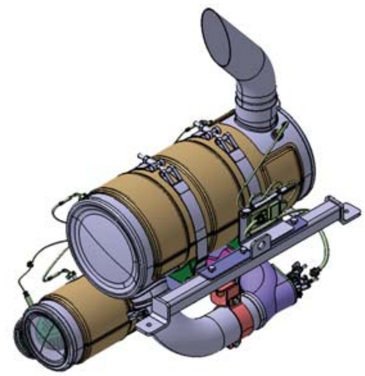


Figure 42 EX1402359

25. Remove bolts (1, Figure 43) (11 ea) with side door assembly (2).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Side door assembly weight: about 38 kg (83.8 lb)

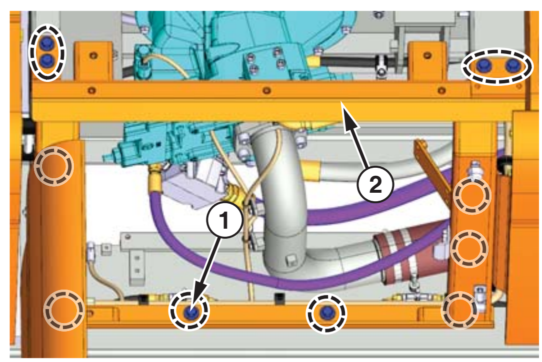


Figure 43 DS1602773

26. Disconnect the connector of main harness from EPPR valve (A, Figure 44) and pressure sensor (B).

NOTE: *Be careful not to let water get into electrical components (sensor, connectors). If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.*

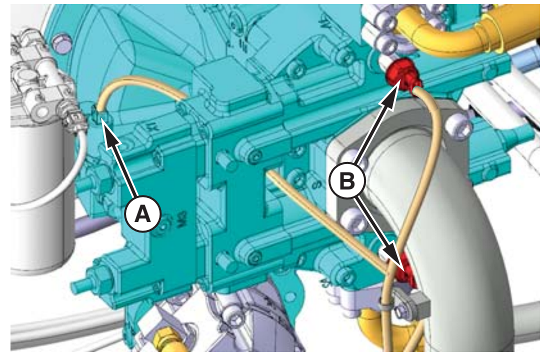


Figure 44

How to disconnect the harness connector.

A. EPPR valve

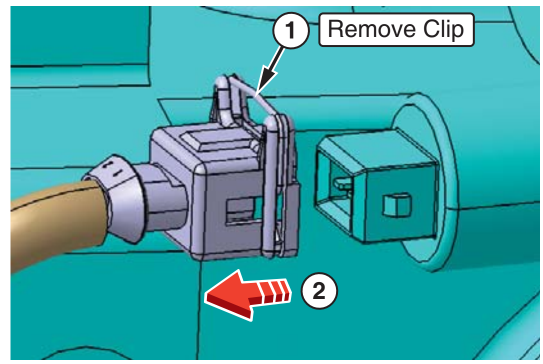


Figure 45

B. Pressure sensor

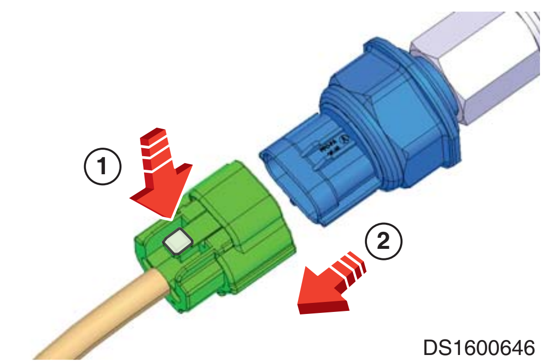


Figure 46

27. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 47

28. Remove bolts (4 ea) and remove suction pipe of pump. Drain the hydraulic oil of suction pipe to bowl.

- Tool: 14 mm ( )
- Torque: 264.8 N.m (27 kg.m, 195.3 ft lb)

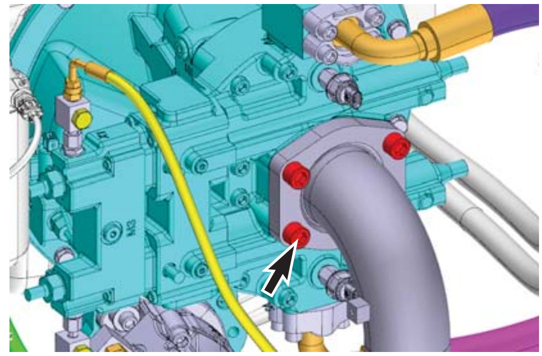


Figure 48 DS1602775

29. Remove hoses and adapters from pump.

NOTE: *Attach an identification tags to the removed hoses for reassembling*
After disconnecting hoses, plug them to prevent dirt or dust from entering.
Disconnect the hoses from the bottom to top of main pump.

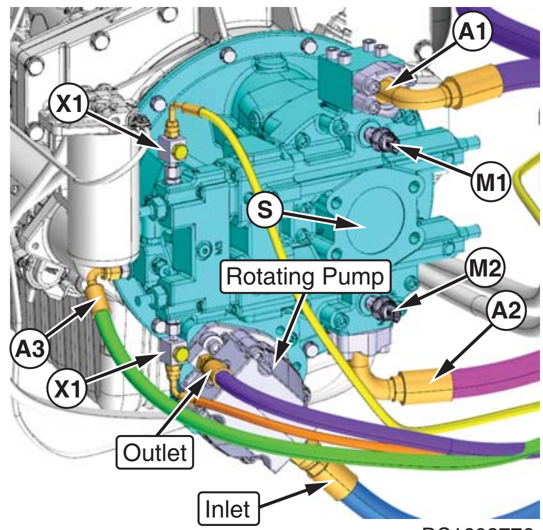


Figure 49 DS1602776

- Hoses and plug ports

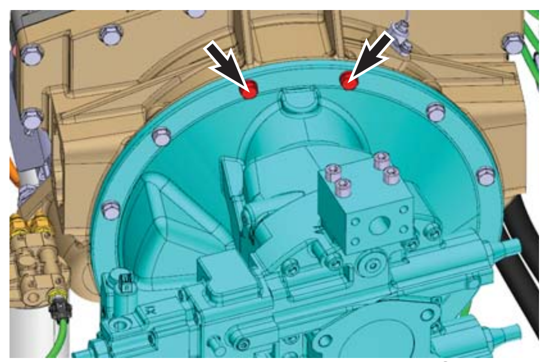
Port		Name	Plug/Flange Size (Hose)	(mm)	(mm)	Torque		
						N.m	kg.m	ft lb
Main Pump	A1	to Control Valve "P1"	SAE 1", D25		10	107.9	11.0	79.6
	A2	to Control Valve "P2"	SAE 1", D25		10	107.9	11.0	79.6
	X1	from Control Valve "ps1"	UNF 9/16"-18-2B	19		25.5	2.6	18.8
	X1	from Control Valve "ps2"	UNF 9/16"-18-2B	19		25.5	2.6	18.8
	A3	to Pilot Filter	UNF 13/16"-16-2B	24		55.9	5.7	41.2
	M1, M2	Pressure Sensor	PF 1/4"	27		39.2	4.0	28.9
Rotating Pump	Outlet	to Control Valve (One Spool) "P"	UNF 13/16"-16-2B	24		55.9	5.7	41.2
	Inlet	from Oil Tank Suction Pipe	UNF 1 7/16"-12-2B	41		169.7	17.3	125.1

- Fitting

Port		Name	Size A	Size B (C)	(mm)	Torque N.m	Torque kg.m	Torque ft lb
Main Pump	X1	Adapter	M14 x 1.5	UNF 9/16"-18	19	39.2	4.0	28.9
	A3		M18 x 1.5	UNF 13/16"-16	24	93.2	9.5	68.7
	M1, M2		UNF 9/16"-18	PF 1/4"	24	25.5	2.6	18.8
Main Pump	S	O-ring	ID: 98.02, W: 3.53, Class1 (2180-1026D33)					
	A1, A2		DS2856003 (1", ID:33.2, OD:40.2, 1B)					
	A3			S8030081 (1B F-08)				
	X1			2180-1216D11 (ID:7.65, W:1.78, 1B)				
	M1, M2		S8040061 (1B B-06)					
Rotating Pump	Outlet	Elbow	PF 3/4"	UNF 13/16"-16	36	176.5	18.0	130.2
		O-ring	S8000235 (4D P22.4)	S8030081 (1B F-08)				
	Inlet	Adapter	PF 1"	UNF 1 7/16"-12	41	205.9	21.0	151.9
		O-ring	S8000291 (1B P29)	S8030165 (4D F-16)				

* A: Opposite side of hose, B: Hose side

30. Remove bolts (10 ea) of pump without top bolts (2 ea).
    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)



DS1602777

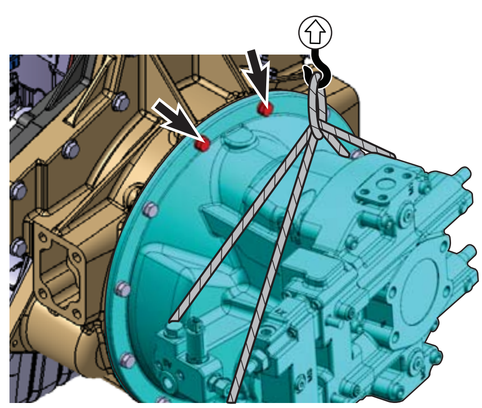
Figure 50

31. Attach a lifting device around pump. Raise the lifting device until the pump is supported prior to removing remaining bolts (2 ea).
    - Main pump weight: about 120 kg (265 lb)

CAUTION

AVOID INJURY

Support the pump prior to removing remaining bolts to prevent pump from falling.



DS1602801

Figure 51

32. Remove remaining bolts (2 ea).
    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

33. Lift the pump from engine slowly and carefully.

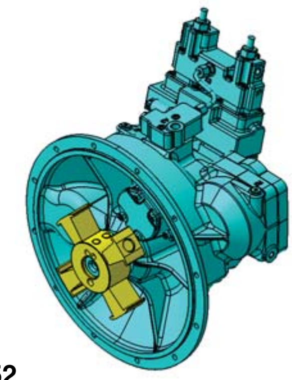


Figure 52 EX1403069

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

1. Perform installation in the reverse order to removal.
2. When installing the pump to engine, be careful assembling pump shaft and drive coupling. Refer to drive coupling installation.

COMPLETING WORK

NOTE: *If pump is run without sufficient oil in the main hydraulic pump, damage can occur. Always vent pump of air after draining hydraulic system.*

1. With the engine stopped, remove vent plug (Figure 53) to see if any oil is present.
2. If oil is not present, fill oil tank with oil.
3. Install vent plug (Figure 53) first.
4. Slowly loosen vent plug (Figure 53) several turns, until hydraulic oil flows out of plug. This shows that air has been released.
5. Tighten the plug (Figure 53).
    - Tool: 6 mm ( )
    - Torque: 30 N.m (3.1 kg.m, 22 ft lb)

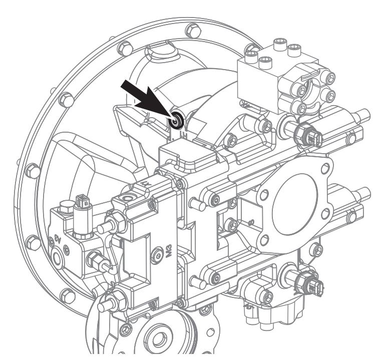
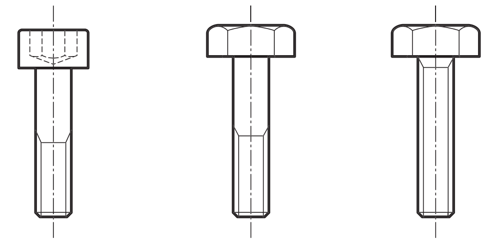


Figure 53 DS1602721

ASSEMBLY GUIDELINES FOR TIGHTENING TORQUES

Bolts

Values stated are valid for bolts with metric ISO threads to DIN 13 part 13, and head areas to DIN 912 socked head cap screws, DIN 931 hexagon bolt or DIN 933 hexagon bolts with threads up to the head.



FG021156

Figure 54

Thread	Tensile Strength Class		
	8.8	**10.9**	**12.9**
	Tightening Torque (N.m)		
M 3	1.1	1.6	1.9
M 4	3.1	4.5	5.3
M 5	6.1	8.9	10.4
M 6	10.4	15.5	18
M 8	25	37	43
M 10	51	75	87
M 12	87	130	150
M 14	140	205	240
M 16	215	310	370
M 18	300	430	510
M 20	430	620	720
M 22	480	830	970
M 24	740	1060	1240

Plugs with Internal Hexagon and Profile Seal Ring

Thread	Tightening Torque (N.m)
M8 x 1	5
M10 x 1	10
M12 x 1.5	20
M14 x 1.5	30
M16 x 1.5	35
M18 x 1.5	40
M20 x 1.5	50
M22 x 1.5	60
M26 x 1.5	70
M27 x 2	90
M30 x 1.5	100
M33 x 2	140
M42 x 2	240
M48 x 2	300
G 1/8 A	10
G 1/4 A	30
G 3/8 A	35
G 1/2 A	60
G 3/4 A	90
G 1 A	140
G 1 1/4 A	240
G 1 1/2 A	300

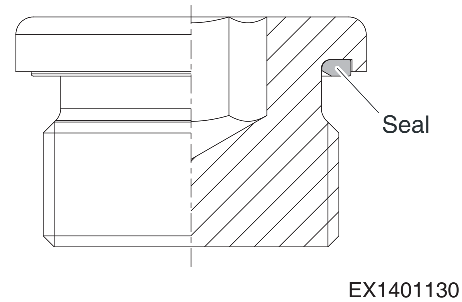


Figure 55

Seal-lock - Sealing Nuts

Thread	Tightening Torque (N.m)
M6	10
M6 x 0.5	11
M8	22
M8 x 1	24
M10	40
M10 x 1	44
M12	69
M12 x 1.5	72
M14	110
M14 x 1.5	120
M16	170
M16 x 1.5	180

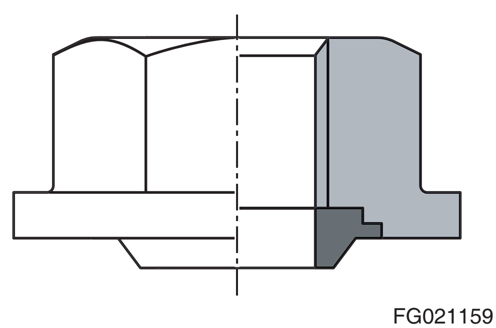


Figure 56

DISASSEMBLY AND REASSEMBLY

General Repair Guidelines

NOTE: *Observe the following cautions when performing repairs on hydraulic units.*

WARNING

AVOID DEATH OR SERIOUS INJURY

Observe the following notices and instructions when carrying out repairs on hydraulic units.

Figure 57

1. Close off all openings of hydraulic unit.

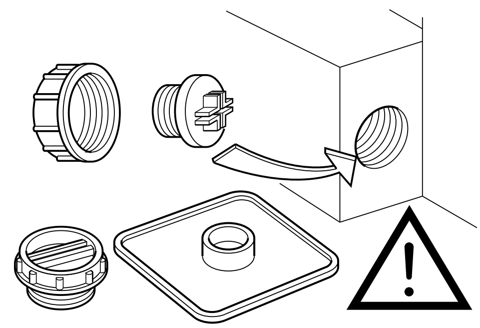


Figure 58

2. Replace all seals.

   Use only original spare parts

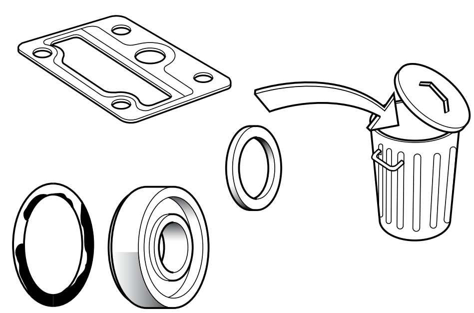


Figure 59

3. Check all sealing and sliding surfaces for wear.

IMPORTANT

Using abrasive materials on sliding surfaces can damage the surface.

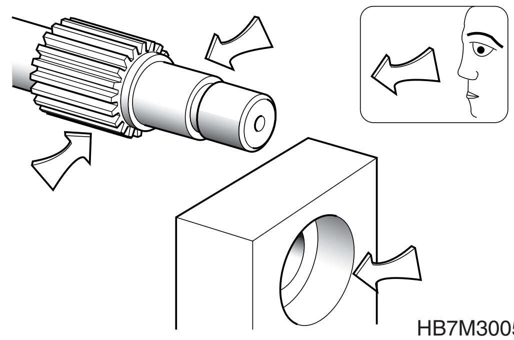


Figure 60

4. Fill hydraulic unit with hydraulic oil before putting into operation.

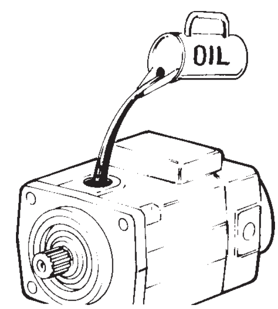
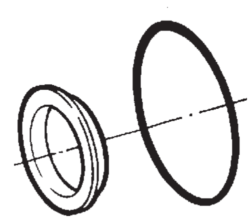


Figure 61

Seal Kits and Subassemblies

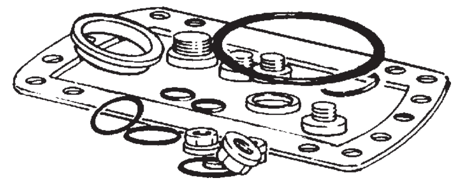
1. Seal kit for driveshaft.



ASS0070L

Figure 62

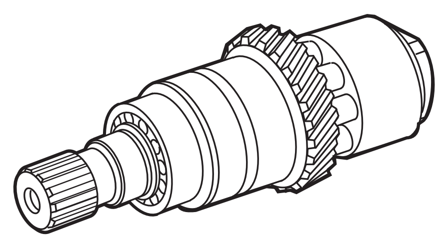
2. Peripheral seal kit.



ASS0080L

Figure 63

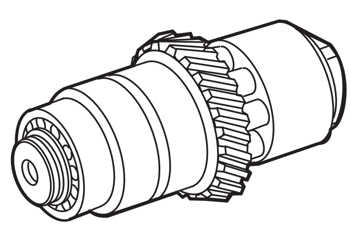
3. Rotary group 1, ready to install.



ASS0090L

Figure 64

4. Rotary group 2, ready to install.



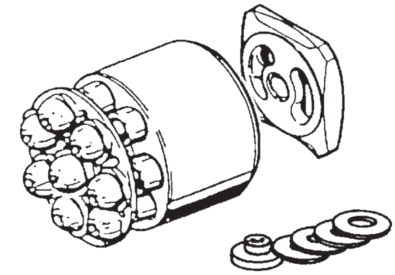
ASS0100L

Figure 65

5. Rotary group, hydraulic component (order rotary groups 1 and 2 separately).

IMPORTANT

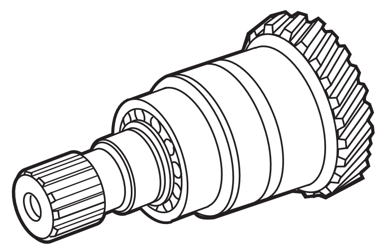
Adjustment is necessary.
Pay attention to direction of rotation.



ASS0110L

Figure 66

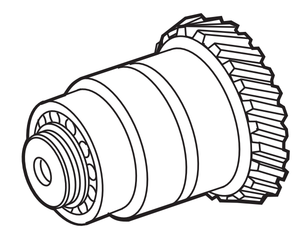
6. Rotary group 1, mechanical section, ready to install.



ASS0120L

Figure 67

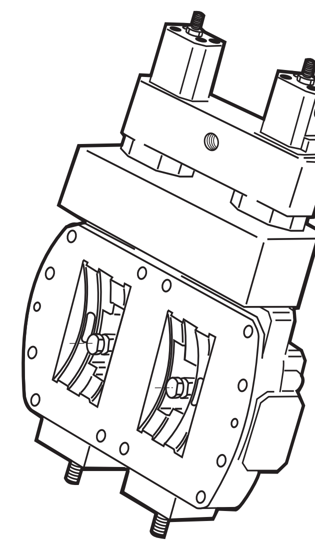
7. Rotary group 2, mechanical section, ready to install.



ASS0130L

Figure 68

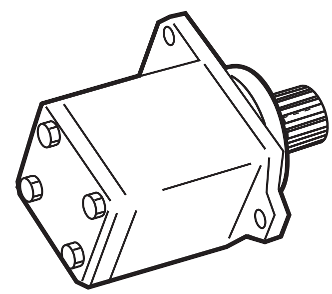
8. Control, pre-adjusted.



ASS0140L

Figure 69

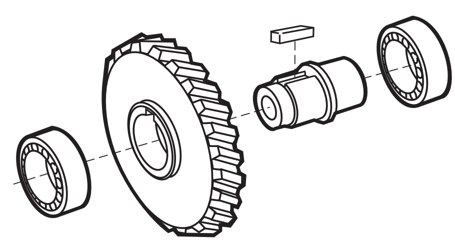
9. Gear pump, complete.



ASS0150L

Figure 70

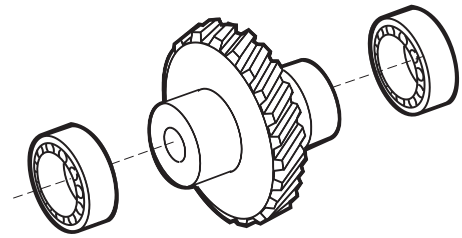
10. Intermediate gear.



ASS0160L

Figure 71

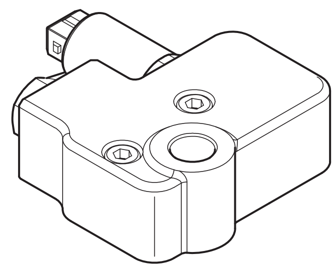
11. Auxiliary drive.



ASS0170L

Figure 72

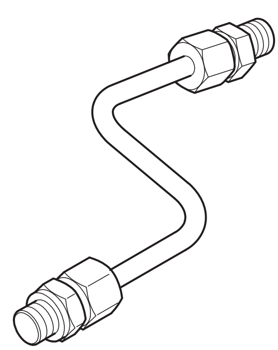
12. Valve plate with valves.



EX1401142

Figure 73

13. Pipe, complete with fittings.



EX1401143

Figure 74

Sealing the Driveshaft

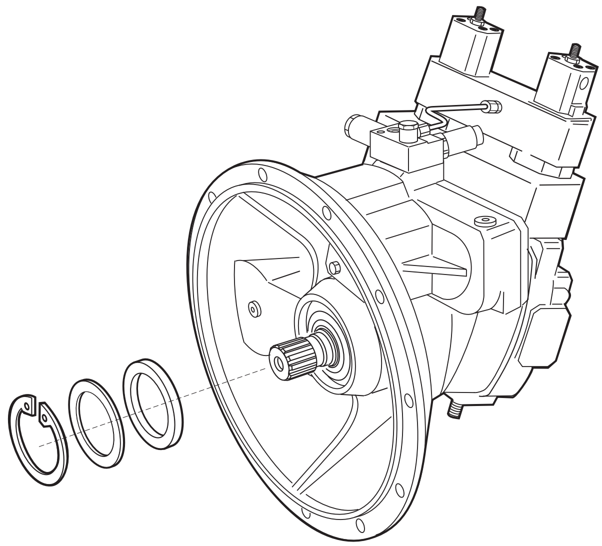


Figure 75

1. Protect driveshaft. (e.g. with tape).

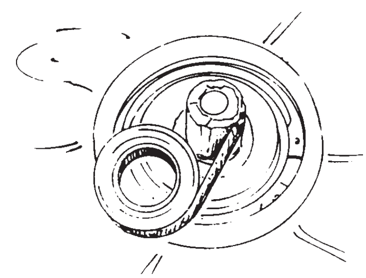


Figure 76

2. Remove retaining ring and shim.

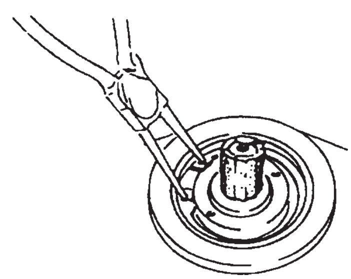
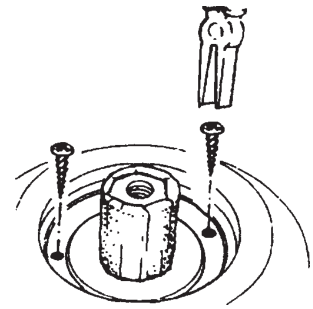


Figure 77

3. Screw sheet metal screw(s) into holes fitted with rubber.

   Pull out seal with pliers.



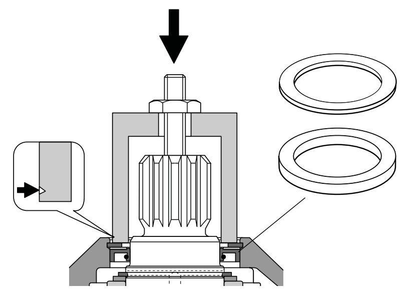
ASS0230L

Figure 78

4. Press in shaft seal ring and shim with bushing to stop.

IMPORTANT

Take note of press-in depth. Install mark for press-in depth of safety ring.



ASS0240L

Figure 79

Gear Pump Sealing

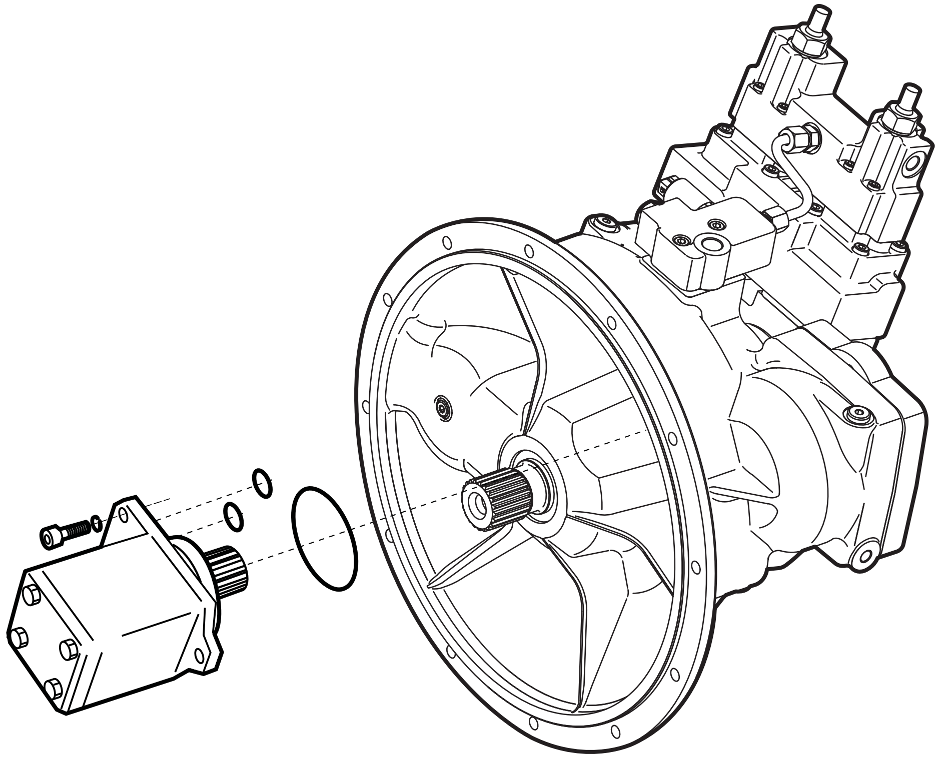


Figure 80

EX1403156

Remove gear pump.

Visually check

1. O-ring (1, Figure 81).

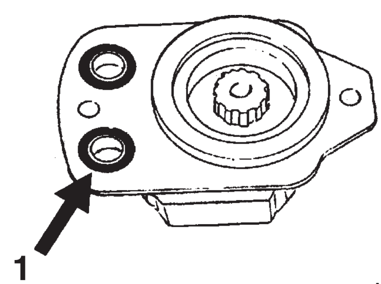


Figure 81

2. Sealing surface of housing (2, Figure 82).

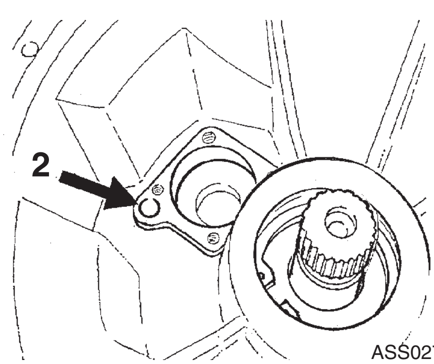


Figure 82

Removing Control Housing

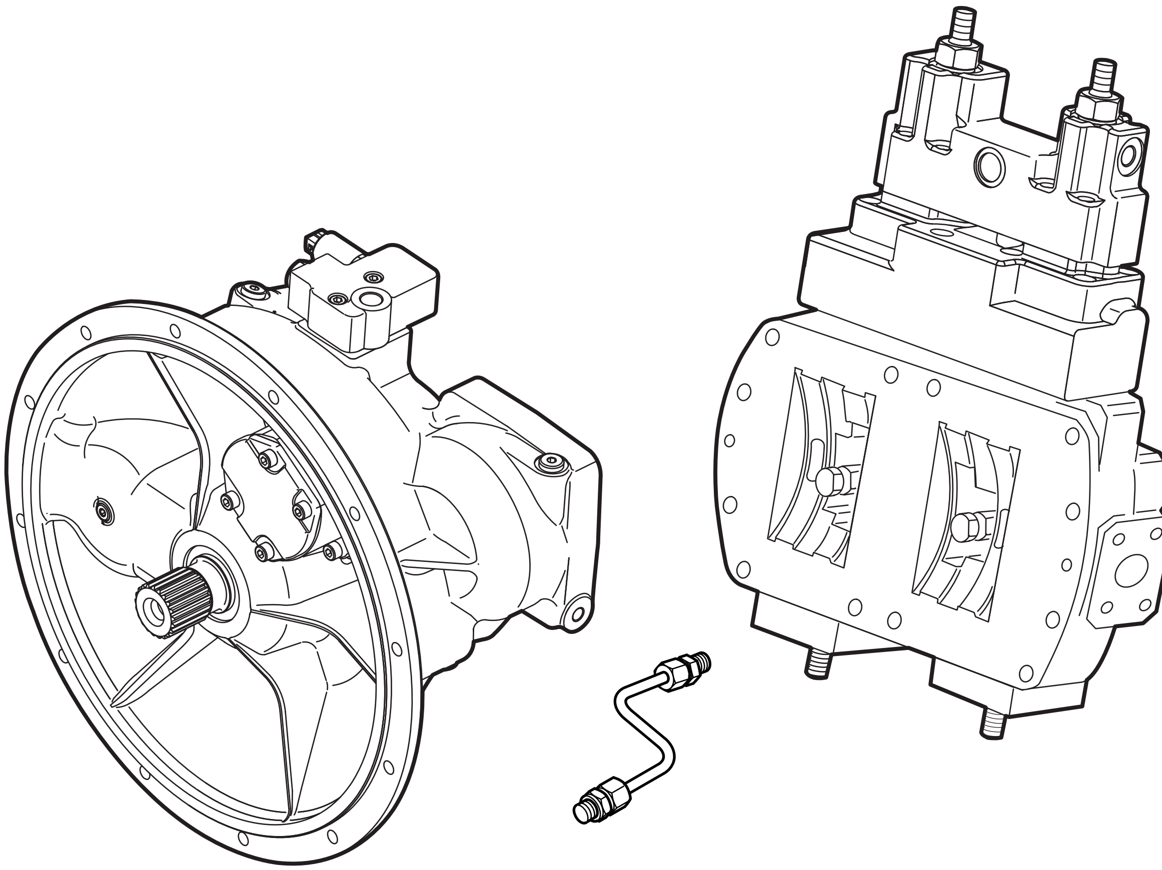


Figure 83 EX1403157

1. Place pump into a disassembly / assembly device with a crane and secure it into position.

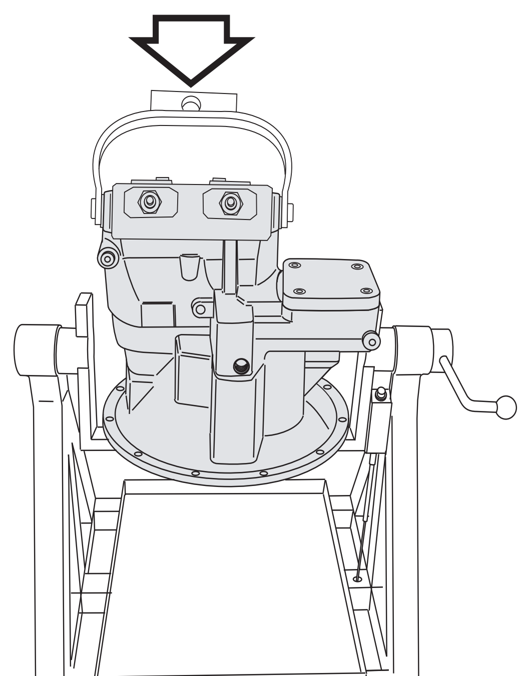


Figure 84 ASS0290L

2. Remove screws holding port plate.
3. Using a suitable lifting device, remove port plate.

IMPORTANT

Mark installation position. Be careful, control lenses can fall out.

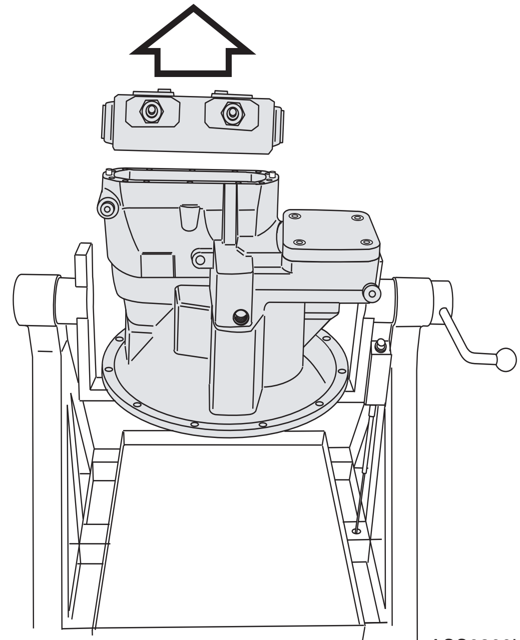

ASS0300L

Figure 85

4. Remove paper seal, and clean sealing surface.

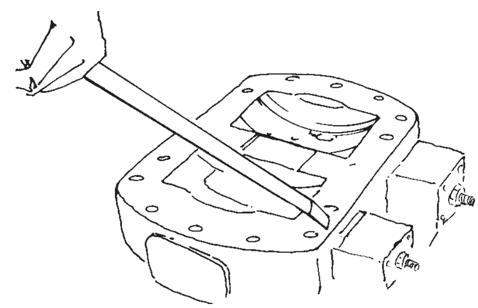

ASS0310L

Figure 86

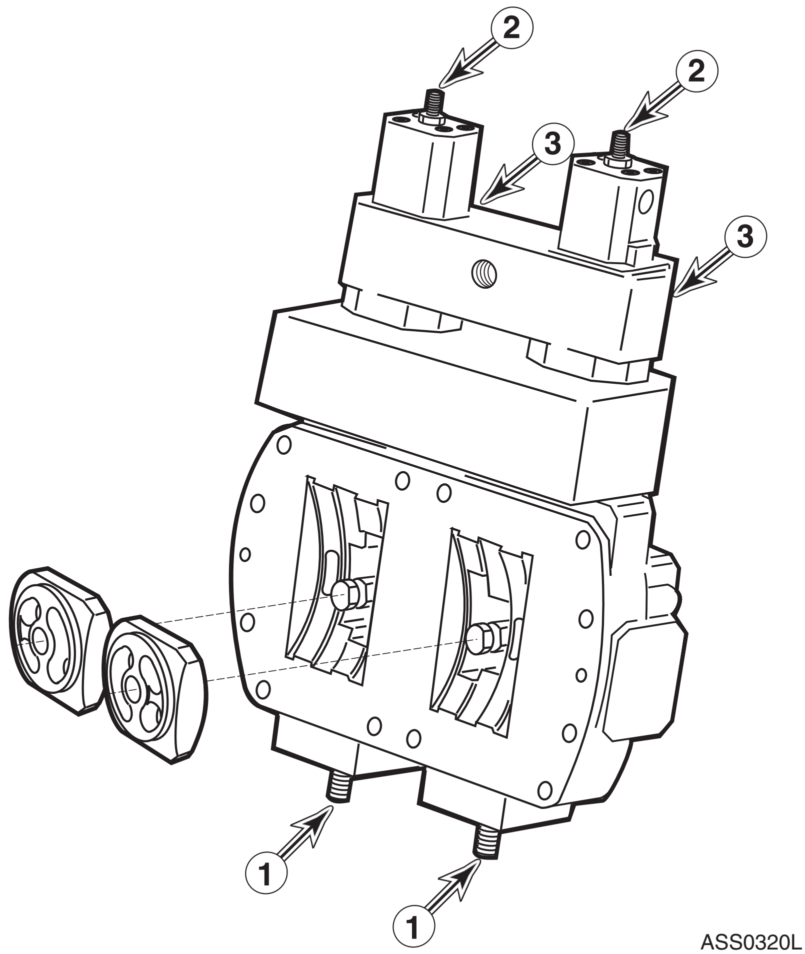


Figure 87

Reference Number	Description
1	Setting Screw: Q_{max}
2	Setting Screw: Hydraulic Stroke Limitation
3	Setting Screw: Power Characteristic (Begin of Regulation)

NOTE: *Before performing setting or disassembly of regulator, measure distance "X" of adjustment screw and record value.*

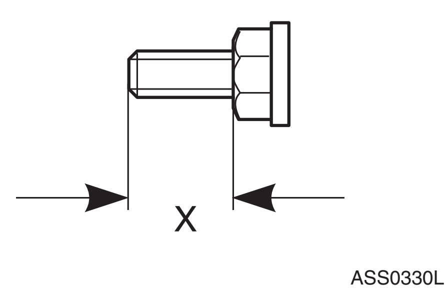


Figure 88

Control Module

Control Module LR

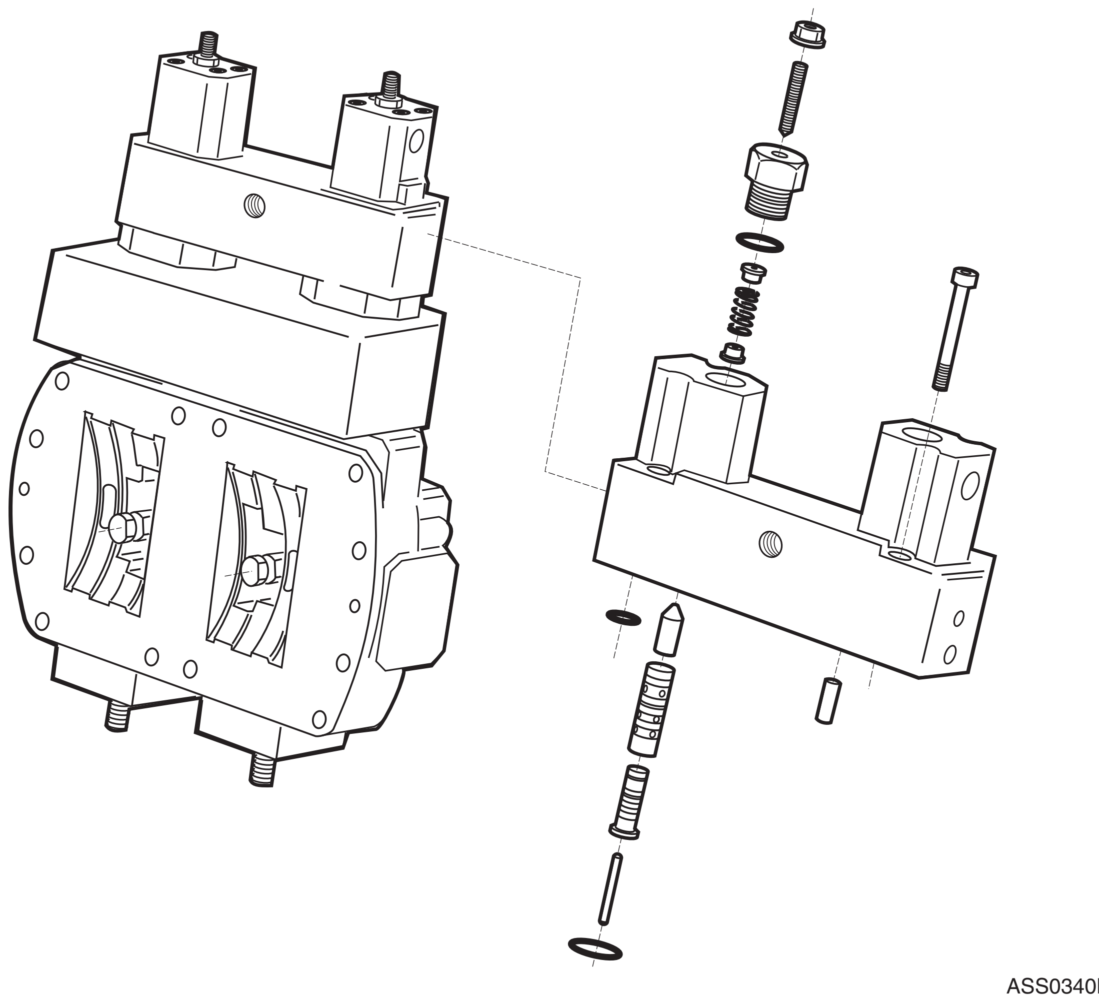


Figure 89

Remove and disassemble control module LR.

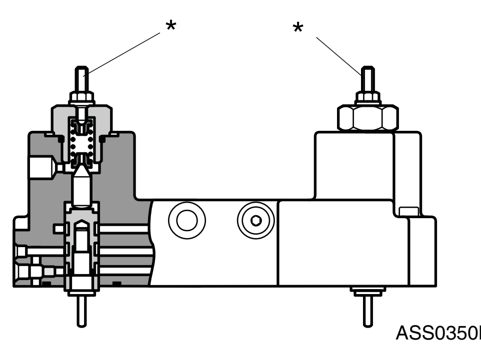


Figure 90

Control Module H

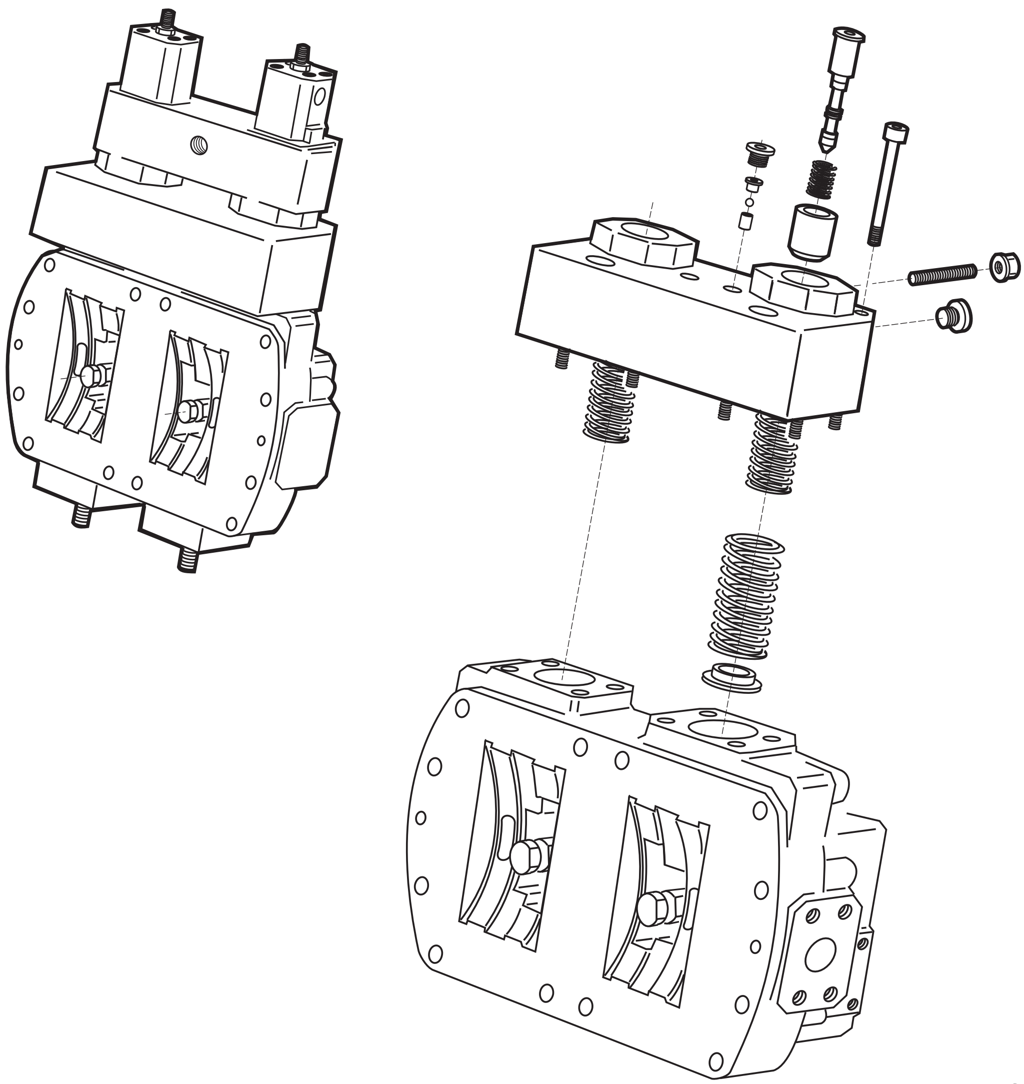

ASS0360L

Figure 91

Remove and disassemble control module H.

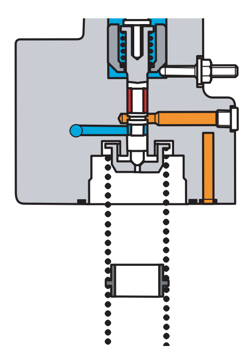

ASS0370L

Figure 92

Removing the Controller

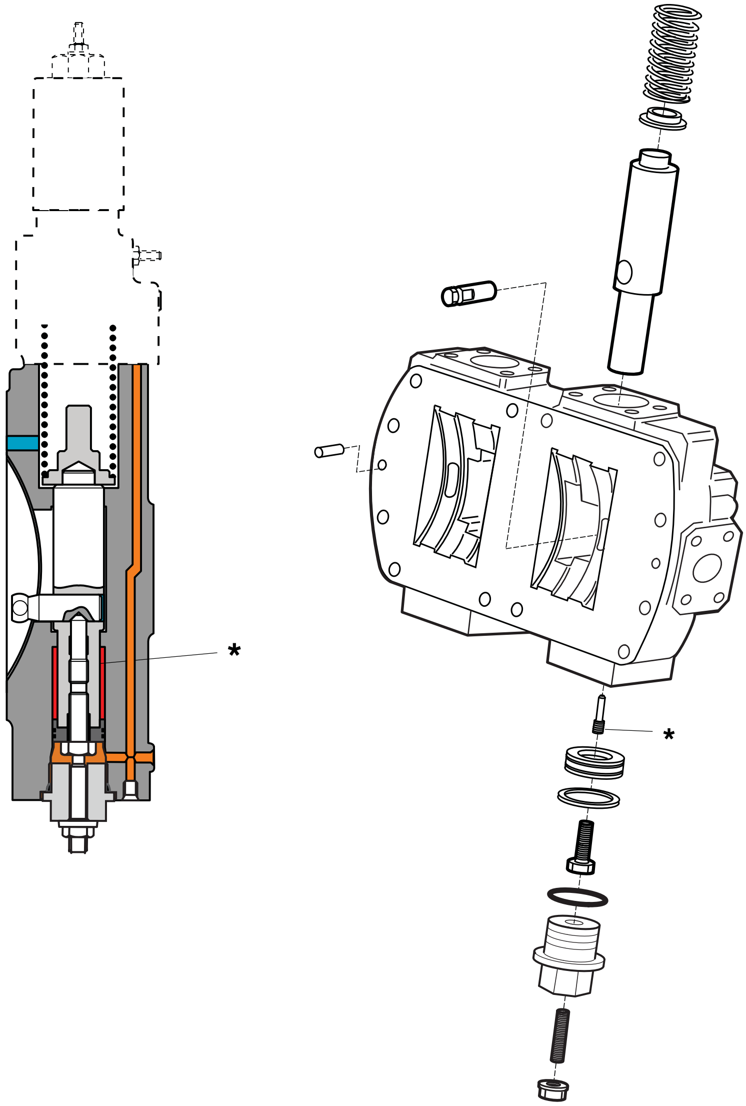


Figure 93 EX1403158

1. Remove screws.

   NOTE: *Install control lens - torque support.*

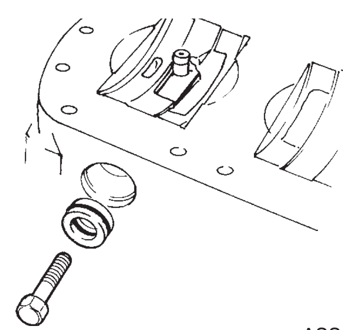
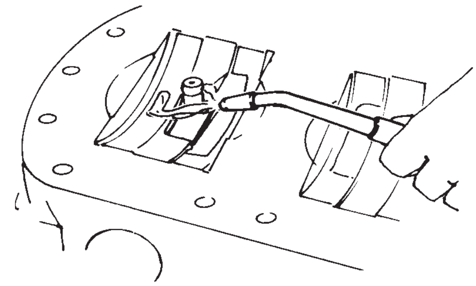


Figure 94

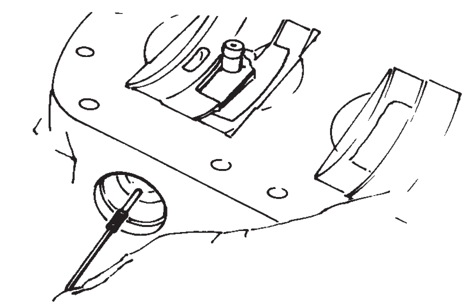
2. Remove locking screw and replace with a new one.

NOTE: *Loosen adhesive with a "gentle" flame (approximately 120°C).*



ASS0410L

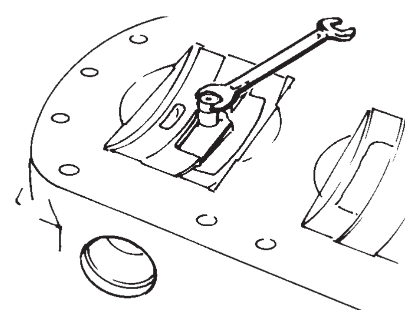
Figure 95



ASS0420L

Figure 96

3. Remove swivel pin.



ASS0430L

Figure 97

Valve Plate with Valves

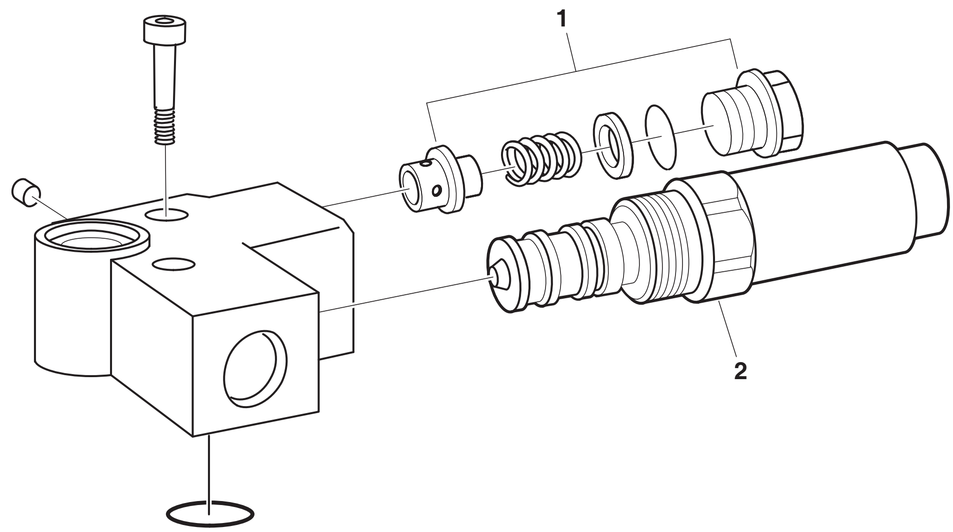
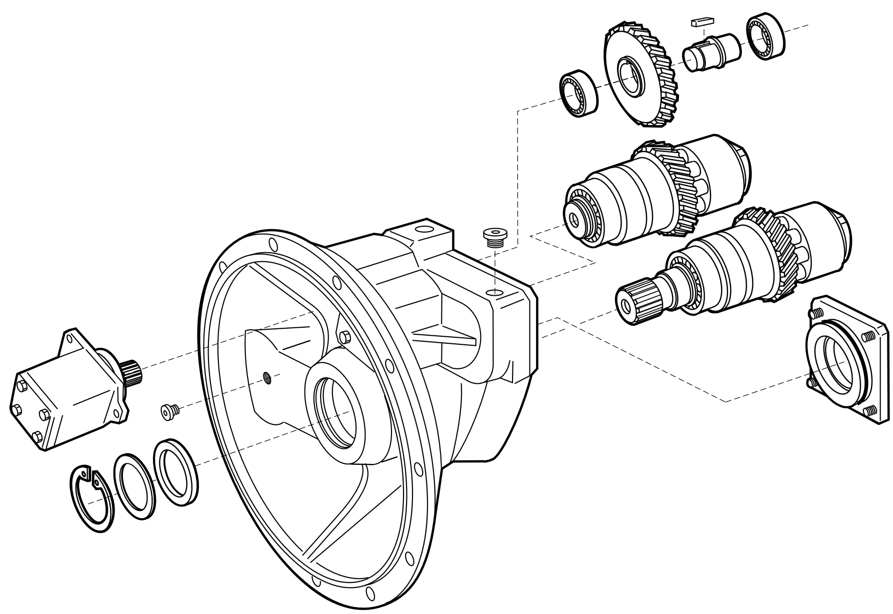


Figure 98 EX1401144

1. Pressure relief valve.
2. Electro- proportional pressure reducing valve (EPPR).

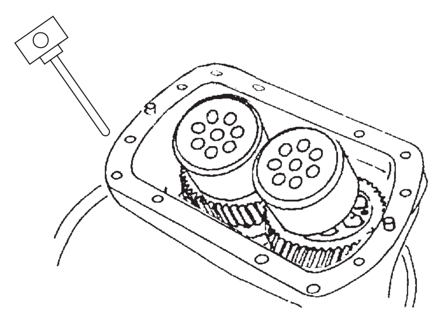
Remove Rotary Groups



EX1403160

Figure 99

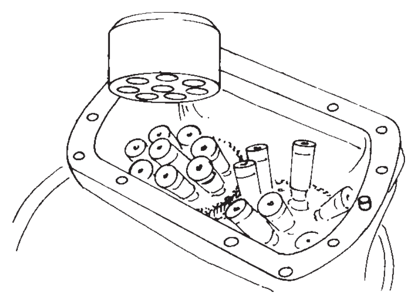
1. Keep cylinder with device (Remove it completely with driveshaft).



ASS0460L

Figure 100

2. Remove cylinder (remove driveshaft without cylinder).



ASS0470L

Figure 101

3. Remove cup springs 1 and spring cup 2.

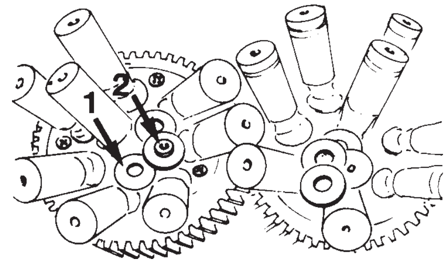


Figure 102

4. Note disassembly position: (1, 2 and 3, Figure 103).

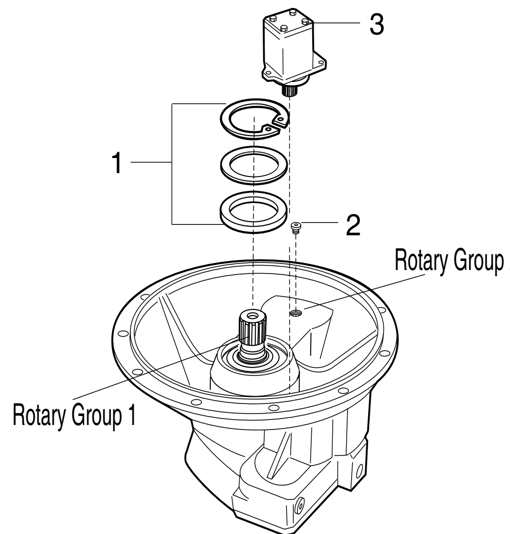


Figure 103

5. Press out rotary group with an appropriate device.

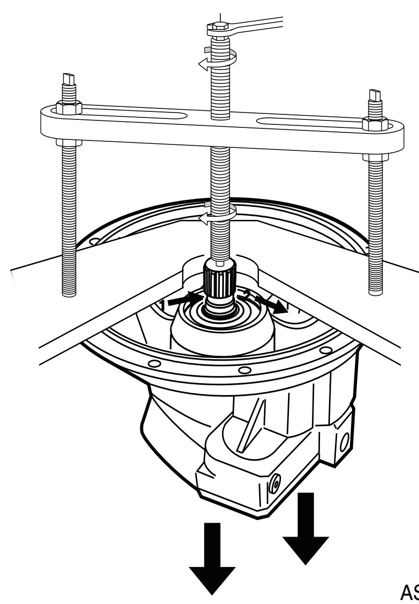


Figure 104

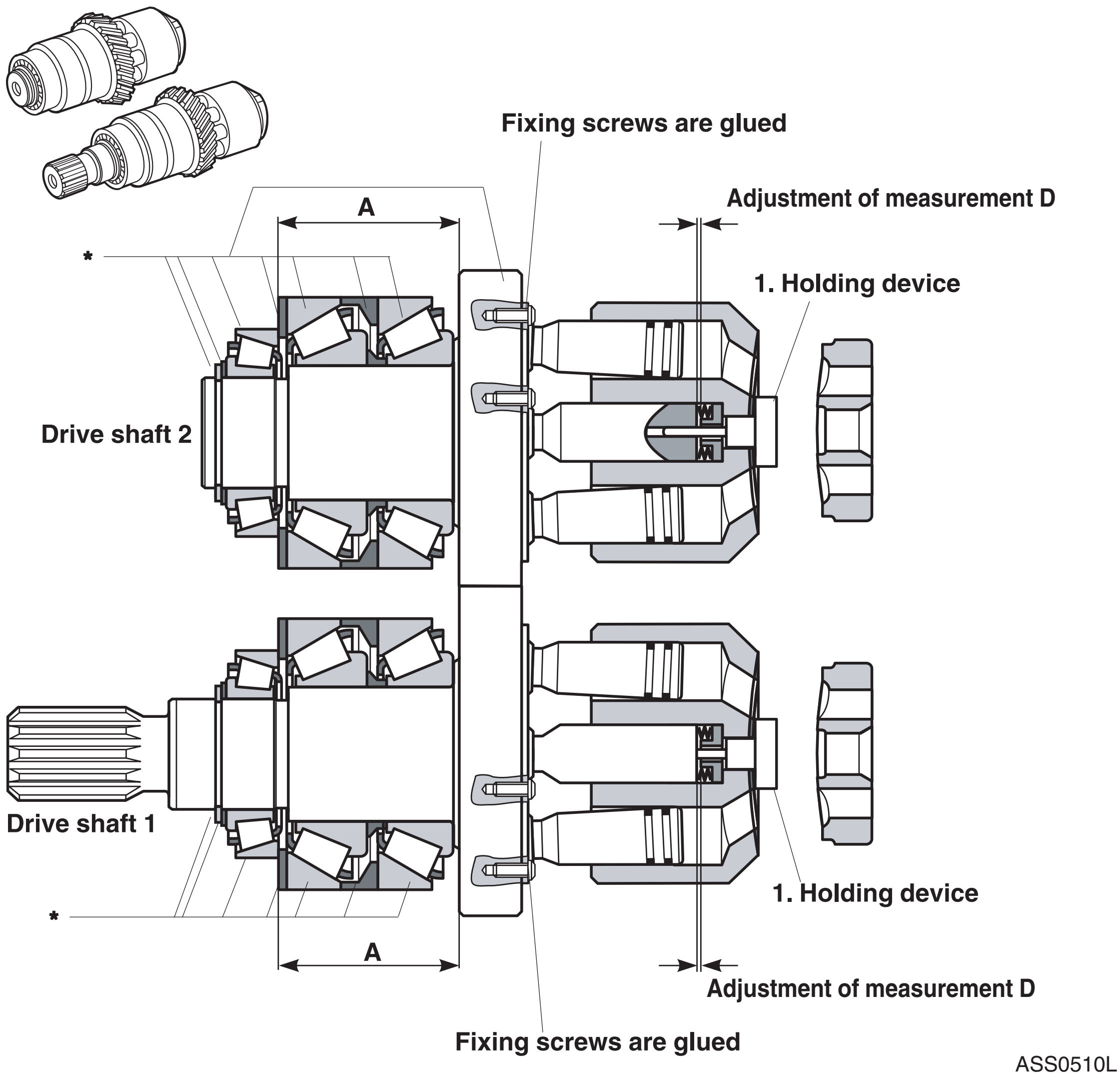


Figure 105

NOTE:

1) *Position (*) driveshafts with bearing set are the smallest assembly group.*

2) *The assembly group is adjusted to measurement A.*

3) *The tapered roller bearings are adjusted to the specified through-torque.*

NOTE:

1) *Fixing screw - Retaining device.*

2) *Removal of screws is only possible if driveshaft is warmed up to a temperature of approximately 120°C for 1/2 hour in an oil bath or heat air furnace.*

3) *Remove screw quickly.*

Remove Intermediate Wheel

1. Press bolt (*, Figure 106) into gear wheel. (Installed pressing fit).

   NOTE: *Can only be disassembled with a hydraulic press.*

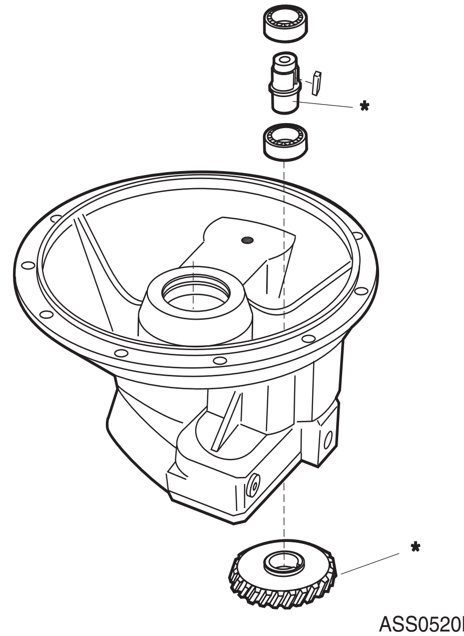


Figure 106

2. Install sleeve.

   NOTE: *Press out bolt with a hydraulic press.*

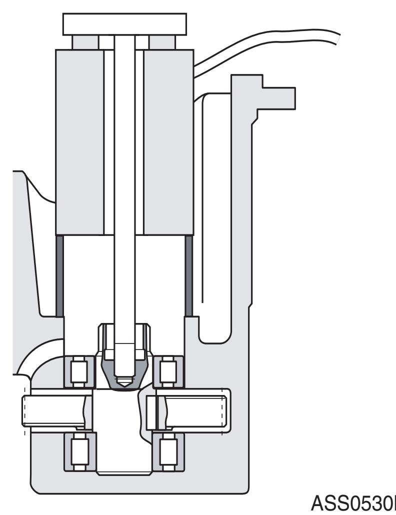


Figure 107

3. Remove gear wheel through side drive opening.

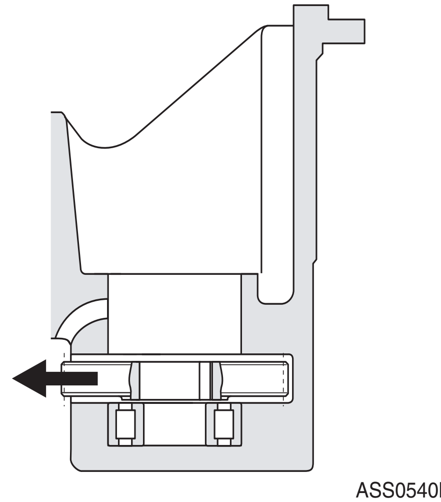


Figure 108

4. Remove bearing with extraction device.

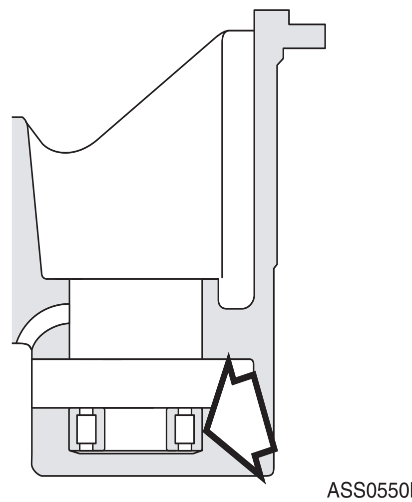
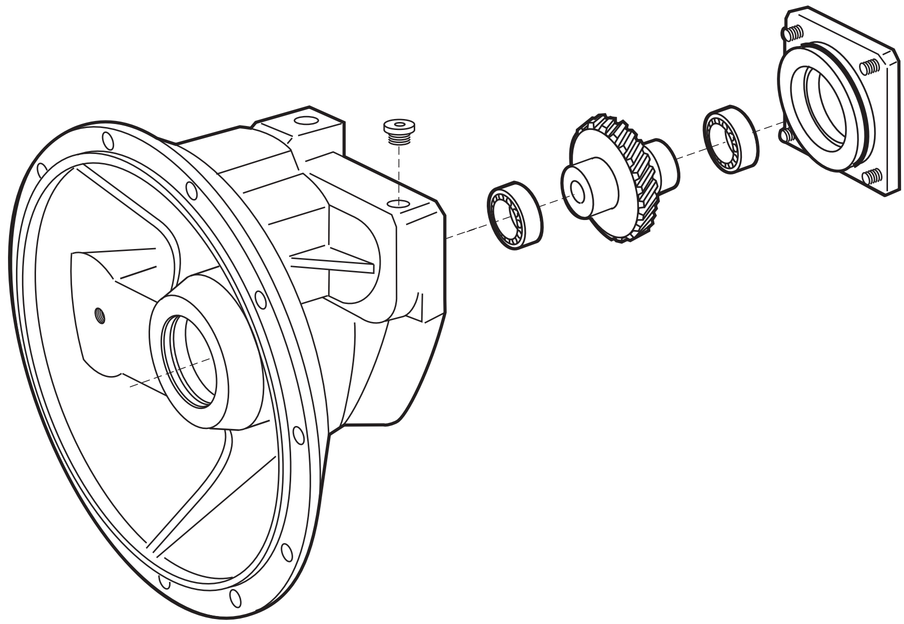


Figure 109

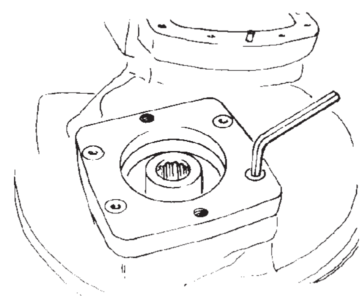
Remove Auxiliary Drive



ASS0560L

Figure 110

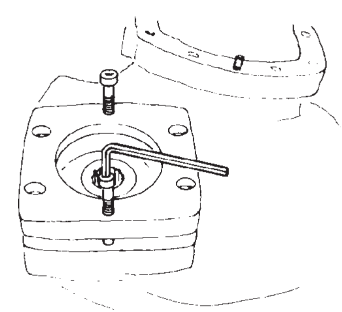
1. Remove screws and auxiliary drive.



ASS0570L

Figure 111

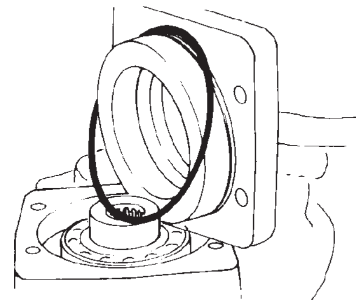
2. Press off bearing cap.



ASS0580L

Figure 112

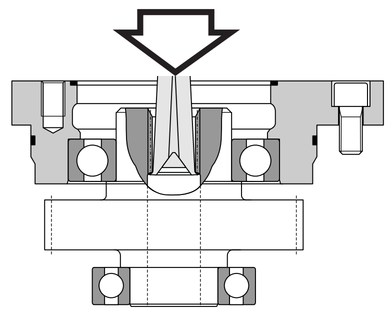
3. In the event of oil leakage, visually check O-ring, housing and groove.



ASS0590L

Figure 113

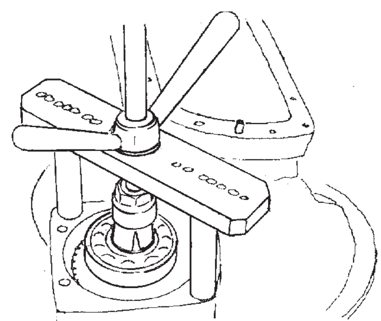
4. Install extractor device.



ASS0600L

Figure 114

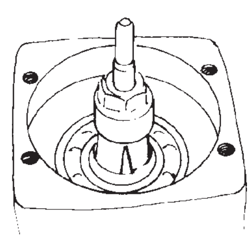
5. Pull out output pinion.



ASS0610L

Figure 115

6. Install bearing extractor device.



ASS0620L

Figure 116

7. Completely mount device and pull out bearing.

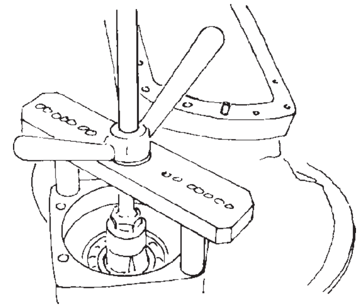


Figure 117

8. Pull out pinion bearing.

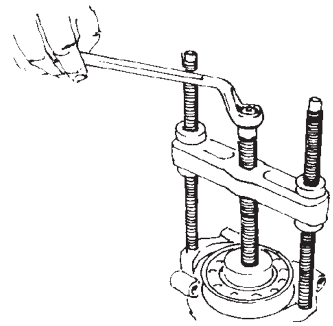
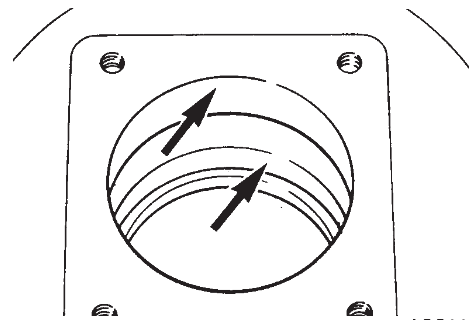


Figure 118

Inspection

1. Check to see that bearing bore is free of scores and there is no evidence of wear.

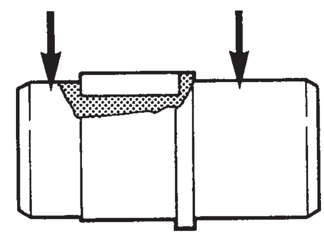


ASS0650L

Figure 119

2. Visually check:

   To ensure that bearing seats are free of scores.

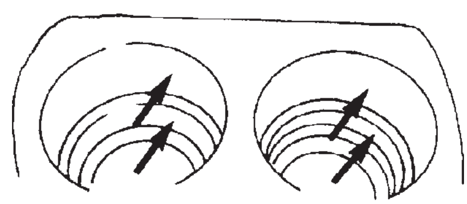


ASS0660L

Figure 120

3. Visually check:

   Check to see that bearing bores are free of scores and there is no evidence of wear.

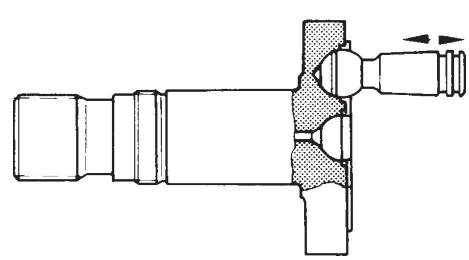


ASS0670L

Figure 121

4. Axial piston play:

   Checked with retaining plate installed.



ASS0680L

Figure 122

5. Driveshafts:

   Check to ensure that cups are free of scores and there is no pitting (1, Figure 123).

   Check to see there is no evidence of corrosion and wear steps (2, Figure 123).

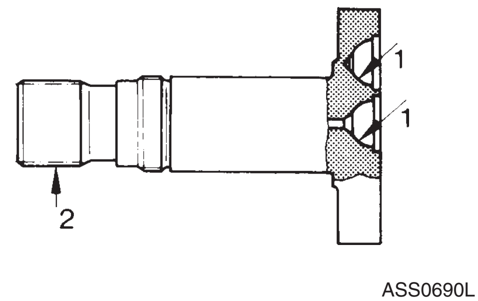


Figure 123

6. Piston:

   Check to ensure that they are free of scores and there is no pitting.

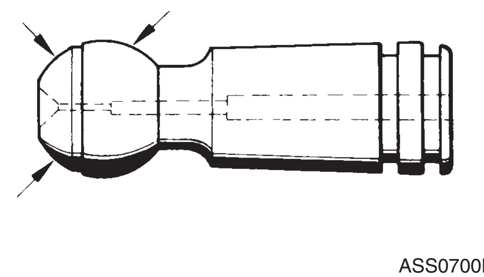


Figure 124

7. Central pin:

   Check to ensure that it is free of scores and there is no pitting.

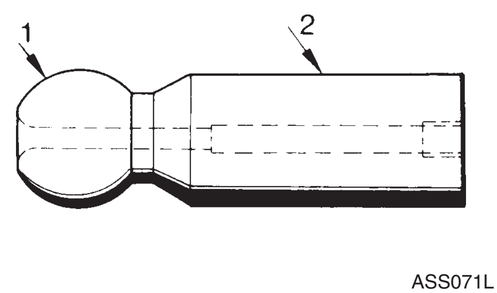


Figure 125

8. Retaining plate:

   Check to ensure that it is free of scores and there is no evidence of wear.

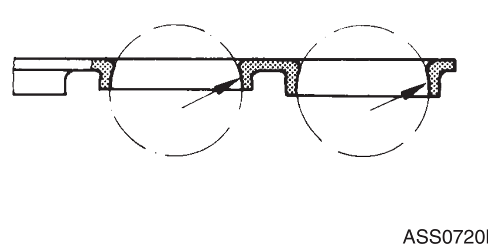


Figure 126

9. Check cylinder block / control lens.

   Bores (1, Figure 127) are free of scores, no evidence of wear.

   Faces (2, Figure 127) are even, there are no cracks, no scores.

   Side guides (3, Figure 127) show no evidence of wear, free of scores.

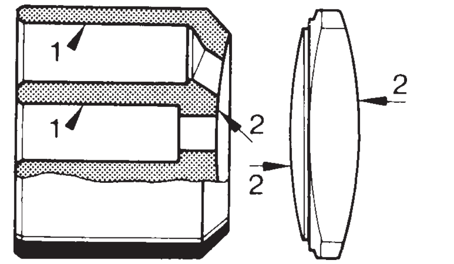


Figure 127

10. Check:

    Control land (1, Figure 128), internal control drilling (2, Figure 128) and pin cups (3, Figure 128).

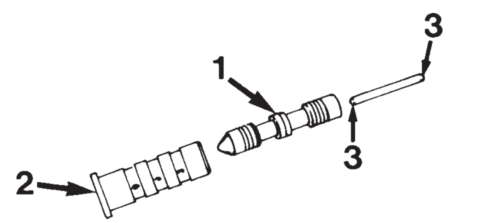


Figure 128

11. Check:

    That sliding surfaces (1, Figure 129) are free of scores.

    Seal (2, Figure 129).

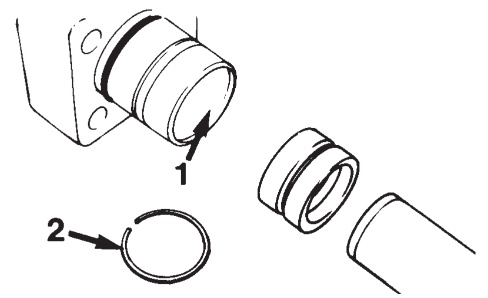


Figure 129

12. Complete rotary group.

NOTE: *Adjustment of the hydraulic component is necessary.*

Mechanical component: driveshaft is adjusted with the bearing (1, Figure 130).

Hydraulic component (2, Figure 130): Adjustment is necessary (*, Figure 130).

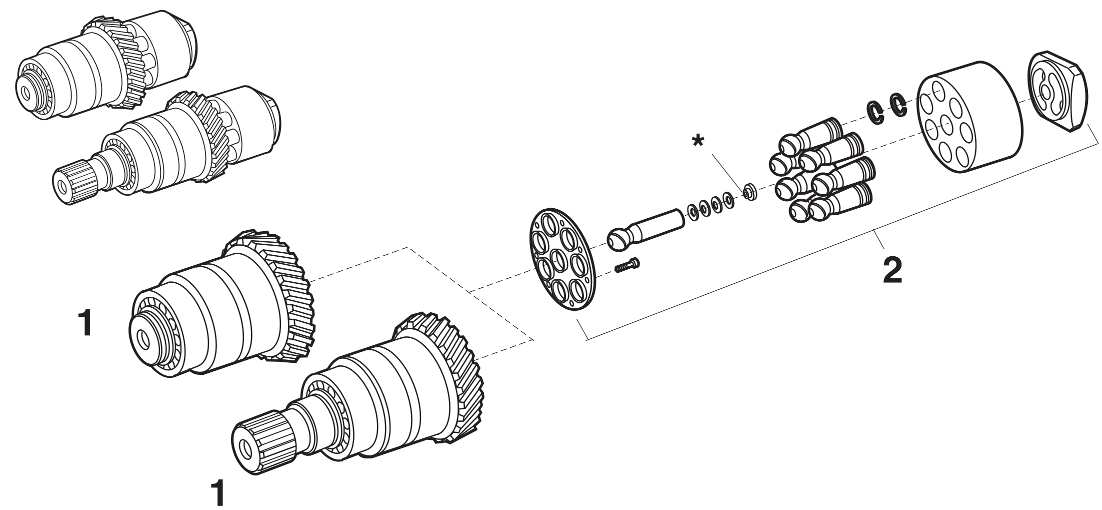


Figure 130

13. Rotary group: All of the components.

    * Adjustment (Figure 131).

    For adjustment values and torque values, see service information.

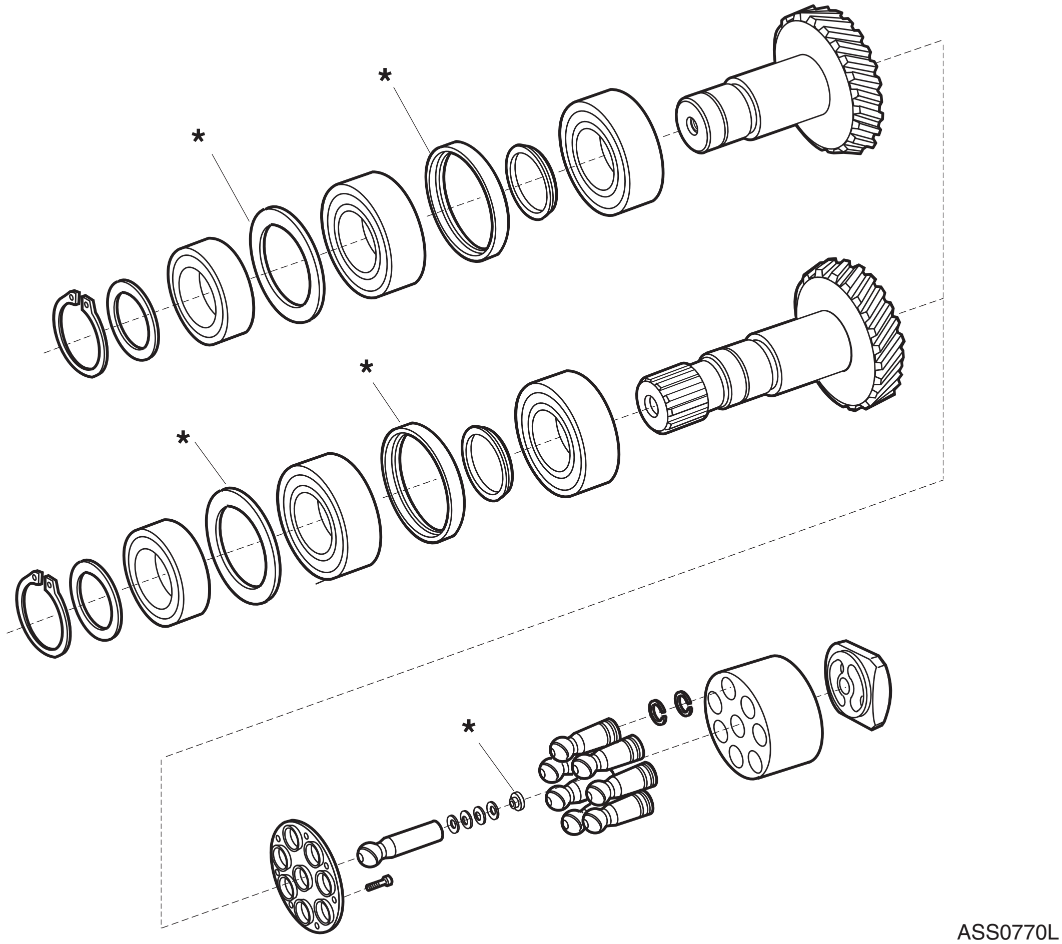
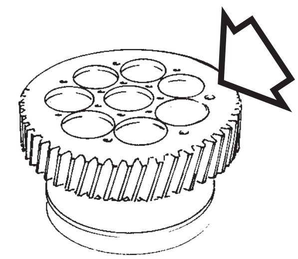


Figure 131

Assembling the Rotary Group

1. Threads must be free of oil, grease, dust or any other contaminants which may impair locking of screws.

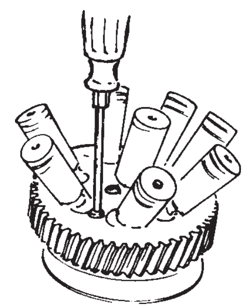


ASS0780L

Figure 132

2. Assemble retaining plate with pistons and center pin in position. Use screws that have a precoat coating.

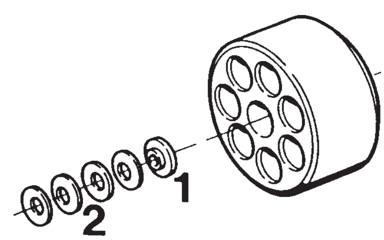
   NOTE: *For tightening torques, see service information.*



ASS0790L

Figure 133

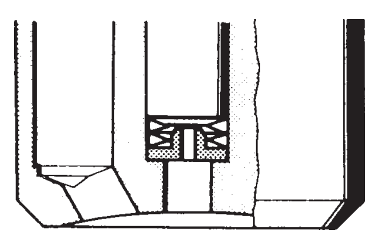
3. Insert spring plate (1, Figure 134) and cup springs (2, Figure 134) into their correct position (and orientation) using grease to hold them into place.



ASS0800L

Figure 134

4. Ensure that all parts are assembled in correct order and orientation.



ASS0810L

Figure 135

5. Insert pistons into cylinder. Using a soft surface as a support to prevent sliding surfaces from being damaged. Preassemble both rotary groups in this manor.

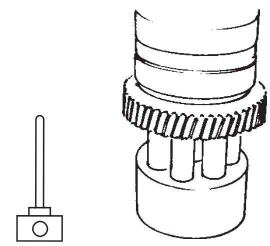
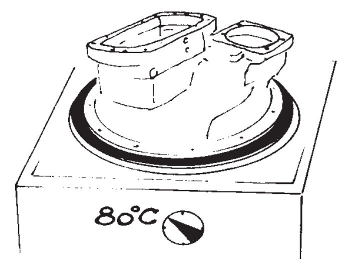


Figure 136

Pump Assembly

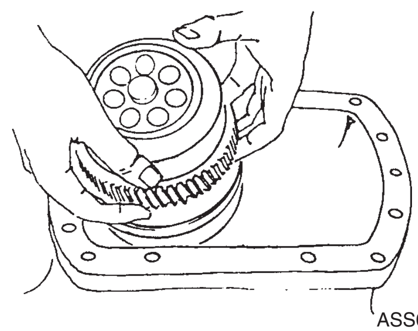
1. Warm up housing to approximately 80°C.



ASS0830L

Figure 137

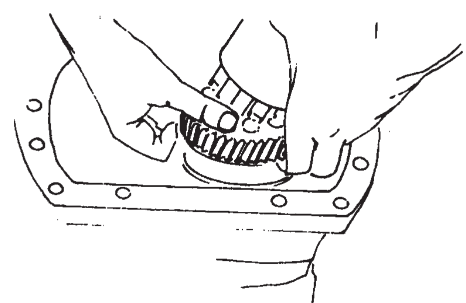
2. Insert preassembled rotary group 2, being sure to align gear tooth marks.



ASS0840L

Figure 138

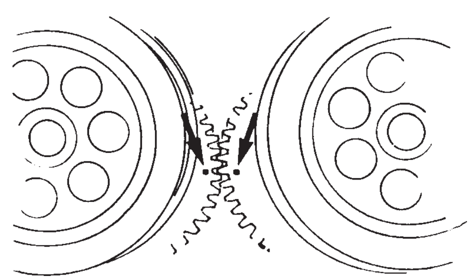
3. Insert rotary group 1. Align the marked gear teeth.



ASS0850L

Figure 139

4. Gear tooth marks must align with each other.



ASS0860L

Figure 140

5. Adjustment of measurement D.

NOTE: *Hydraulic control portion.*

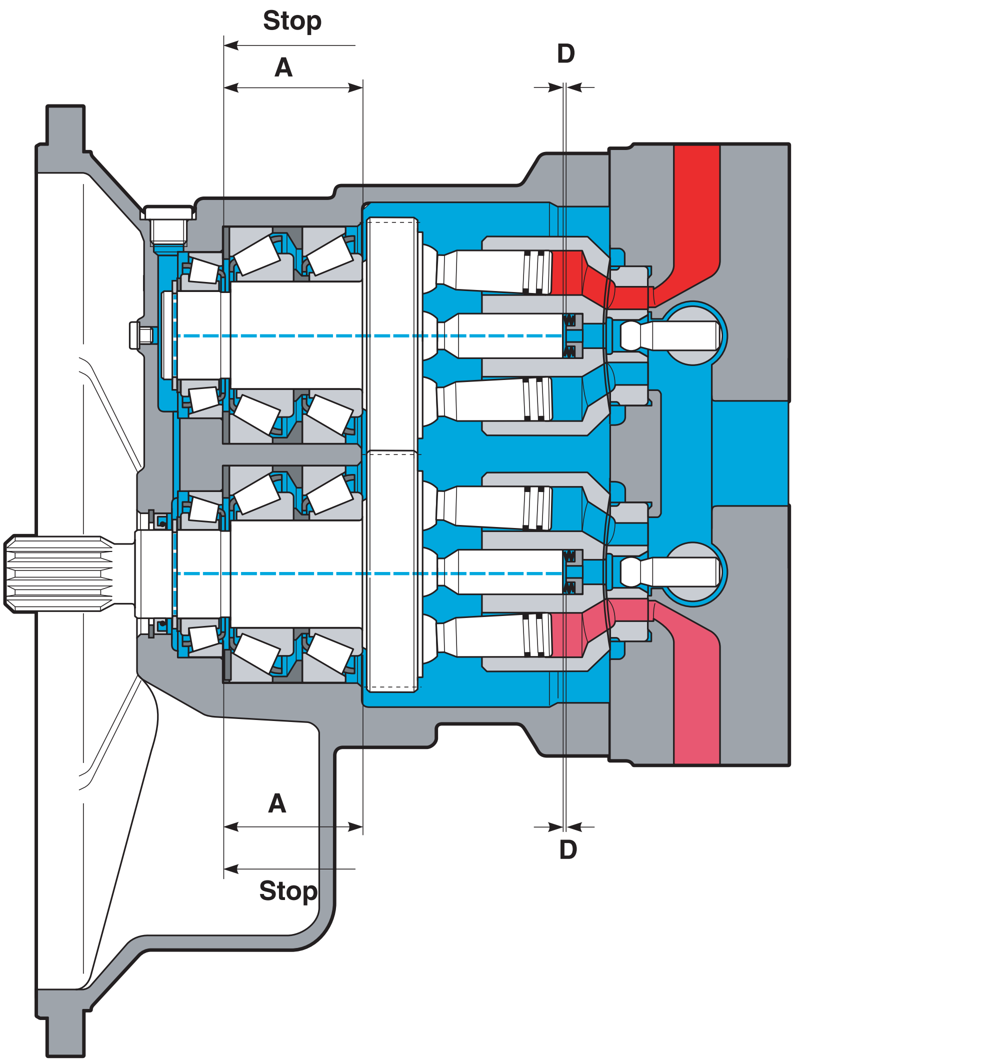


Figure 141

NOTE: *Driveshafts with bearing set.*

The assembly group is adjusted to dimension (A). The tapered roller bearings are adjusted to the stipulated breakaway torque.

Assembly Guideline

Retaining force:

After rotary group has been installed into housing, it has to be pressed in until end stop is reached. Allow housing to cool down from its assembly temperature (approximately 80°C) to room temperature.

Adjustment of the Hydraulic Component of the Rotary Group

The adjustment of dimension "D" is done using spring plates of differing thickness, so correct clearance is achieved between the rotary group which is installed in housing and center pin, and spring plates.

NOTE: *Dimension (D) = 0.4 ±0.1 mm.*

After assembling complete unit, the breakaway torque of the rotary group has to be checked with a torque wrench.

Hydraulic Component - Measurement "D"

Measuring Device - Hydraulic Component

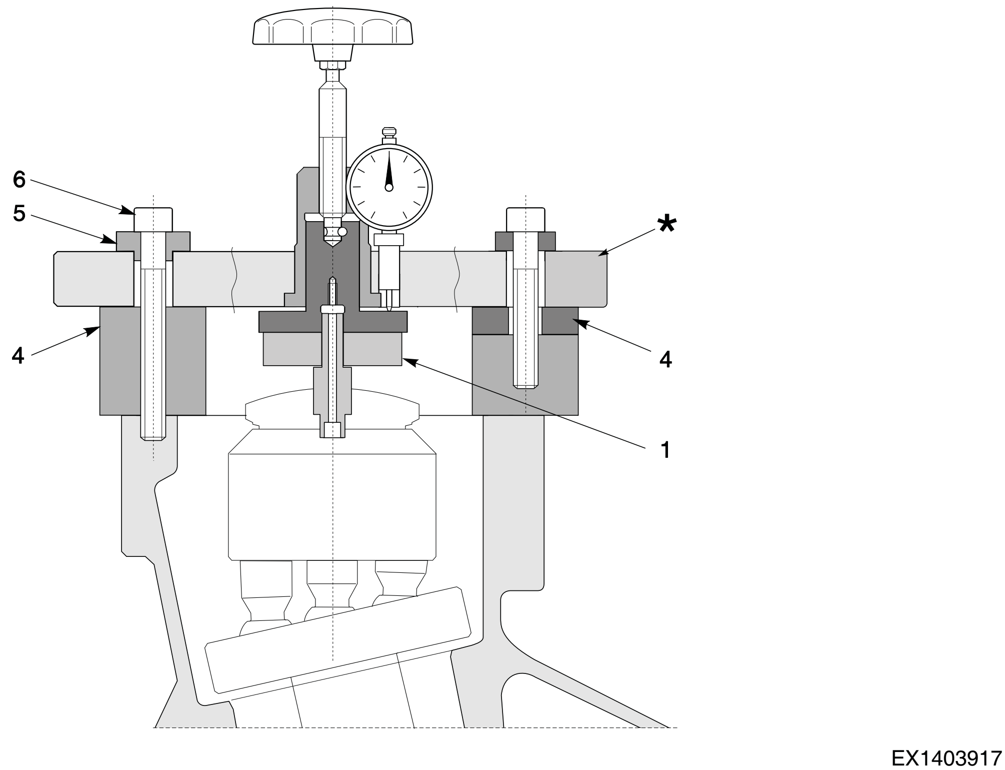


Figure 142

Measuring Device (*)	Centering Device (1)	Intermediate Ring (4)	Shim (5)	S.H.C.S (6)
	1x	2x	2x	2x
9452269	02797872	09452014	09083277	09083105

Mounting Position

NOTE: *Be sure that correct mounting position is used. The numbers on the top of the measuring device (*, Figure 142) refer to the piston diameter.*

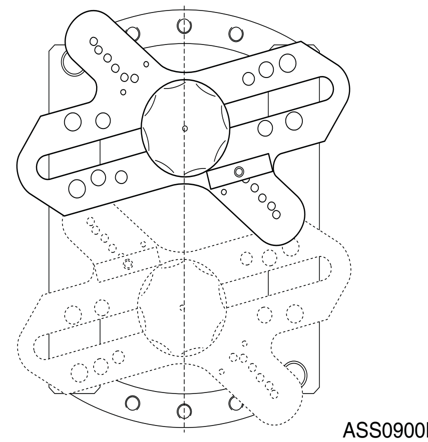


Figure 143

Mounting Position	Distance (mm)
22	168

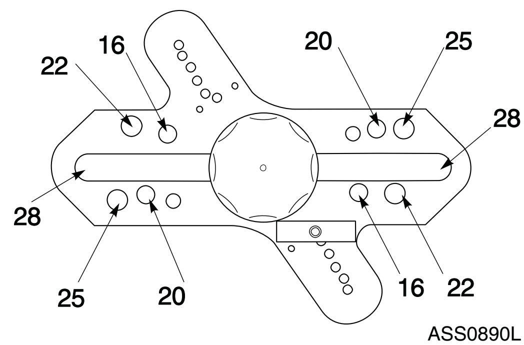


Figure 144

1. Install intermediate ring or plates onto the housing. (Figure 145)

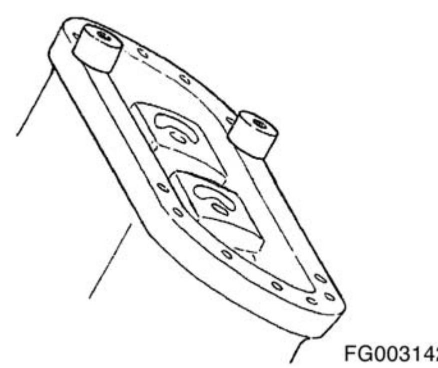


Figure 145

2. Zero adjustment - measuring device.

   Turn using the hand wheel until stop is reached. Set dial gauge to zero. (Figure 146)

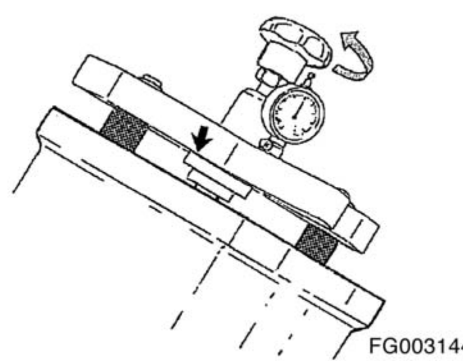


Figure 146

Measuring Procedure

1. Turn down by 4 turns on the dial gauge. (Figure 147)

   Check: 2 mm clearance, set dial gauge to "Zero".

   NOTE: *Clearance: Size 28 ~ 160 0.4 mm ±0.1.*

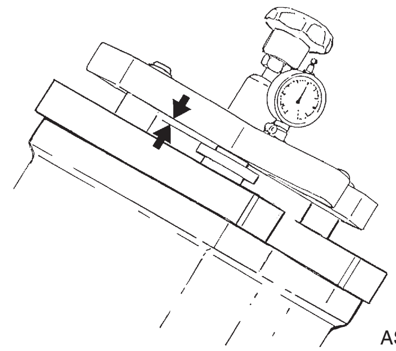


Figure 147

2. Turn down, using the hand wheel, until resistance is met. Read the measured value. (Figure 148)

   NOTE: *Do not use excessive force.*

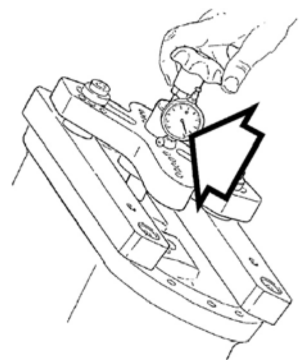


Figure 148

Installation of Control Housing

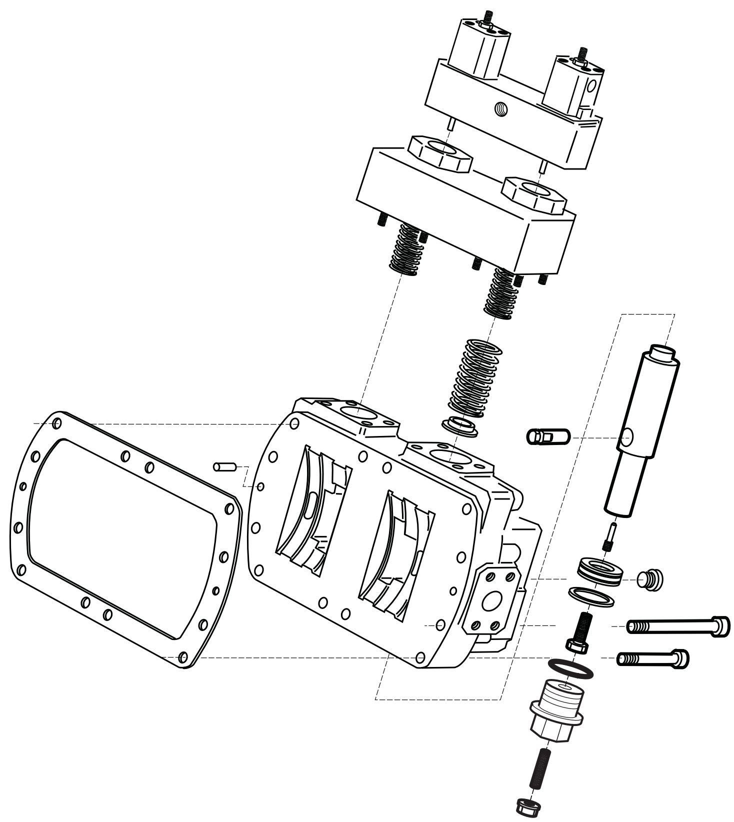


Figure 149

1. Install swivel pin into correct position and orientation. Take hardening time and tightening torque into account.

   NOTE: *Tightening Torques (*):*
   M6 = 8.5 N.m (0.87 kg.m (6.27 ft lb))
   M8 = 14 N.m (1.43 kg.m (10.33 ft lb))
   M10 = 35 N.m (3.57 kg.m (25.81 ft lb))
   M12 = 69 N.m (7.04 kg.m (50.89 ft lb))

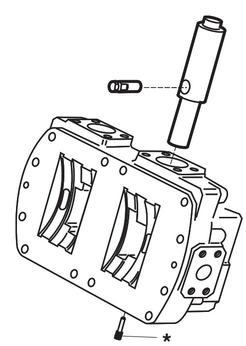


Figure 150

2. Push on piston ring by hand. Install adjustment piston. Take the tightening torques into account.

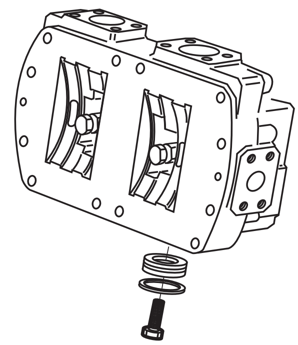


Figure 151

3. Install control housing.

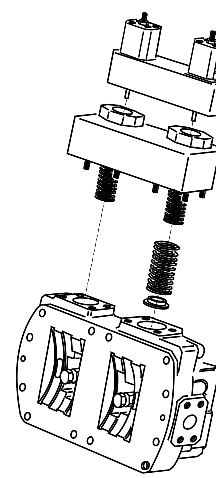


Figure 152

4. Install control lens in their correct position using grease to hold them in place.

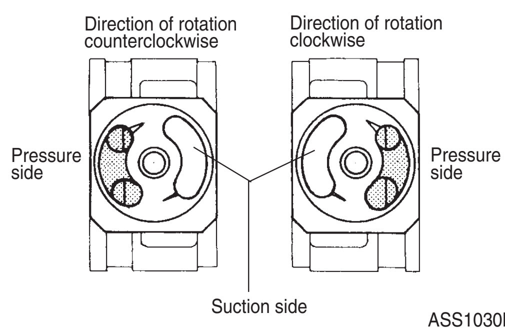


Figure 153

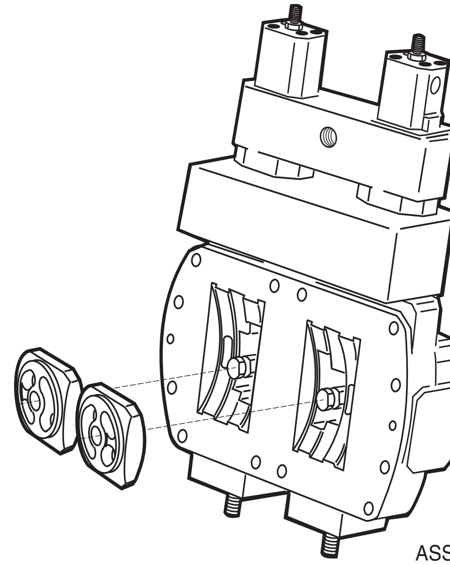


Figure 154

5. Install seal and controller.

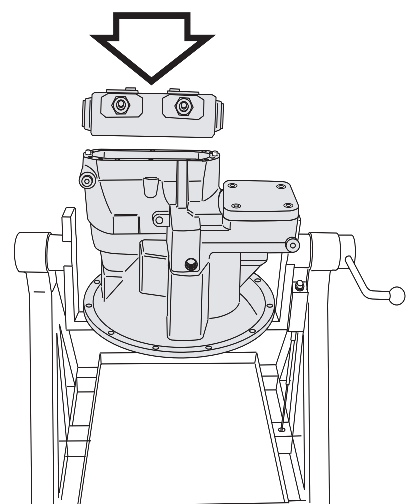


Figure 155

Assembly of Intermediate Wheel

1. Press bearing (1, Figure 156) into housing.
2. After assembly key (3, Figure 156) to the shaft (5) and install the gear (2).
3. Assembly the bearing (4, Figure 156).

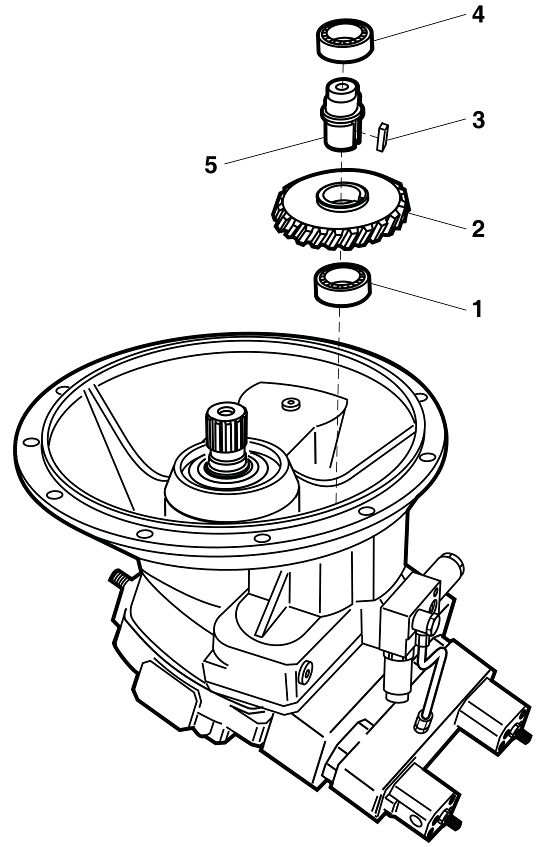


Figure 156

4. Press bearing (4, Figure 156) into housing.

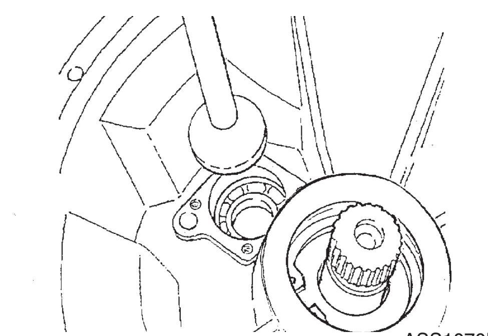
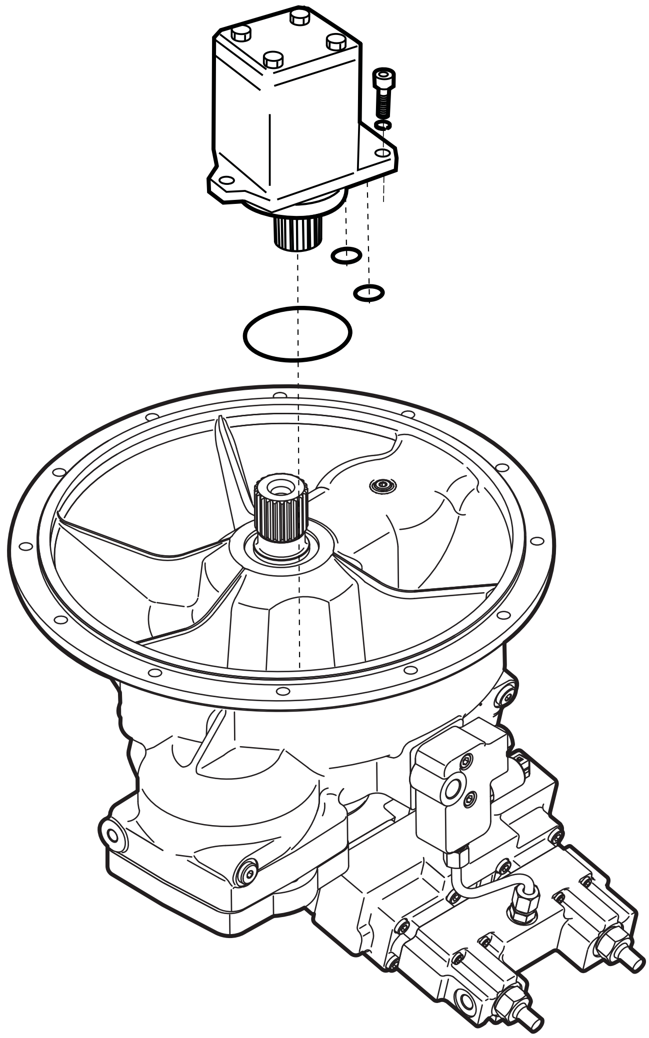


Figure 157

Installation of Gear Pump



EX1403159

Figure 158

1. Assemble shaft seal, disk and safety ring. Press-in with assemble sleeve.

IMPORTANT

Take note of press-in depth.

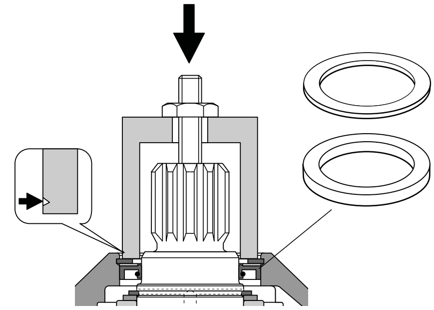


Figure 159

ASS024

Installation of Cover/Auxiliary Drive

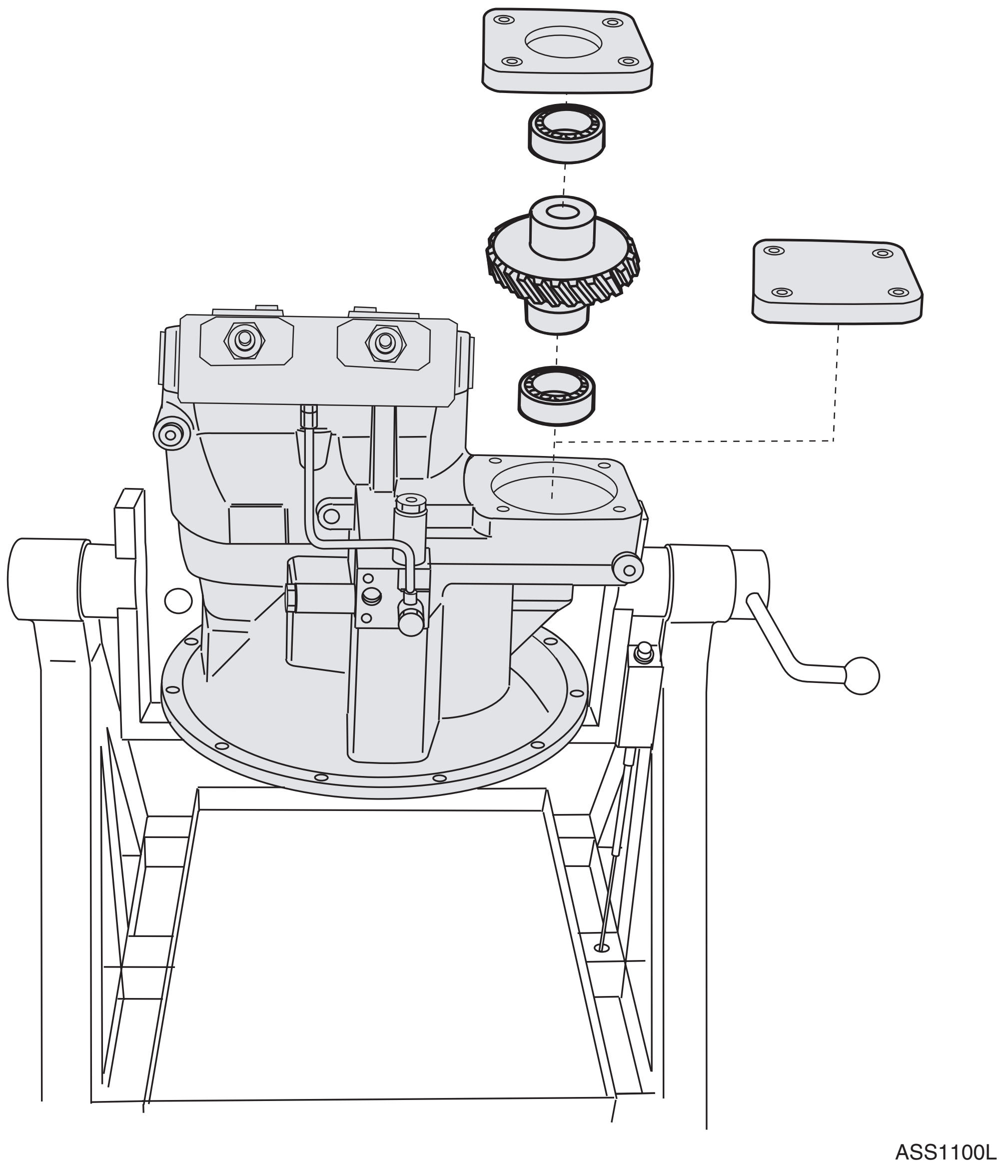


Figure 160

TROUBLESHOOTING

The following table may assist you in troubleshooting. The table makes no claim for completeness.

In practical use, problems which are not listed here may also occur.

How to Proceed for Troubleshooting

1. Always act systematically and targeted, even under pressure of time. Random and imprudent removal and readjustment of settings could result in the inability to ascertain the original error cause.
2. First obtain a general overview of how your product works in conjunction with the entire system.
3. Try to determine whether the product worked properly in conjunction with the entire system before the error occurred.
4. Try to determine any changes of the entire system in which the product is integrated.
    - Were there any changes to the product's application conditions or operating range?
    - Were there any changes (conversions) or repairs on the complete system (machine/system, electrics, control) or on the product? If yes, which?
    - Has the hydraulic fluid been changed?
    - Was the product or machine operated as intended?
    - How did the malfunction appear?
5. Try to get a clear idea of the error cause. Directly ask the (machine) operator.
6. If you cannot rectify the error, contact one of the contact addresses which can be found under:
   www.doosaninfracore.co.kr

Malfunction Table

Fault	Possible cause	Remedy
Unusual noises	Drive speed too high.	Machine or system manufacturer.
	Wrong direction of rotation.	Ensure correct direction of rotation.
	Insufficient suction conditions, e.g. air in the suction line, inadequate diameter of the suction line, viscosity of the hydraulic fluid too high, suction height too high, suction pressure too low, contaminants in the suction line.	Machine or system manufacturer (e.g. optimize inlet conditions, use suitable hydraulic fluid).
		Completely air bleed the axial piston unit, fill the suction line with hydraulic fluid.
		Remove contaminants from the suction line.
	Improper fixing of the axial piston unit.	Check fixing of the axial piston unit according to the specifications of the machine or system manufacturer. Observe tightening torques.
	Improper fixing of the attachment parts, e.g. coupling and hydraulic lines.	Fix attachment parts according to the information provided by the coupling or fitting manufacturer.
	Malfunction of the pressure relief valve of the axial piston unit (pressure cut-off).	Bleeding the axial piston unit. Check viscosity of the hydraulic fluid. Contact our service.
	Mechanical damage to the axial piston unit (e.g. bearing damage).	Exchange axial piston unit, contact our service.
No or insufficient flow	Faulty mechanical drive (e.g. defective coupling).	Machine or system manufacturer.
	Drive speed too low.	Machine or system manufacturer.
	Insufficient suction conditions, e.g. air in the suction line, inadequate diameter of the suction line, viscosity of the hydraulic fluid too high, suction height too high, suction pressure too low, contaminants in the suction line.	Machine or system manufacturer (e.g. optimize inlet conditions, use suitable hydraulic fluid).
		Completely air bleed the axial piston unit, fill the suction line with hydraulic fluid.
		Remove contaminants from the suction line.
	Hydraulic fluid not in optimum viscosity range.	Use suitable hydraulic fluid (machine or system manufacturer).
	External control of the control device defective.	Check external control (machine or system manufacturer).
	Insufficient pilot pressure or control pressure.	Check pilot pressure or control pressure, contact our service.
	Malfunction of the control device or controller of the axial piston unit.	Contact our service.
	Wear of axial piston unit.	Exchange axial piston unit, contact our service.
	Mechanical damage to the axial piston unit (e.g. bearing damage).	Exchange axial piston unit, contact our service.

Fault	Possible cause	Remedy
No or insufficient pressure	Faulty mechanical drive (e.g. defective coupling).	Machine or system manufacturer.
	Drive power too low.	Machine or system manufacturer.
	Insufficient suction conditions, e.g. air in the suction line, inadequate diameter of the suction line, viscosity of the hydraulic fluid too high, suction height too high, suction pressure too low, contaminants in the suction line.	Machine or system manufacturer (e.g. optimize inlet conditions, use suitable hydraulic fluid).
		Completely air bleed the axial piston unit, fill the suction line with hydraulic fluid.
		Remove contaminants from the suction line.
	Hydraulic fluid not in optimum viscosity range.	Use suitable hydraulic fluid (machine or system manufacturer).
	External control of the control device defective.	Check external control (machine or system manufacturer).
	Insufficient pilot pressure or control pressure.	Check pilot pressure or control pressure, contact our service.
	Malfunction of the control device or controller of the axial piston unit.	Contact our service.
	Wear of axial piston unit.	Exchange axial piston unit, contact our service.
	Mechanical damage to the axial piston unit (e.g. bearing damage).	Exchange axial piston unit, contact our service.
	Output unit defective (e.g. hydraulic motor or cylinder).	Machine or system manufacturer.
Pressure/ flow fluctuations	Axial piston unit and/or control unit not or insufficiently air bled.	Completely air bleed axial piston unit. The pressure reducing valve must be exchanged. contact service.
	Insufficient suction conditions, e.g. air in the suction line, inadequate diameter of the suction line, viscosity of the hydraulic fluid too high, suction height too high, suction pressure too low, contaminants in the suction line.	Machine or system manufacturer (e.g. optimize inlet conditions, use suitable hydraulic fluid).
		Completely air bleed the axial piston unit, fill the suction line with hydraulic fluid.
		Remove contaminants from the suction line.
Excessive hydraulic fluid and case temperature	Excessive inlet temperature at the axial piston unit.	Machine or system manufacturer: Inspect system, e.g. malfunction of the cooler, insufficient hydraulic fluid in the reservoir.
	Malfunction of the pressure control valves (e.g. pressure cut-off, pressure controller).	Contact Service.
	Wear of axial piston unit.	Exchange axial piston unit, contact service.
Instability/vibrations	Setpoint value not stable.	Machine or system manufacturer.
	Resonance in the reservoir line.	Machine or system manufacturer.
	Axial piston unit and/or control unit not insufficiently air bled.	Completely air bleed axial piston unit. The pressure reducing valve must be exchanged. Contact service.
	Malfunction of the control devices or controller.	Contact service.

Drive Coupling (Main Pump)

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Drive Coupling (Main Pump)

GENERAL

Description

When installing the main pump on the engine, it is very important to properly adjust clearance between the face of the coupling hub and end of pump drive shaft to a specific value.

Specification

Nominal Torque		785 N.m (80 kg.m, 579 ft lb)
Max. Torque		1,560 N.m (160 kg.m, 1,157 ft lb)
Max. Speed		4,000 rpm
Max. Permissible Displacements	Radial	0.4 mm (0.015 in)
	Angular	0.5°
	Axial	±2 mm (±0.08 in)
Dynamic Torsion Spring Stiffness Cdyn		1.96 x 10^6 kg.cm/Rad
Mass Moment of Inertia		2.33 kg.cm. S^2
Allowable Environment Temperature		-40 ~ +120 °C

Parts List

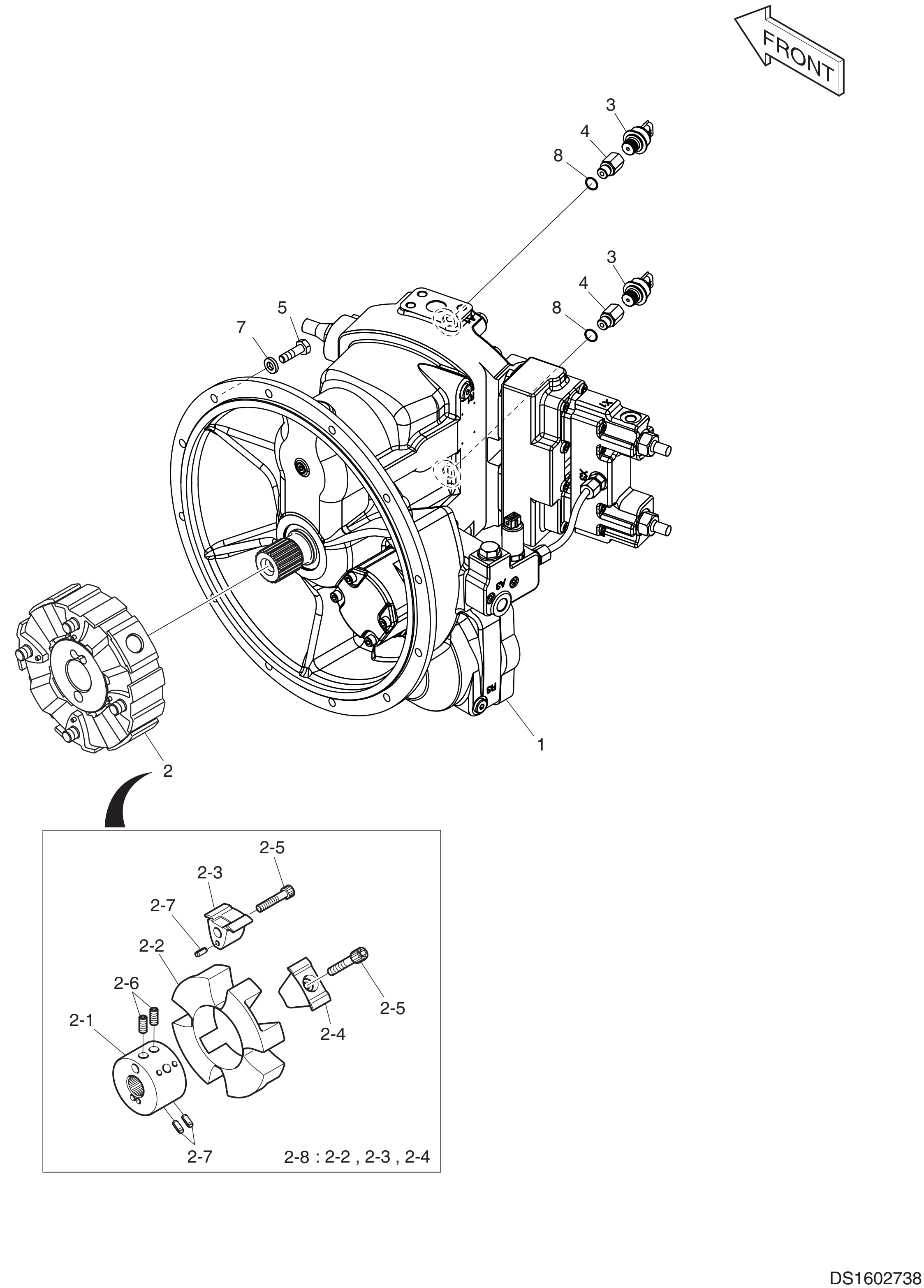


Figure 1

Reference Number	Description
1	Pump, Main
2	Coupling, Pump
2-1	Hub
2-2	Element
2-3	Insert (A)
2-4	Insert (R)
2-5	Socket Bolt Set (8 ea)
2-6	Bolt

Reference Number	Description
2-7	Pin, Spring
2-8	Element Kit
3	Sensor, Pressure
4	Adatper, Reducing
5	Bolt
7	Washer
8	O-ring

SECTION VIEW

Whenever the drive coupling for main pump is installed, the following mounting dimensions and installation procedures must be observed.

NOTE: *If these procedures are not followed, noise will occur and/or the service life of drive coupling or main pump will be reduced.*

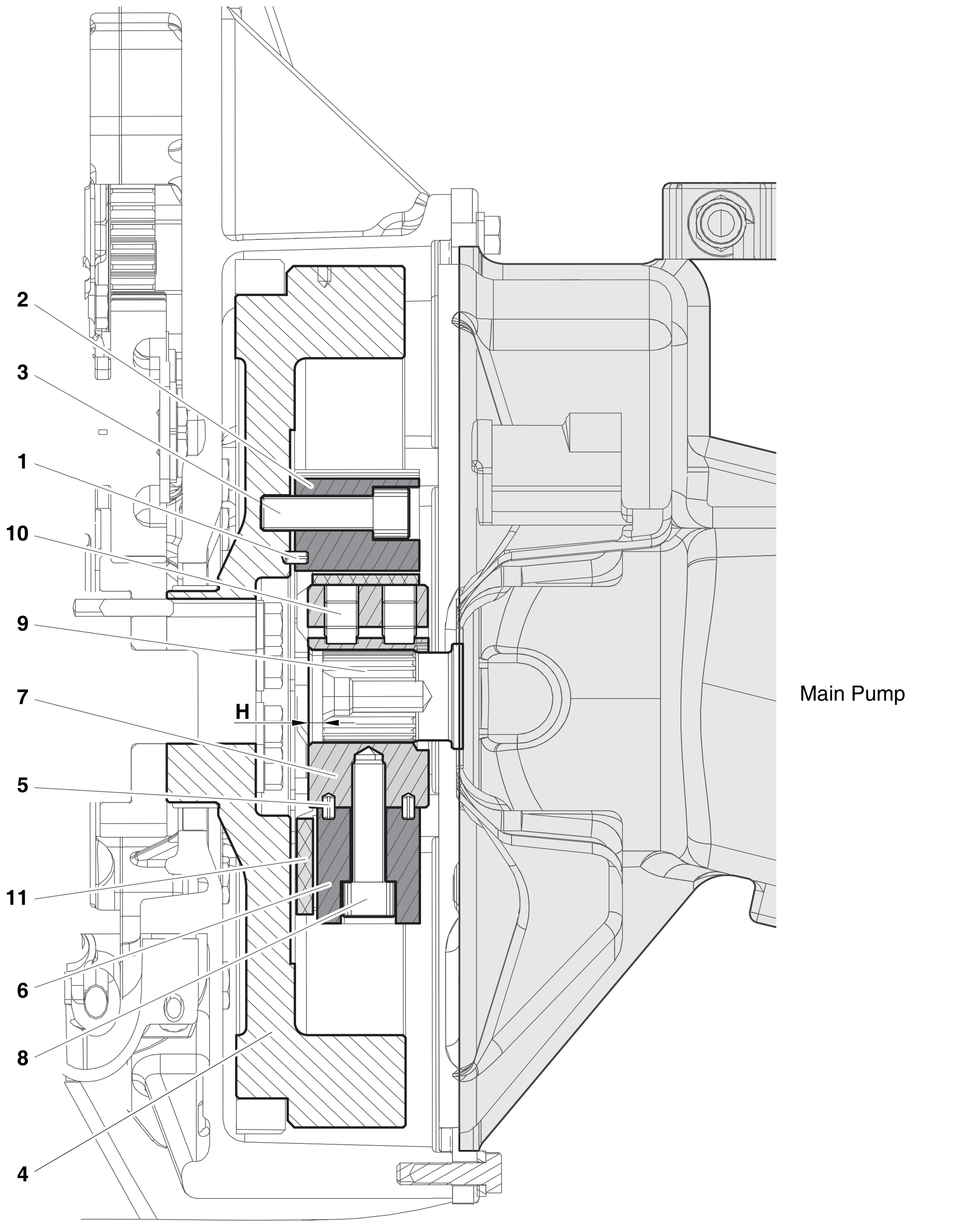


Figure 2 Drive Coupling Installation

Reference Number	Description	Qty.	Torque
1	Spring Pin	4	
2	Insert	4	
3	Socket Bolt M16 x 50	4	206 ~ 226 N.m (21 ~ 23 kg.m, 152 ~ 166 ft lb)
4	Flywheel	1	
5	Spring Pin	8	
6	Insert	4	
7	Hub	1	
8	Socket Bolt M16 x 50	4	206 ~ 226 N.m (21 ~ 23 kg.m, 152 ~ 166 ft lb)
9	Pump Shaft	1	
10	Clamping Screw M16 x 20	2	98 ~ 118 N.m (10 ~ 12 kg.m, 72 ~ 87 ft lb)
11	Element	1	

Symbol	Dimension	Remarks
H	6.5 mm (0.56 in)	Distance between from Pump Shaft to Coupling Hub

Tools

Name	Description
Allen Wrench	8 mm, 14 mm
Plastic Hammer	One Plastic Hammer

DISASSEMBLY

When the pump is removed from an engine, the hub and insert would be attached on the pump.

1. After removing pump remove socket bolts (5, Figure 3) (4 ea) and remove insert (4) (4 ea).

    • : 14 mm

2. Remove clamp bolts (6, Figure 3) (2 ea) and remove hub (1).

    • : 8 mm

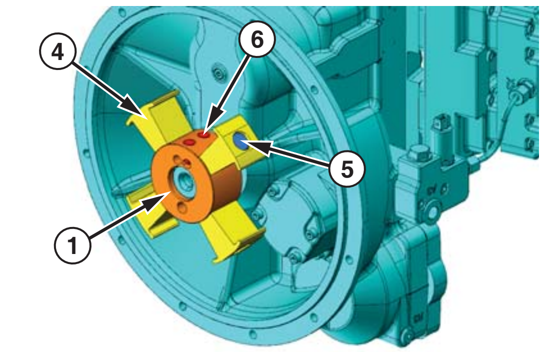


Figure 3 DS1602760

3. Remove socket bolts (5, Figure 4) (4 ea) and insert (3, Figure 4) (4 ea) with element (2) from flywheel.

    • : 14 mm

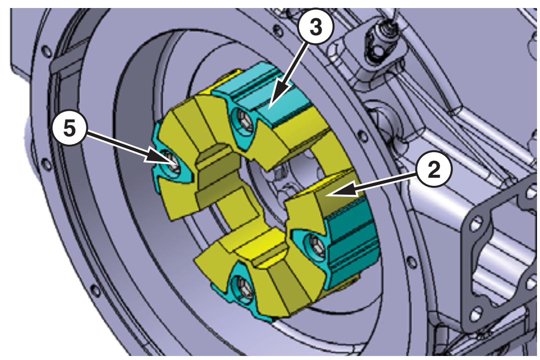


Figure 4 EX1403072

REASSEMBLY

1. Install insert (3, Figure 5) (4 ea) and spring pin (7, Figure 6) (4 ea) with socket bolts (5) (4 ea) to engine flywheel.

   - : 14 mm
   - Torque: 205.9 ~ 225.6 N.m
     (21 ~ 23 kg.m, 151.9 ~ 166.4 ft lb)

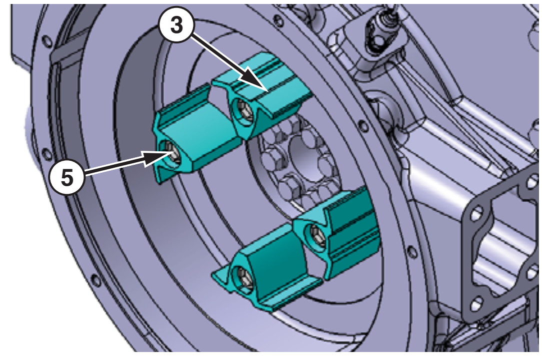
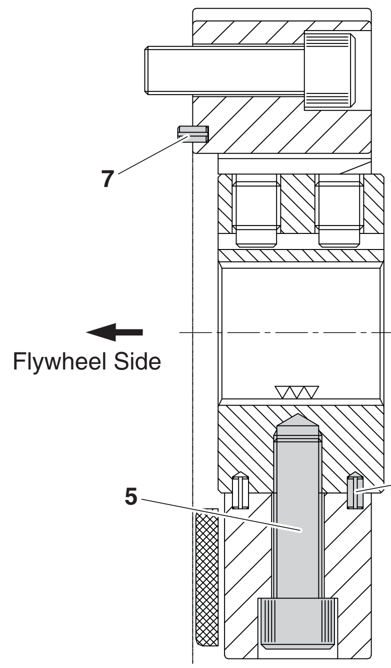


Figure 5 EX1403073

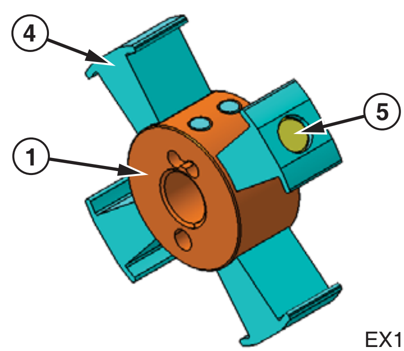


EX1403074

Figure 6

2. Assemble the insert (4, Figure 7) (4 ea) with socket bolts (5) (4 ea) to hub (attached by spring pin) (7, Figure 6) (8 ea).

   - Torque: 205.9 ~ 225.6 N.m
     (21 ~ 23 kg.m, 151.9 ~ 166.4 ft lb)



EX1404097

Figure 7

3. Slide hub into place on pump shaft (8, Figure 8). Keep the dimension 6.5 mm between end of pump shaft to hub and secure it in position with clamping bolts (6).

   - Torque: 98 ~ 117.7 N.m
     (10 ~ 12 kg.m, 72.3 ~ 86.8 ft lb)

   NOTE: *Coat clamping bolts (6, Figure 8) with Loctite #262.*

   NOTE: *Refer to "Dimension" of "H" on page -7.*

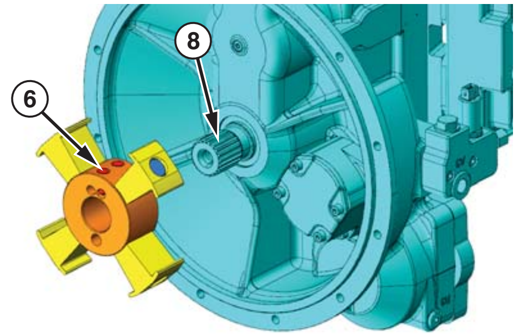


Figure 8 DS1602761

4. Install element (2, Figure 9) to inserts (3) on engine flywheel.
5. Install main pump and hub (Figure 9) by pushing it softly into element (2).

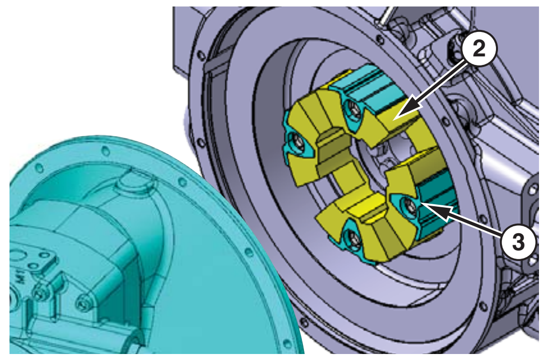


Figure 9 DS1602762

IMPORTANT

1. **Bolts are coated against loosening with a bonding compound. Do not use any additional bonding compounds, oils or cleaning solvents on them.**
2. **Element (2, Figure 9) is not resistant to bonding compounds, oil or grease. Be careful not to expose them to it.**
3. **Remove oil or dirt from flywheel cover and pump shaft before assembly.**
4. **Misalignment between pump and engine must be controlled to less than 0.6 mm (0.023 in).**

Main Control Valve

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Main Control Valve

GENERAL

Specification

Control Method		Negative Control
Rated Flow		270 L/min (50 L/min in neutral)
Main Relief Pressure	High	343 bar (350 kg/cm^2, 4,978 psi) at 136 L/min
	Low	323 bar (330 kg/cm^2, 4,694 psi) at 156 L/min
Overload Relief Pressure	A2, B2, A5, B5, A8, B8	353 bar (360 kg/cm^2, 5,120 psi) at 20 L/min
	A7, B7	245 bar (250 kg/cm^2, 3,555 psi) at 20 L/min
Permitted Back Pressure		Max. Pressure of 14.7 bar or Less
		Used Pressure of 5 bar or Less
Permitted Use of Oil Temperature		Normally -20 ~ 80°C
		Highest 100°C
		(Use of the Rubber for NBR)
Weight		193 kg (425 lb)

Overview

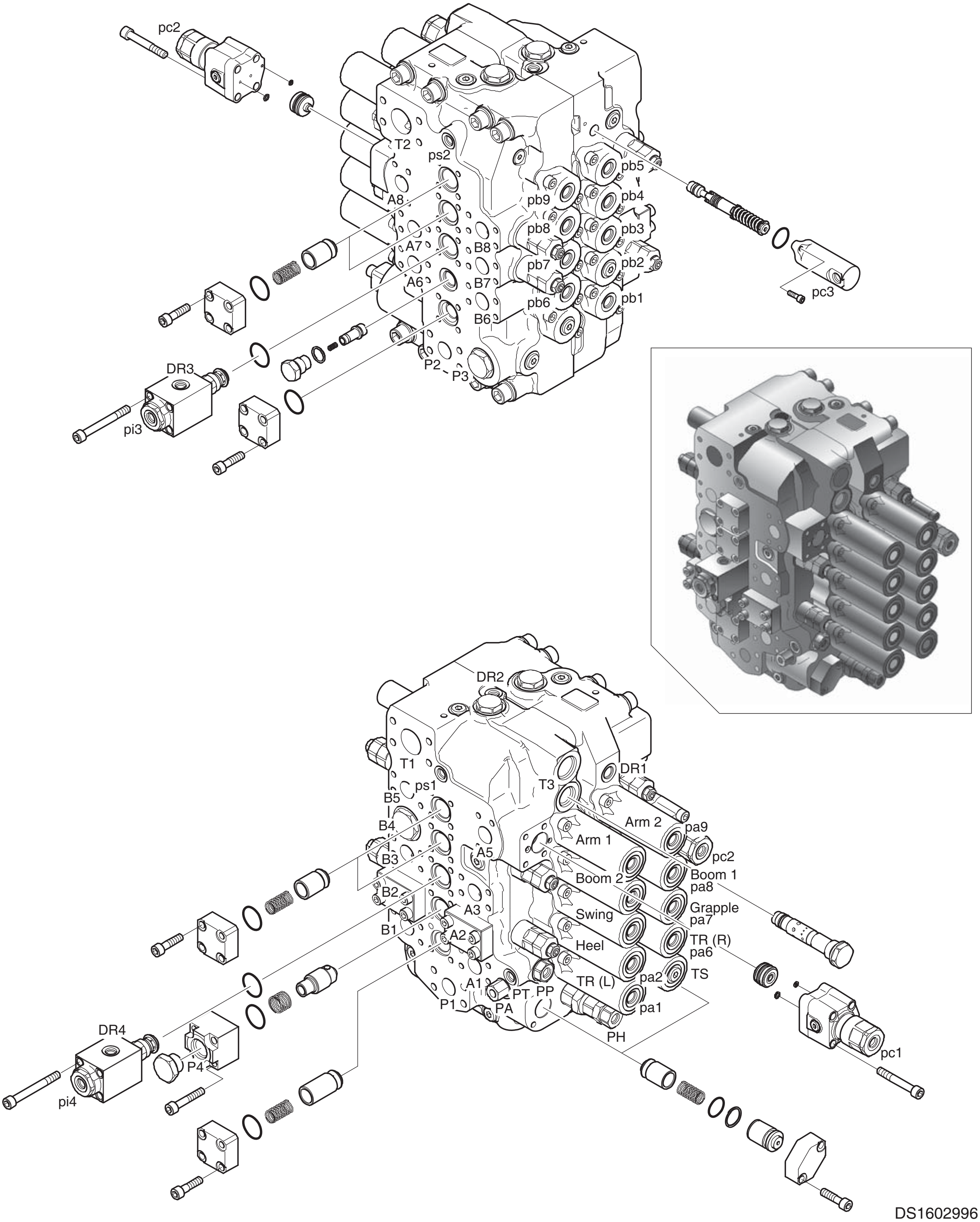


Figure 1

Port	Name	Size
P3	Pump High-pressure	PF 3/4"
P4	Two Pump Flow Valve	
B4	Boom 2 (Plugged)	
T3	Plug	PF 1"
P1	Idle Pump High-pressure (A1)	27.76 x 57.15 (M12 x 1.75)
P2	Drive Pump High-pressure (A2)	
A1	Travel Backward (LH)	SAE 1"
B1	Travel Forward (LH)	
A2	Heel Rack OUT	
B2	Heel Rack IN	
A3	Swing Motor Left	
B3	Swing Motor Right	
A5	Arm Cylinder Rod Side	
B5	Arm Cylinder Tube Side	
A6	Travel Backward (RH)	
B6	Travel Forward (RH)	
A7	Grapple Cylinder Tube Side	
B7	Grapple Cylinder Rod Side	
A8	Boom Cylinder Tube Side	
B8	Boom Cylinder Rod Side	
T1	Return Line 1	35.71 x 69.85 (M12 x 1.75)
T2	Swing Motor Make Up (C)	
PP	Pilot Pressure (40 bar)	PF 1/4"
PT	Pressure Sensor Port	
pc3	Drain Port	
pc1	Lock Valve Pilot (Arm Crowd)	
pc2	Lock Valve Pilot (Boom Down)	
PA	Swing Parking Brake Port (SH) and Pressure Sensor	
PH	Pressure Up	
ps1	Negacon Pressure (X1) (A1)	
ps2	Negacon Pressure (X2) (A2)	
DR2	Drain 2	
DR3	Drain 3	
Pi3	Boom Priority Signal	
DR4	Drain 4	
Pi4	Boom Priority Signal	

Port	Name	Size
pa1	Travel Backward Pilot (LH)	PF 3/8"
pa2	Heel Rack OUT Pilot	
pa3	Swing Left Pilot	
pa4	Drain (Boom 2)	
pa5	Arm 1 Crowd Pilot	
pa6	Travel Backward Pilot (RH)	
pa7	Grapple Cylinder Head	
pa8	Boom 1 Up Pilot	
pa9	Arm 2 Crowd Pilot	
pb1	Travel Forward Pilot (LH)	
pb2	Heel Rack IN Pilot	
pb3	Swing Right Pilot	
pb4	Boom 2 Up Pilot (pb8)	
pb5	Arm 1 Dump Pilot	
pb6	Travel Forward Pilot (RH)	
pb7	Grapple Cylinder Rod	
pb8	Boom 1 Down Pilot	
pb9	Arm 2 Dump Pilot (pb5)	
DR1	Drain Port 1	
pr	Plugged	

Port and Hydraulic Circuit

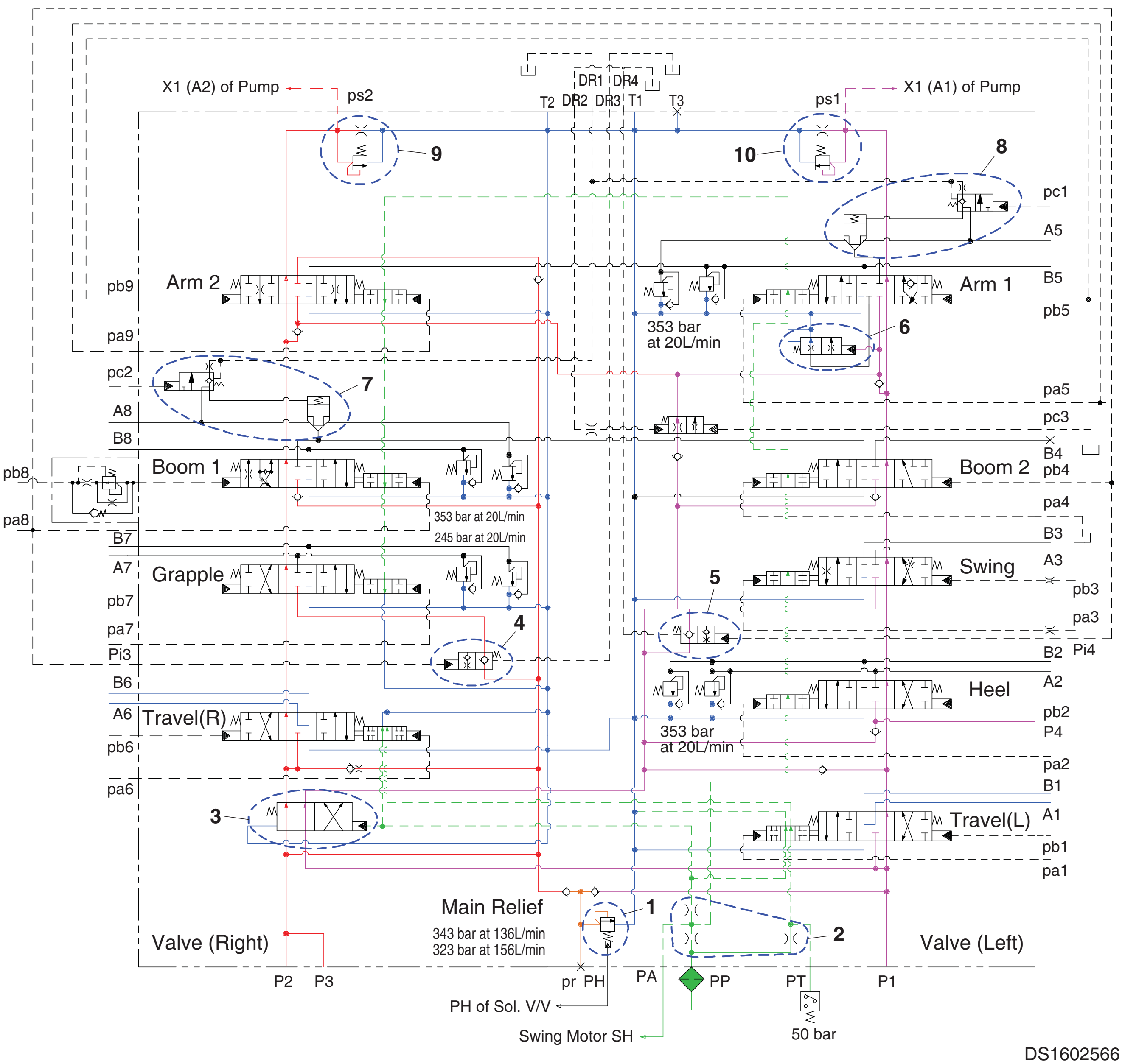
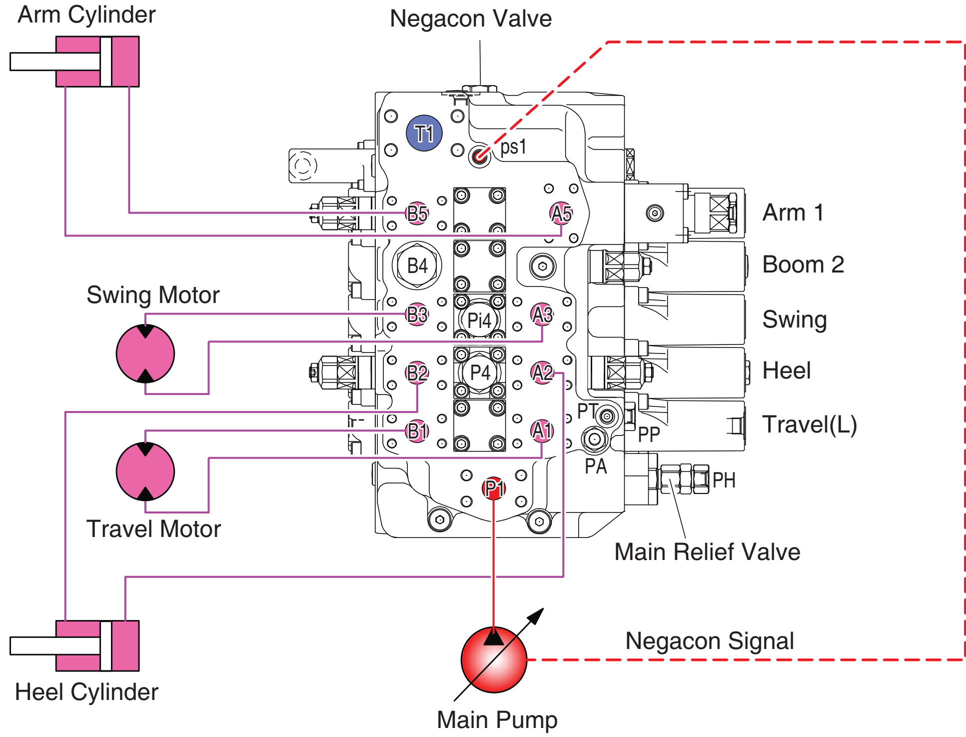
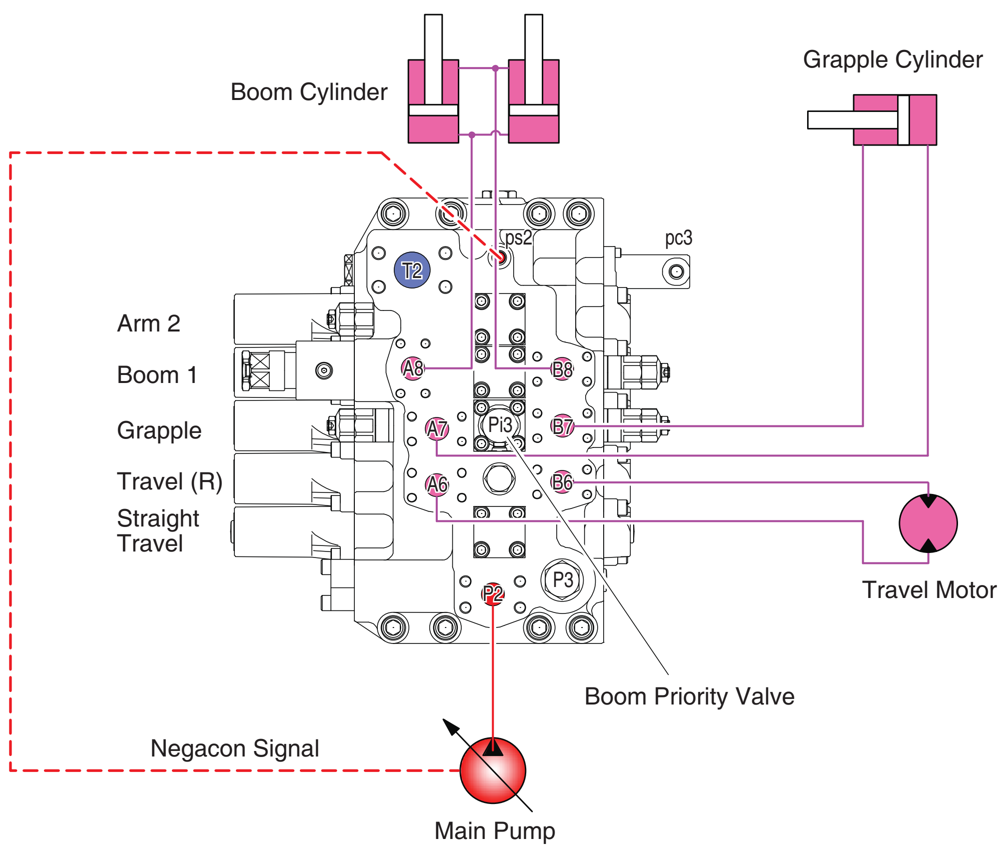


Figure 2

Reference Number	Description
1	Main Relief Valve
2	Orifice
3	Travel Straight Valve
4	Boom Priority Valve
5	Boom Priority Valve

Reference Number	Description
6	Arm Regeneration Valve
7	Boom Holding Valve
8	Arm Holding Valve
9	Negacon Valve
10	Negacon Valve

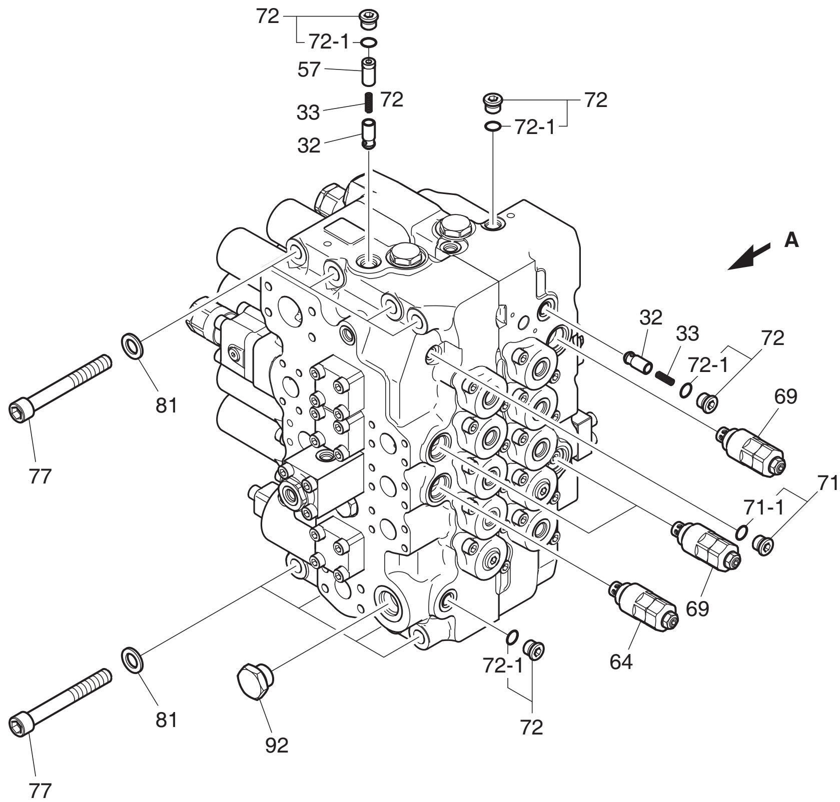


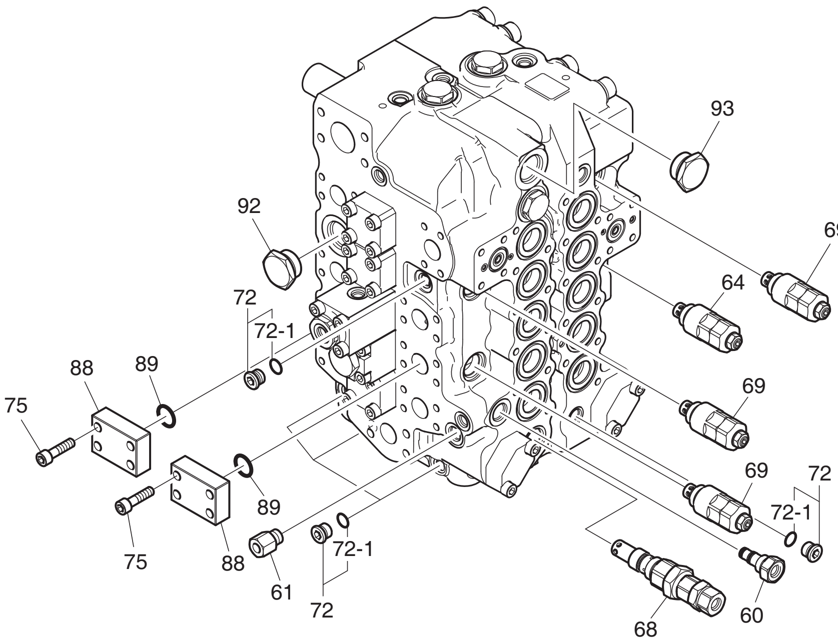


DS1602567

Figure 3

Parts List





VIEW **A**

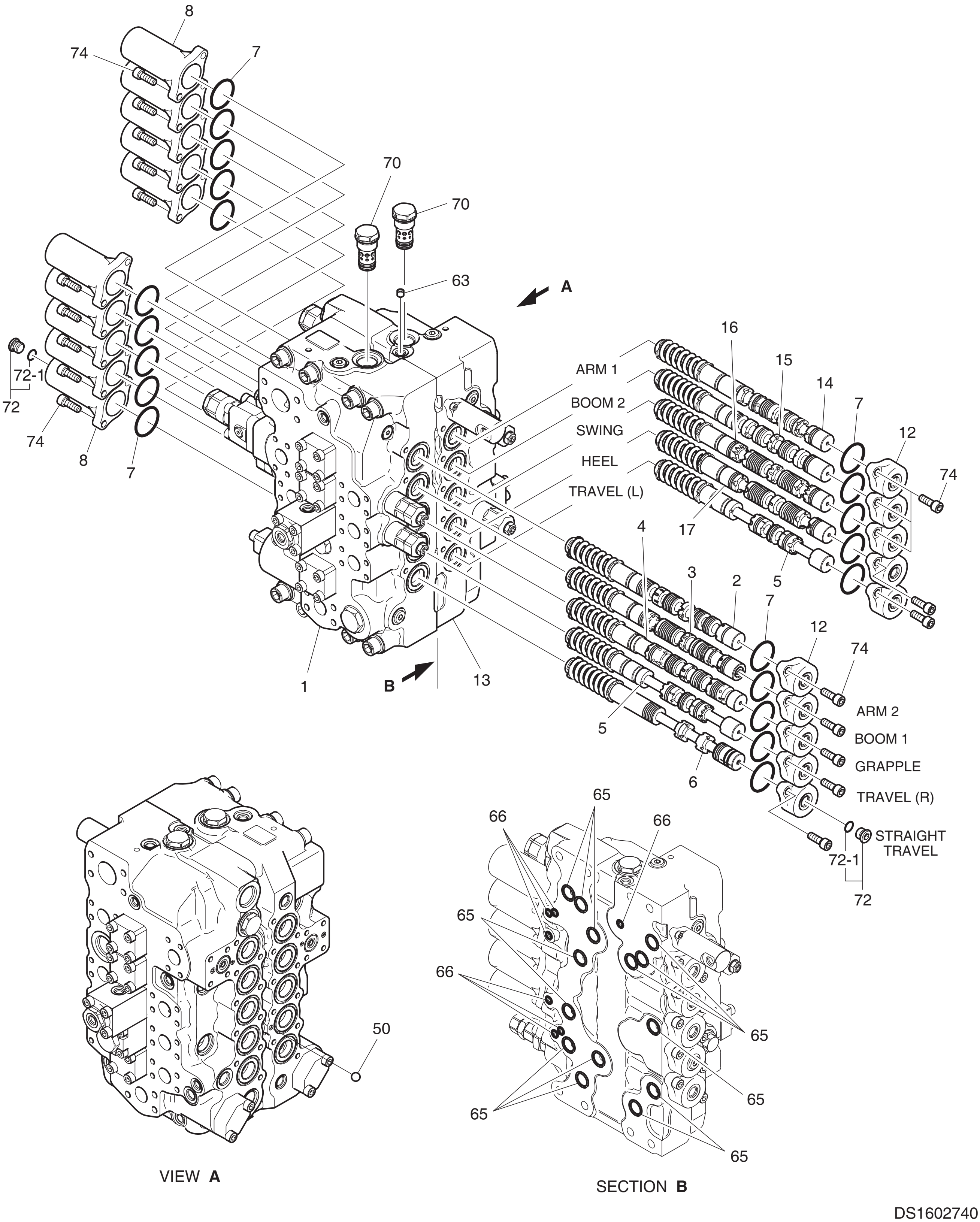
DS1602739

Figure 4

Reference Number	Description
32	Poppet
33	Spring
57	Spacer
60	Plug Assembly
61	Plug
64	Overload Relief Valve
68	Main Relief Valve
69	Overload Relief Valve
71	Plug Assembly
71-1	O-ring
72	Plug Assembly

Reference Number	Description
72-1	O-ring
75	BOLT
77	Socket Bolt
81	Washer
82	O-ring
88	Flange
89	O-ring
92	Plug Assembly
93	Plug Assembly
*	Seal Kit; Control Valve

*: 71-1, 72-1, 89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A
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72-1
72
74
8
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ARM 1
BOOM 2
SWING
HEEL
TRAVEL (L)
4
17
3
2
5
7
12
74
1
B
13
5
6
ARM 2
BOOM 1
GRAPPLE
TRAVEL (R)
STRAIGHT TRAVEL
72-1
72
66
65
66
65
66
50
65
65
65
65
VIEW A
SECTION B
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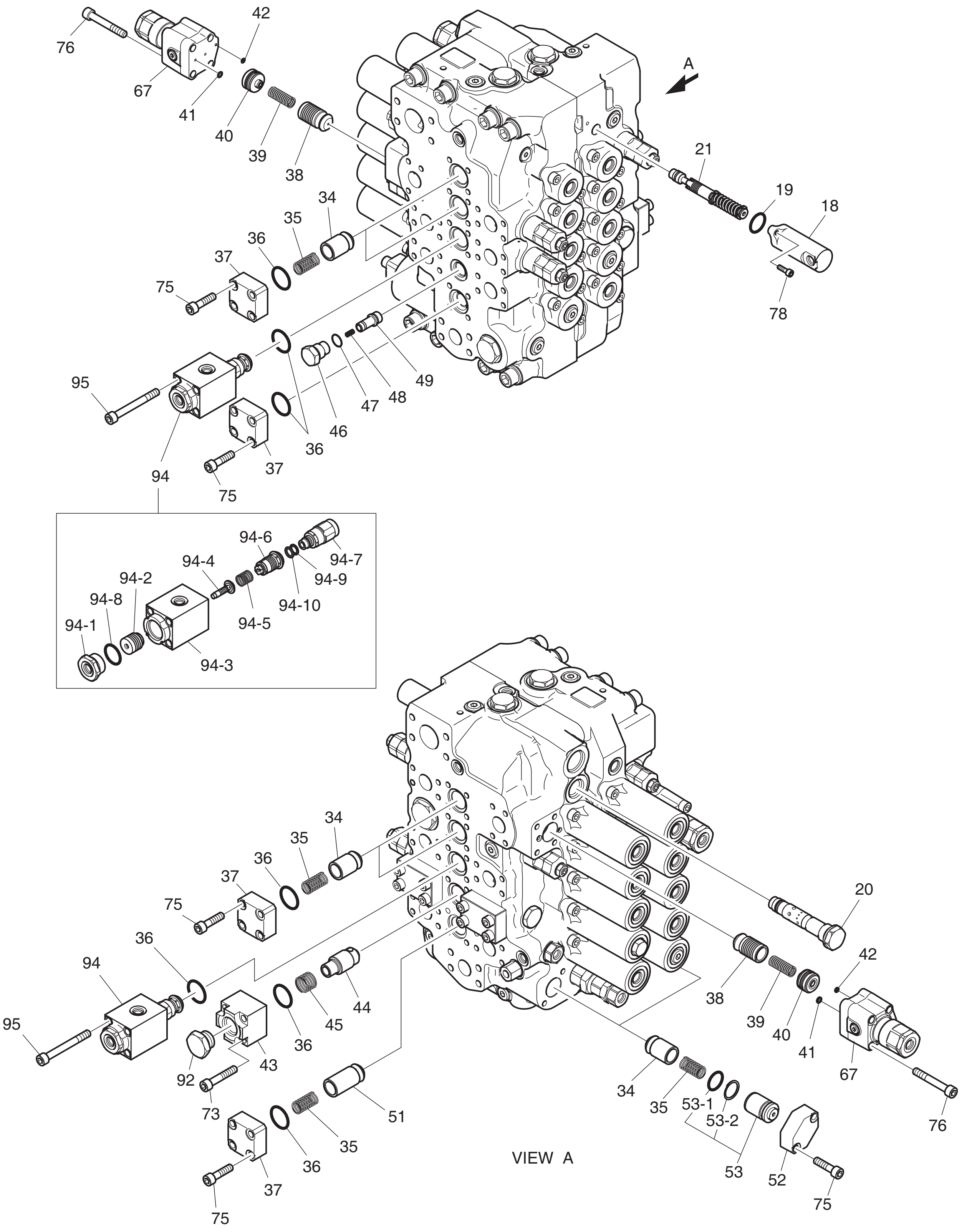
Figure 5

Reference Number	Description
1	Housing Valve
2	Arm Spool Assembly 2
3	Boom Spool Assembly 1
4	Option Spool Assembly
5	Travel Spool Assembly
6	Travel Straight Spool Assembly
7	O-ring
8	Cap
12	Cap
13	Housing
14	Arm Spool Assembly 1

Reference Number	Description
15	Boom Spool Assembly 2
16	Swing Spool Assembly
17	Heel Spool Assembly
50	Ball
63	Orifice Plug
65	O-ring
66	O-ring
70	Foot Relief Valve
72	Plug Assembly
74	Socket Bolt (M10 x 28 L)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53-2
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52
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76
VIEW A
DS1602741

Figure 6

Reference Number	Description
18	Cap
19	O-ring
20	Arm Regeneration Assembly
21	SP Spool Assembly
34	Poppet
35	Spring
36	O-ring
37	Flange
38	Poppet
39	Spring
40	Spacer Assembly
41	O-ring
42	O-ring
43	Flange
44	Poppet
45	Spring
46	Plug
47	O-ring
48	Spring
49	Poppet
51	Poppet
52	Flange

Reference Number	Description
53	Spacer Assembly
53-1	O-ring
53-2	Backup Ring
67	Valve, Holding
73	Bolt
75	Bolt
76	Bolt
78	Bolt
92	Plug Assembly
94	Boom Priority Valve
94-1	Plug
94-2	Piston
94-3	Body
94-4	Piston
94-5	Spring
94-6	Sleeve
94-7	Poppet Assembly
94-8	O-ring
94-9	Backup Ring
94-10	O-ring
95	Bolt

Theory of Operation

When All Spools are in Neutral

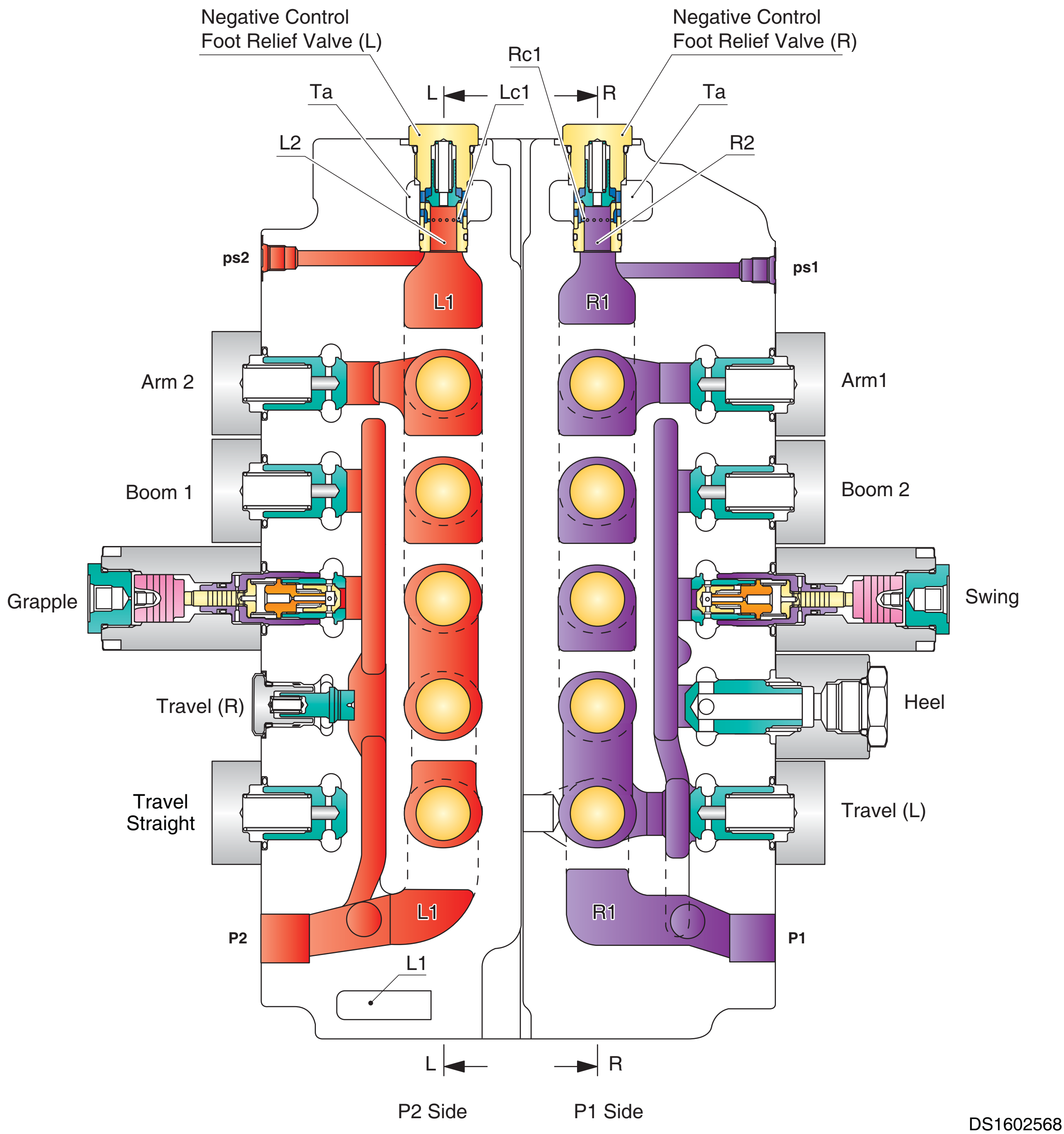
Neutral Passage

The oil supplied from the port (P1) enters into the tank passage (Ta) through the orifice (Rc1) of negative relief from the neutral passage (R1) and returns to ports (T1, T2 and T3).

The oil supplied from the port (P2) passes the tank passage (Ta) through orifice (Lc 1) of negative relief from the neutral passage (L1) and returns to port (T1, T2 and T3).

The pressure of chambers (L2 and R2) flowing over the negative relief, flows into pump from ports (ps1 and ps2), to control the volume of pump P1 and P2.

In addition, when excessive oil flows excessive into the neutral passage, the negative relief operates to prevent the abnormally high-pressure on ports (ps1 and ps2).



Negative Control
Foot Relief Valve (L)
Negative Control
Foot Relief Valve (R)
Rc1
Ta
L
Lc1
R
Ta
L2
R2
ps2
ps1
L1
R1
Arm 2
Arm1
Boom 1
Boom 2
Grapple
Swing
Travel (R)
Heel
Travel
Straight
Travel (L)
L1
R1
P2
P1
L1
L
R
P2 Side
P1 Side
DS1602568

Figure 7

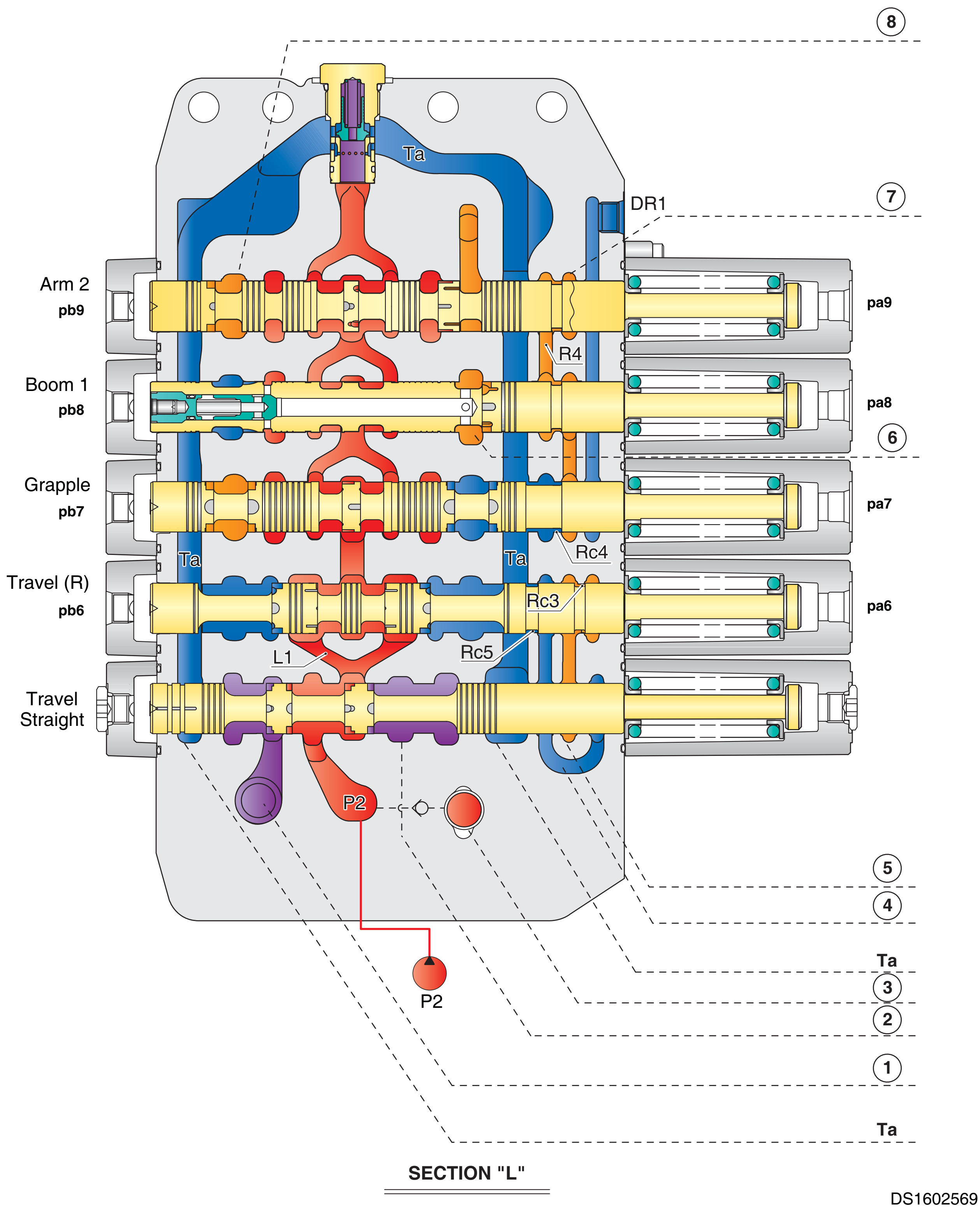

8
7
6
5
4
Ta
3
2
1
Ta
DR1
Ta
Arm 2
pb9
Boom 1
pb8
Grapple
pb7
Travel (R)
pb6
Travel
Straight
pa9
pa8
pa7
pa6
R4
Rc4
Rc3
Rc5
L1
P2
P2
SECTION "L"
DS1602569

Figure 8

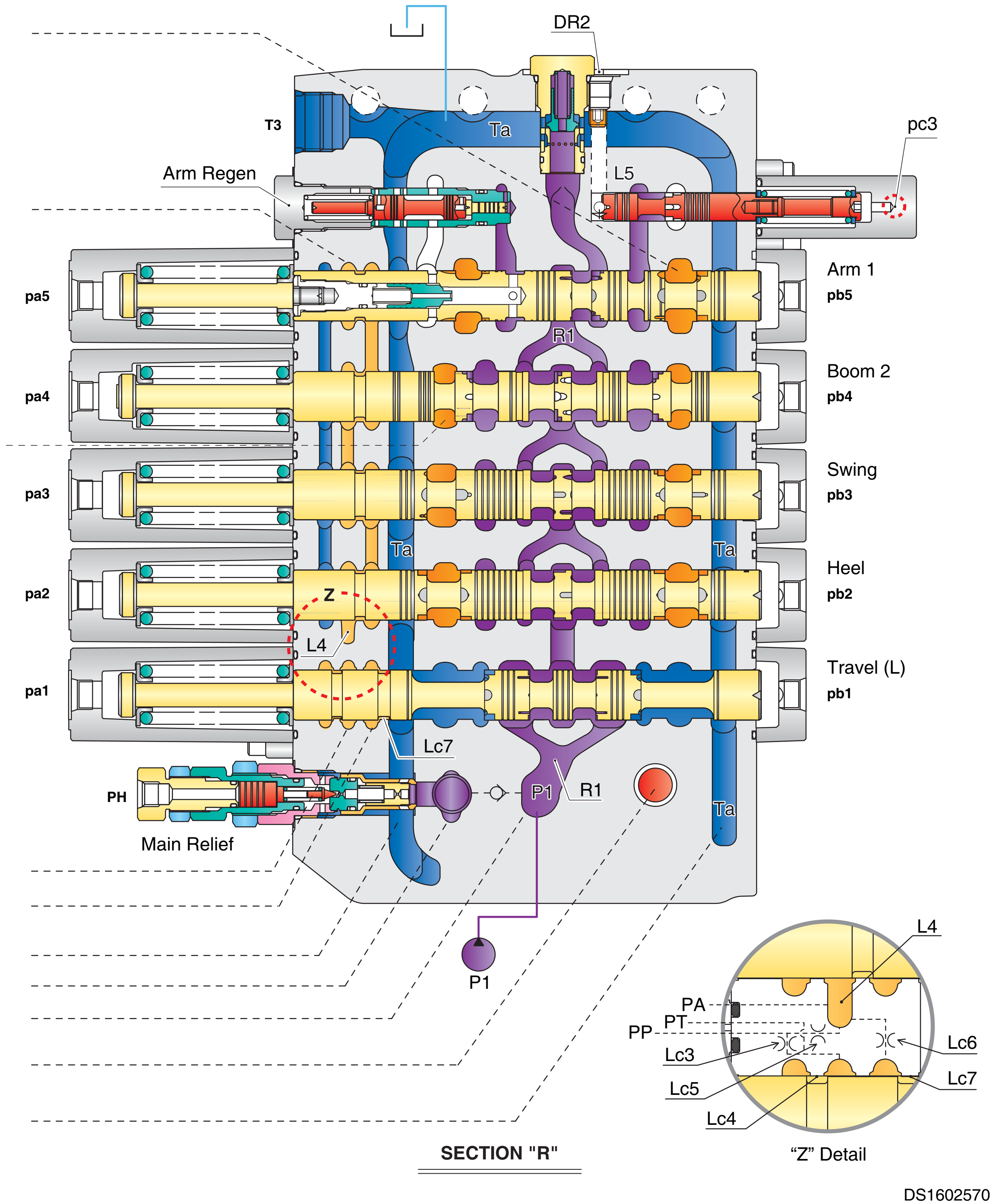

DR2
T3
Ta
pc3
L5
Arm Regen
Arm 1
pa5
pb5
R1
Boom 2
pa4
pb4
Swing
pa3
pb3
Ta
Ta
Heel
pa2
pb2
Z
L4
Travel (L)
pa1
pb1
Lc7
PH
P1
R1
Ta
Main Relief
P1
L4
PA
PT
PP
Lc3
Lc5
Lc4
Lc6
Lc7
SECTION "R"
"Z" Detail
DS1602570

Figure 9

Signal Passage

Oil supplied to port (PP) flows through orifice (Lc3) to port (PT) and simultaneously flows through land (Lc4), passage (5), and land (Rc3) into tank passage (Ta).

The same oil supplied to port (PP), then flows through orifice (Lc5) into port (PA), and it also flows through passages (L4, 7 and R4) to bucket spool land (Rc4) and then flows into drain passage (DR).

The oil passing through orifice (Lc6) flows through land (Lc7) to tank passage (Ta) or flows through passage (4) to travel spool land (Rc5) and then flows into tank passage (Ta).

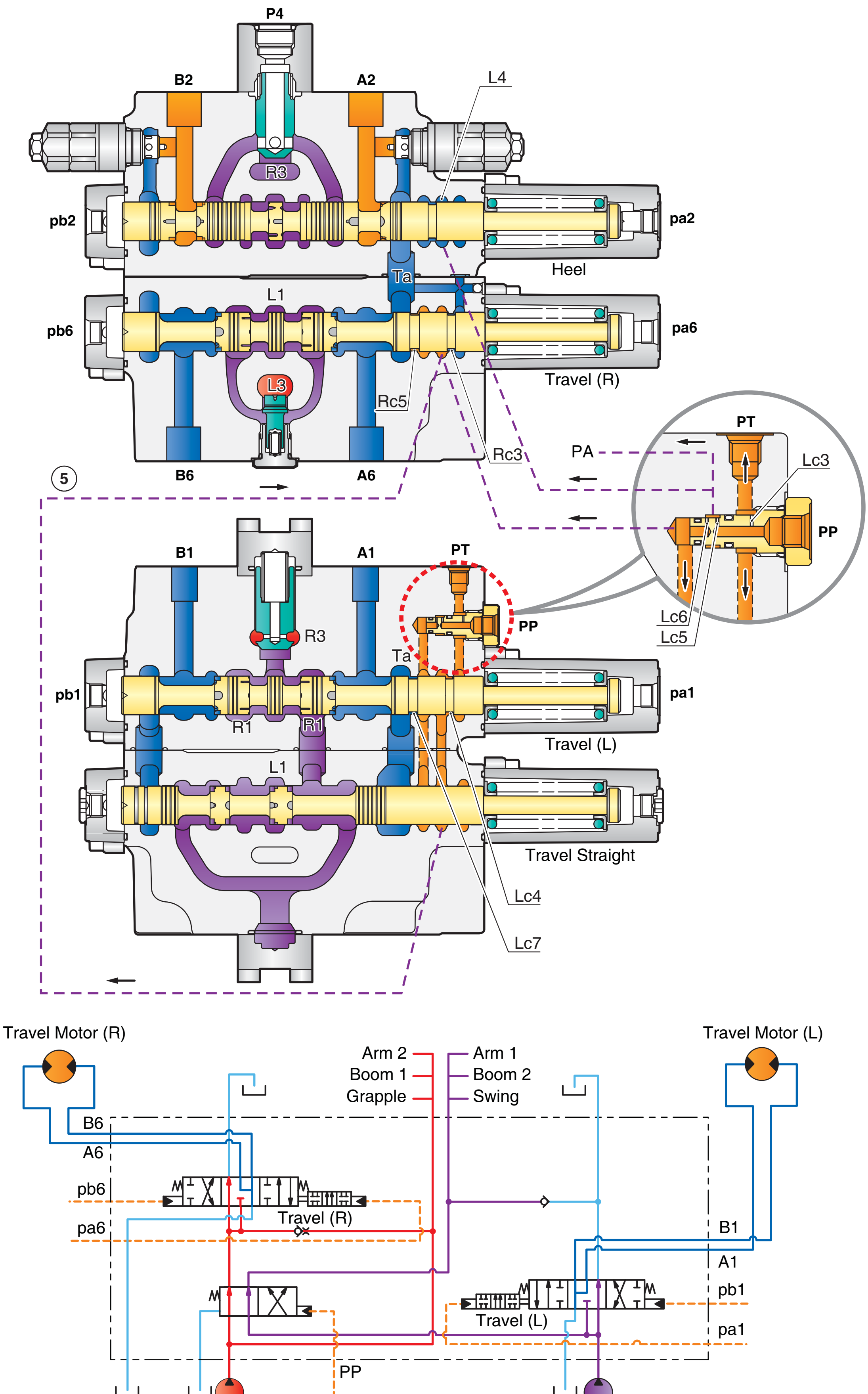


Figure 10

DS1602571

Single Operation

Travel Spool Shift

When shifting travel spool by increasing pressure of travel pilot port (Pb1 (Pa1)), oil supplied to port (P1) flows through neutral passage (R1) to spool and flows to port (B1 (A1)). Return oil flows through port (A1 (B1)), to spool and returns to tank passage (Ta).

When shifting travel spool by increasing pressure of travel pilot port (Pb6 (Pa6)), oil supplied to port (P2) flows through neutral passage (L1) to spool or passage (S6-1) and flows to port (B6 (A6)). Now, pressure of parallel passage (L3) and passage (S6-1) are equal, so poppet (S6-2) does not open. Return oil flows through port (A6 (B6)) to spool and returns to tank passage (Ta).

When shifting either spool, land (Lc4) or (Rc3) is closed. Oil supplied from port (PP) does not flow into tank passage, so pressure at port (PT) rises.

Heel Spool Shift

When shifting heel spool by increasing pressure of heel rack IN (OUT) port (Pb2 (Pa2)), neutral passage (R1) is closed. Oil supplied to port (P1) flows through parallel passage (R3), load check valve (S2-2), passage (S2-1), and spool, it then flows to port (B2 (A2)).

Return oil flows through port (A2 (B2)) to spool and returns to tank passage (Ta).

When oil is also supplied from port (P4), it flows through load check valve (S2-2) and is combined at passage (S2-1).

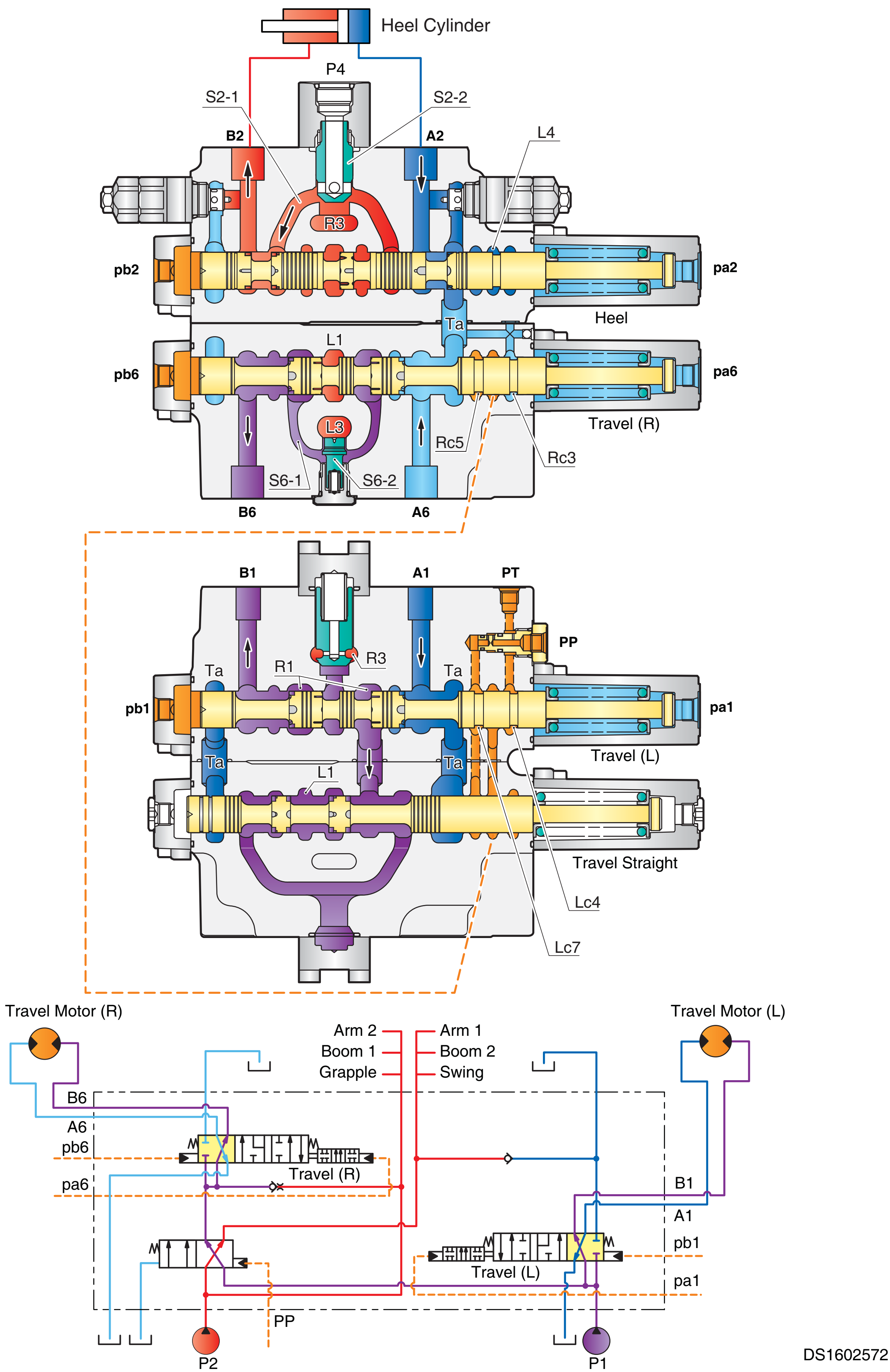

Heel Cylinder
P4
S2-1
S2-2
B2
A2
L4
R3
pb2
pa2
Heel
Ta
L1
pb6
pa6
Travel (R)
L3
Rc5
Rc3
S6-1
S6-2
B6
A6
B1
A1
PT
PP
R1
R3
Ta
Ta
pb1
pa1
Travel (L)
Ta
Ta
L1
Travel Straight
Lc4
Lc7
Travel Motor (R)
Travel Motor (L)
Arm 2
Boom 1
Grapple
Arm 1
Boom 2
Swing
B6
A6
pb6
pa6
Travel (R)
B1
A1
pb1
pa1
Travel (L)
PP
P2
P1
DS1602572

Figure 11

Swing Spool Shift

When shifting swing spool by increasing pressure of swing pilot port (Pb3 (Pa3)), neutral port (R1) is closed. Oil supplied to port (P1) flows through parallel passage (R3), load check valve (S3-2), passage (S3-1) and spool, it then flows to port (B3 (A3)). Return oil flows through port (A3 (B3)) to spool and is returned to tank passage (Ta).

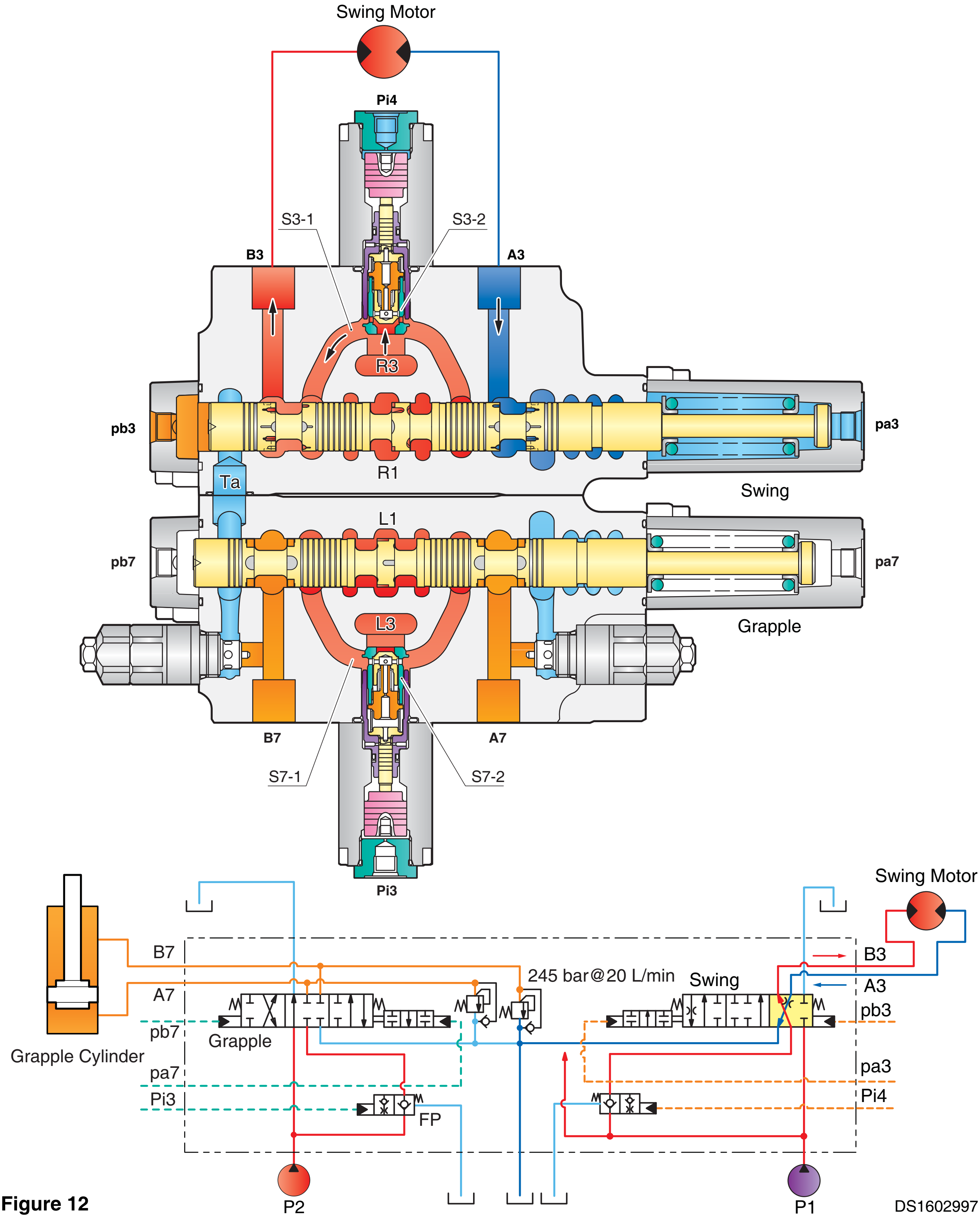


Figure 12

Grapple Spool Shift

Oil flow control in grapple section portion of valve is different from other sections.

1. Retraction

   When grapple spool is shifted by increasing pressure of grapple pilot port (Pb7), neutral passage (L1) is closed. Oil supplied to port (P2) flows through parallel passage (L3), load check valve (S7-2), passage (S7-1), spool and into port (B7). Oil returns through port (A7) and spool to tank passage (Ta).

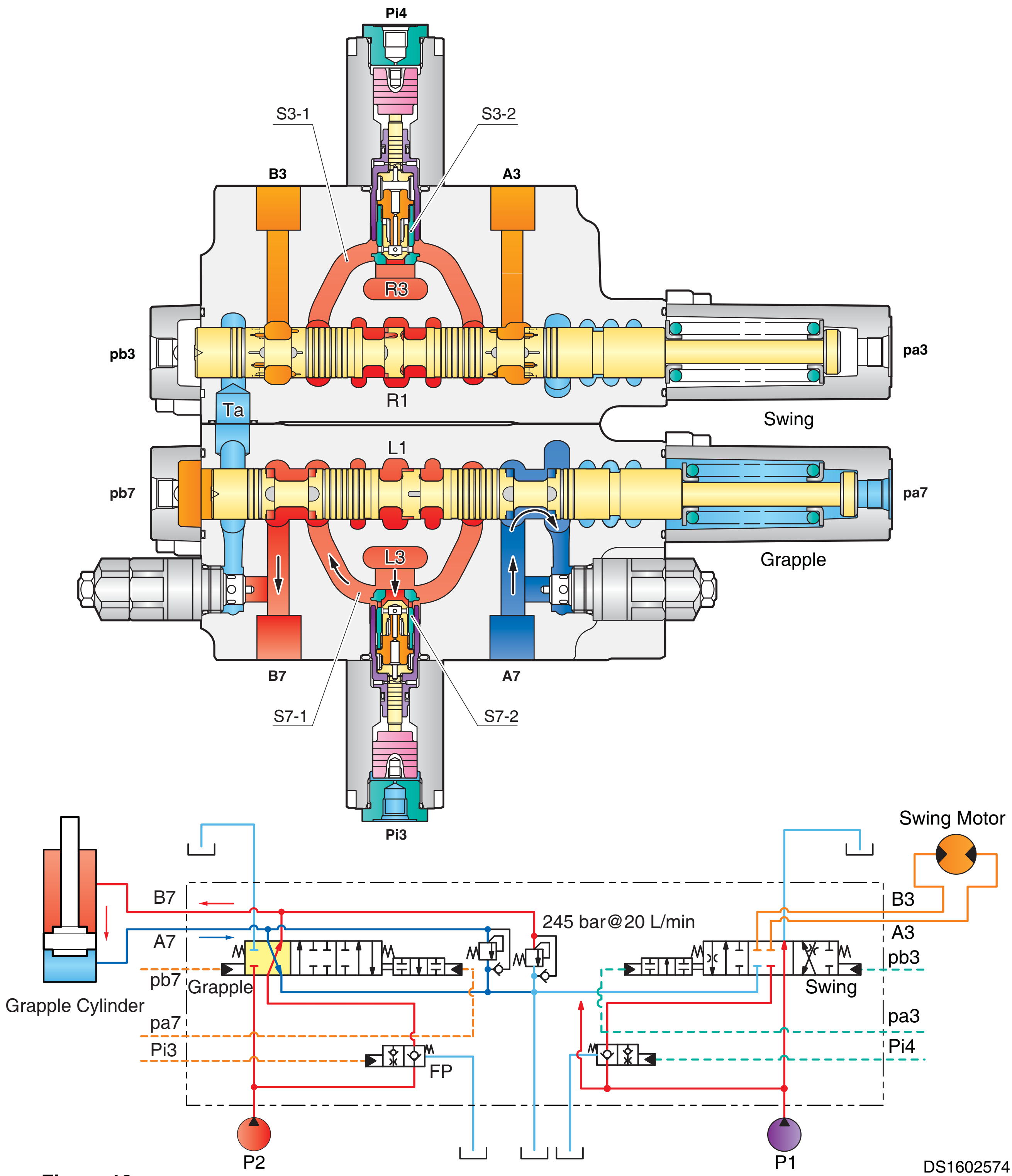
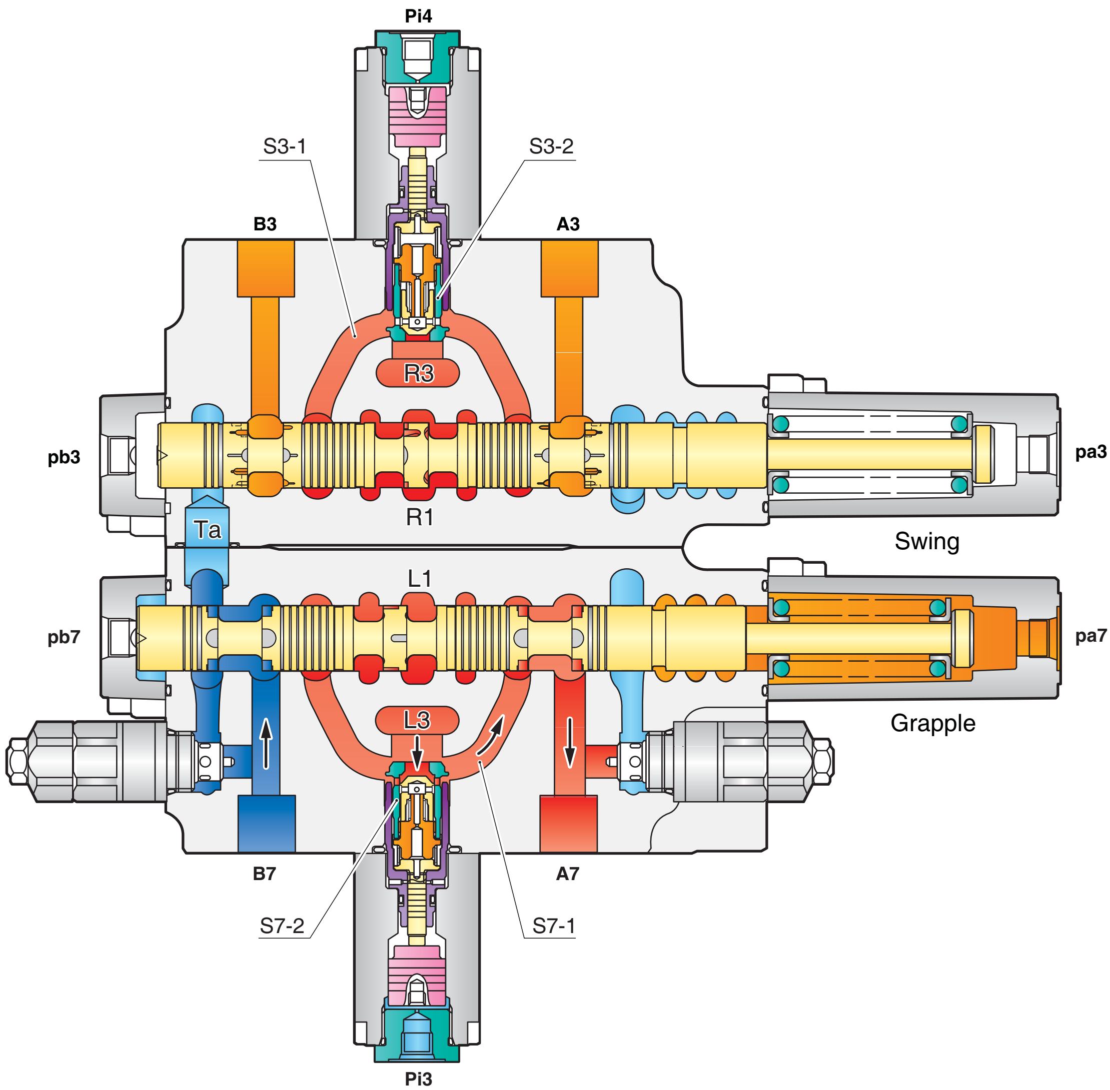


Figure 13

2. Extension

When grapple spool is shifted by increasing pressure of grapple pilot port (Pa7), neutral passage (L1) is closed. Oil supplied to port (P2) flows through parallel passage (L3), load check valve (S7-2), passage (S7-1), spool and into port (A7). Oil flows through port (B7) returns to tank passage (Ta).



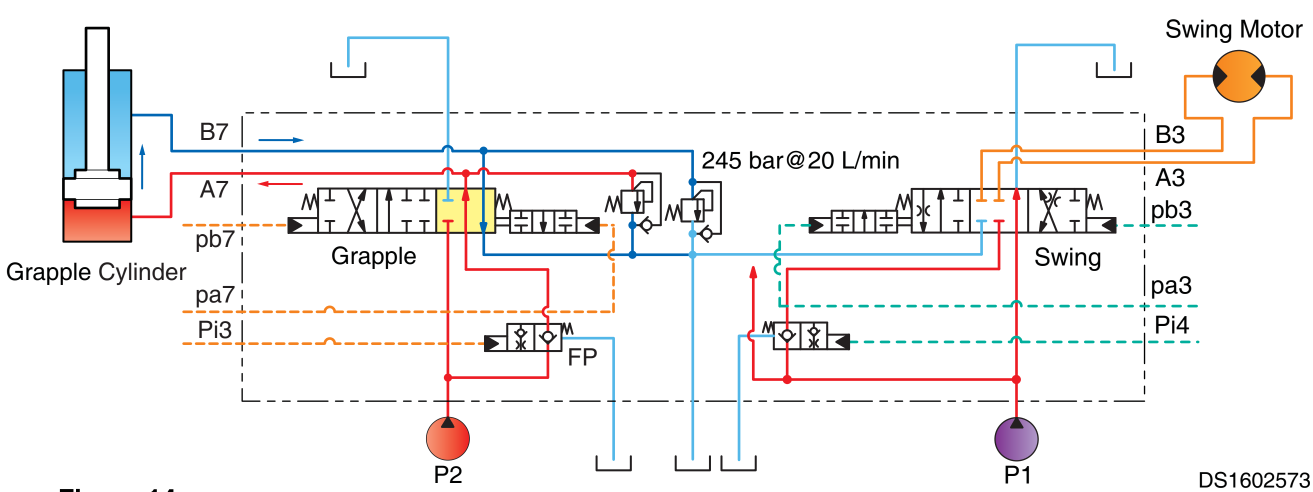


Figure 14

Boom Spool Shift

1. Neutral

This valve also works with antidrift valves that are installed on the bottom side of each boom cylinder. When in neutral, poppet (AD1) is closed by port (A8) pressure that is sent through passage (AD2), spool (AD3) to spring chamber (AD4).

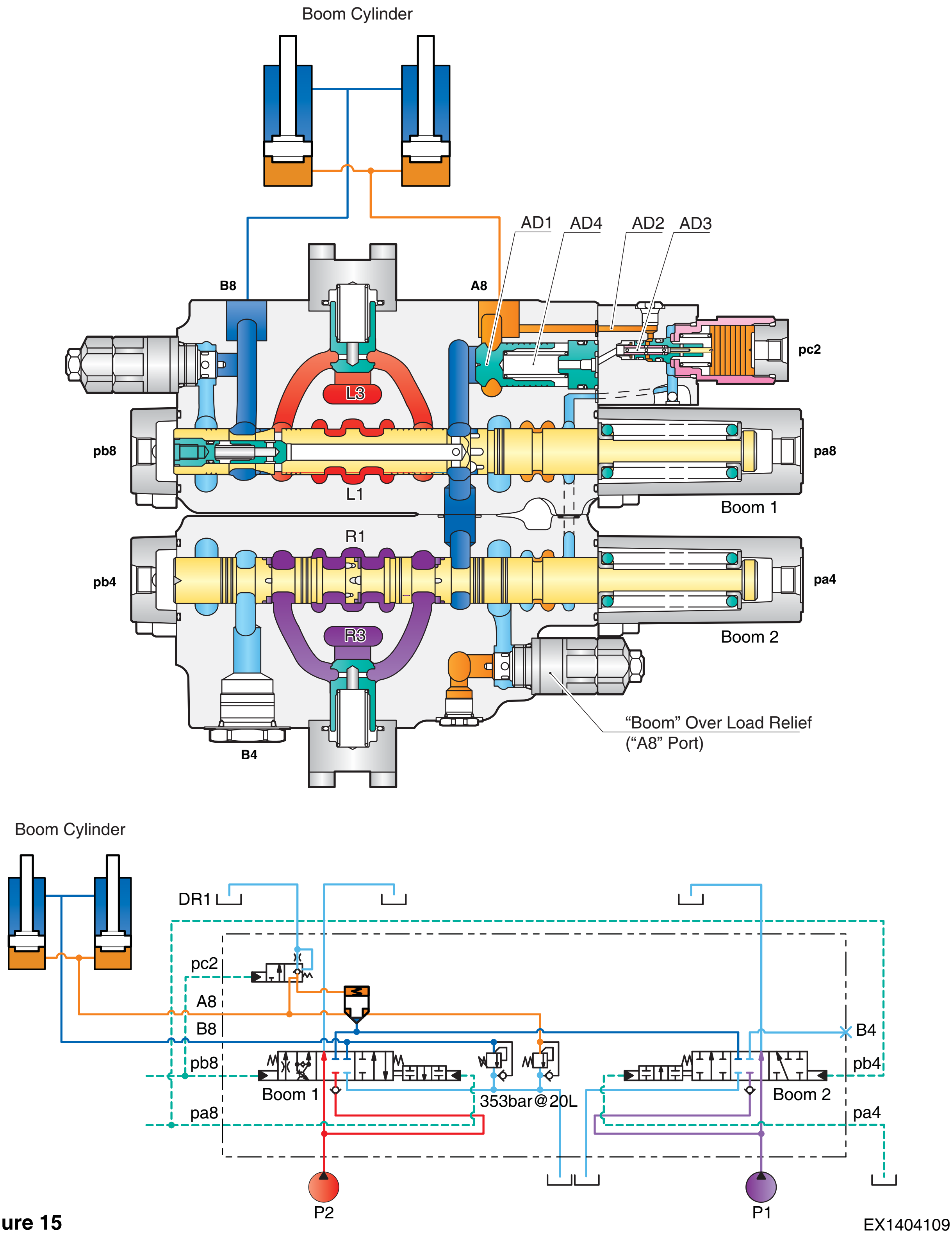
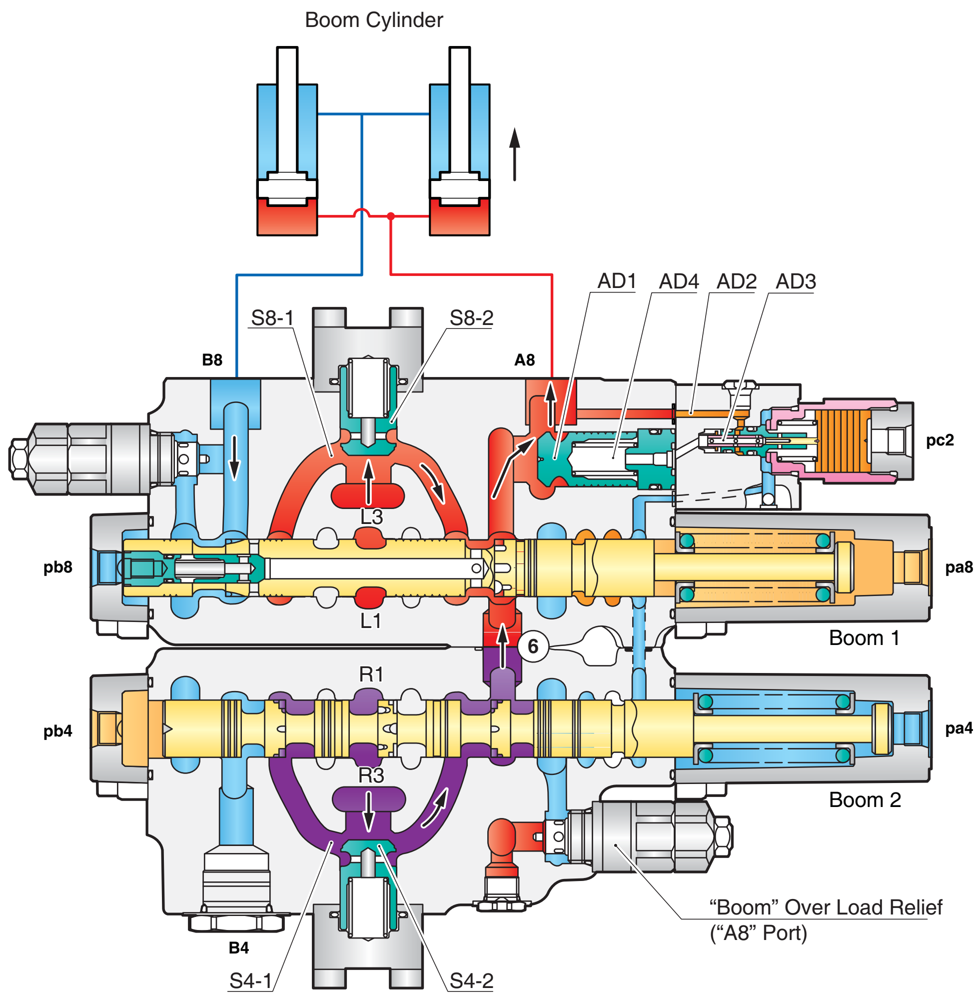


Figure 15

2. Boom up (2-pump confluence)

When boom 1 spool is shifted by increasing pressure of boom 1 pilot port (Pa8), neutral passage (L1) is closed. Oil supplied to port (P2) flows through parallel passage (L3) and load check valve (S8-2) to spool and flows into port (A8). When boom 2 spool is shifted by increasing pressure of boom 2 pilot port (Pb4), neutral passage (R1) is closed. Oil supplied to port (P1) flows through parallel passage (R3), load check valve (S4-2), spool, and to passage (6) and joins at port (A8). Return oil flows from port (B8) to spool and returns to tank passage (Ta).



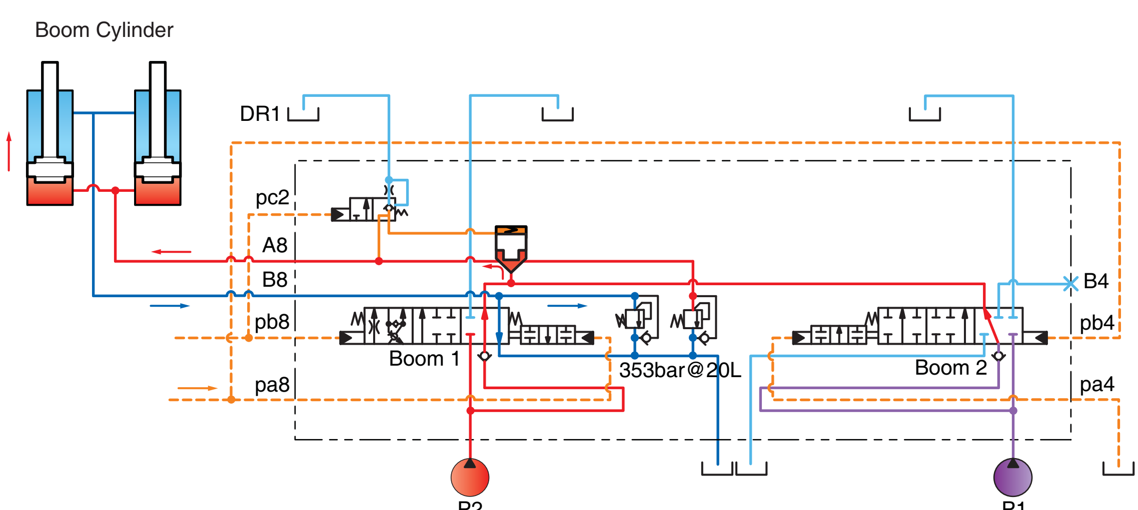


Figure 16

EX1404110

3. Boom down (regeneration)

When boom 1 spool is shifted by increasing pressure of boom 1 pilot port (Pb8), neutral passage (L1) is closed. Oil supplied to port (P2) flows through parallel passage (L3) and load check valve (S8-2) to spool and flows into port (B8). When spool (AD3) of antidrift valve is shifted by increasing pressure of port (P2), poppet (AD1) is opened by decreasing of pressure of spring chamber (AD4), and return oil from port (A8) flows to tank passage. Some return oil opens poppet (S8-3) in boom 1 spool, flows through passage (S8-1), joins at port (B8), and then prevents cavitation of cylinder rod side.

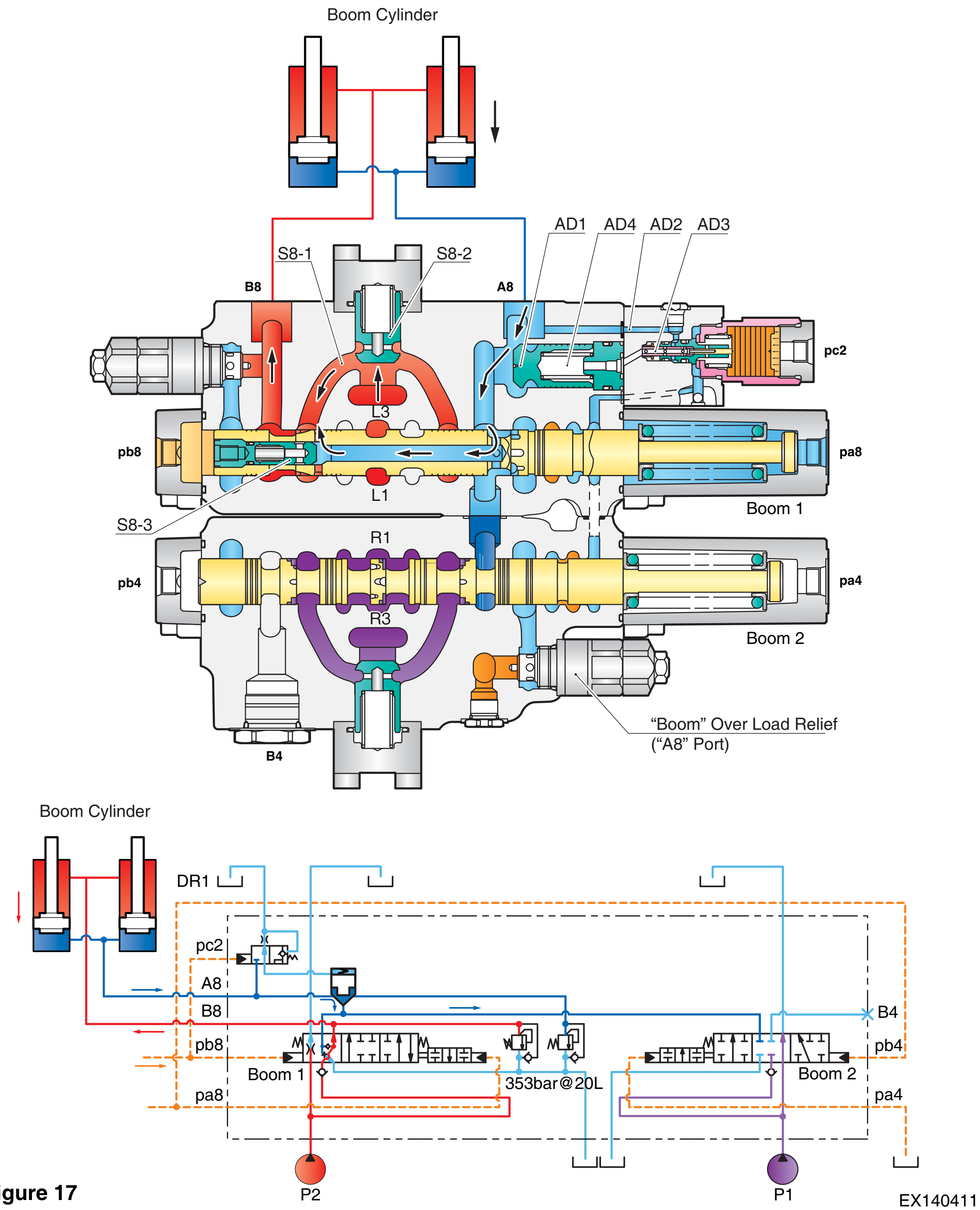


Figure 17

Arm Spool Shift

1. Neutral

This valve also works with an antidrift valve that is installed on rod side of the arm cylinder. When in neutral, poppet (AD1) is closed by port (A5) pressure that is sent through passage (AD2), spool (AD3) and to spring chamber (AD4).

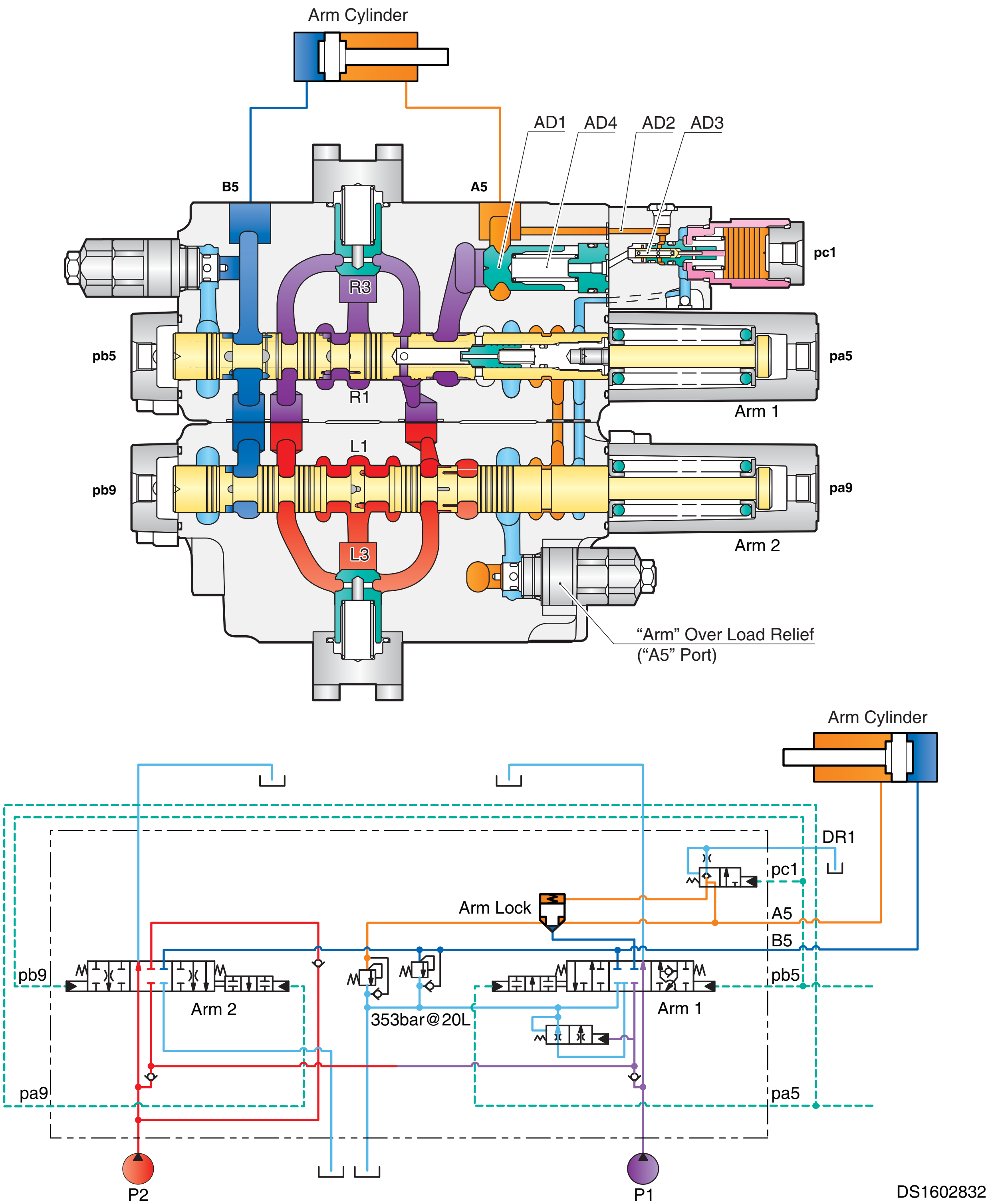


Figure 18

2. Arm Dump

A. 2-pump confluence

When arm 1 spool is shifted by increasing pressure of arm 1 pilot port (Pb5), oil supplied to port (P1) flows through neutral passage (R1), load check valve (S5-2), passage (S5-1) and spool into port (B5). When arm 2 spool is shifted by increasing pressure of arm 2 pilot port (pb9), oil supplied to port (P2) flows through neutral passage (L1), load check valve (S9-2), passage (S9-1), and spool to passage (8) and joins at port (B5). The return oil from port (B5) flows through regeneration check valve in spool, and then flows to port (B5) to regenerate, and some oil returns through variable regeneration release valve to tank (Ta). (Refer to next page)

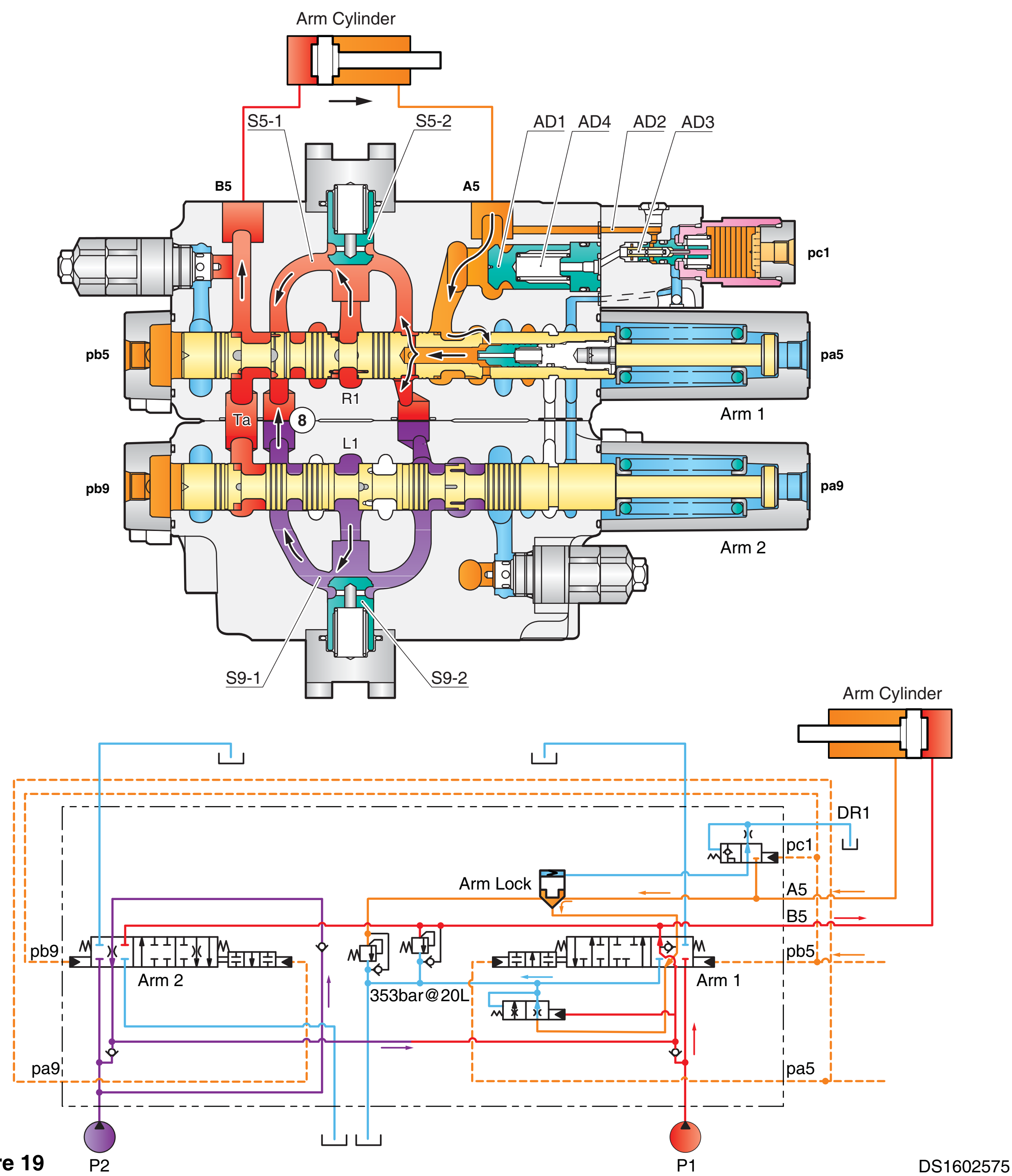


Figure 19

B. Variable regeneration

When crowding arm, after return oil from port (A5) flows through notch (a), one portion of the oil returns through fixed orifice (d), passage (e) and variable orifice (f) and to tank passage (Ta). The other portion of the oil flows through fixed orifice (b), regeneration check (c), and fixed orifice (i) in arm 1 spool, and joins in bridge passage (S5-1).

From there, if load pressure of port (B5) is increased, it flows through regeneration release valve piston (g) and pushes regeneration release spool (h), as a result area of variable orifice (f) is increased, and oil returning to tank (Ta) is increased, and some oil to regenerate in port (B5) is decreased.

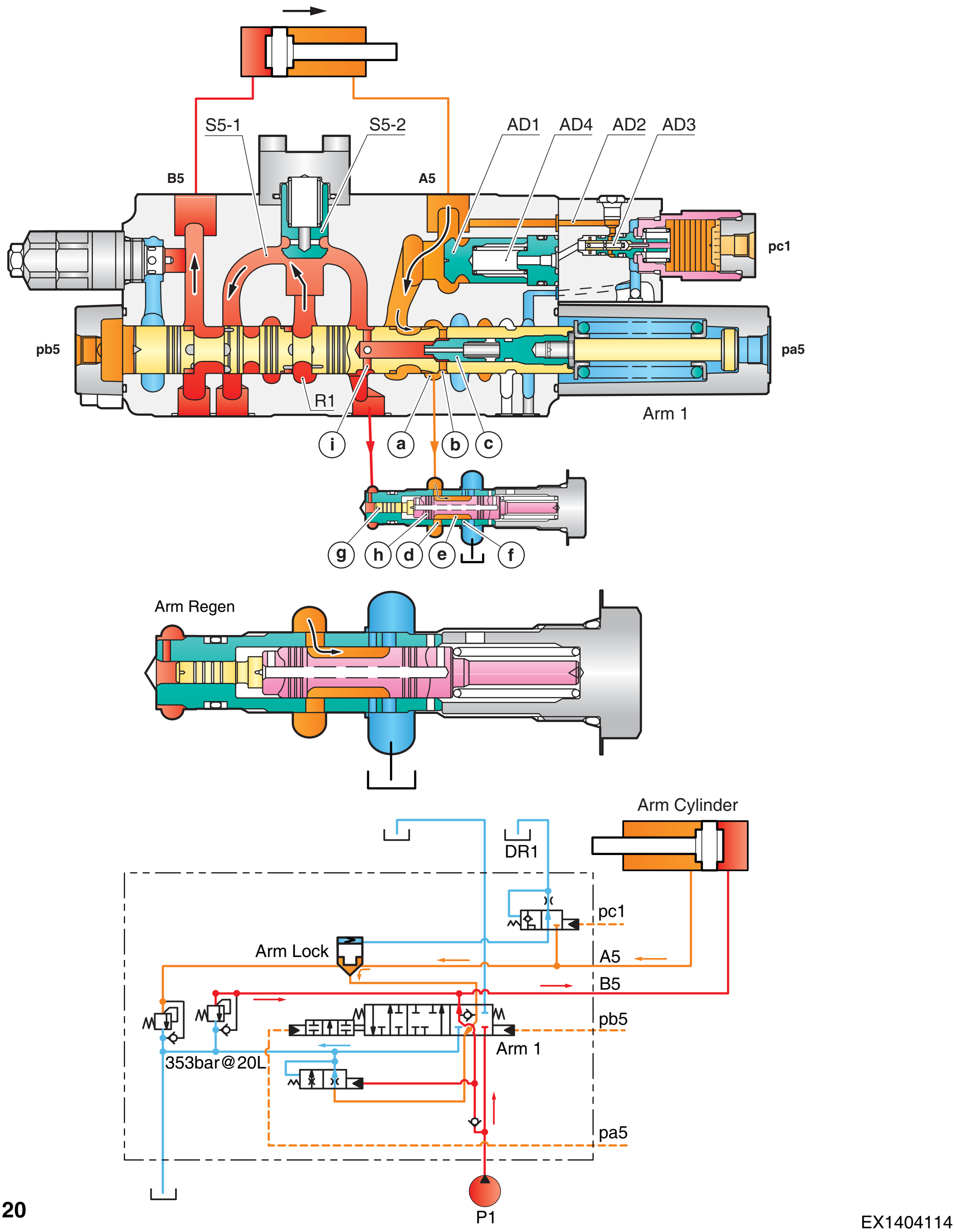


Figure 20

3. Arm Crowd (2-pump confluence)

When arm 1 spool is shifted by increasing pressure of arm 1 pilot port (Pa5), oil supplied to port (P1) flows through neutral passage (R1), load check valve (S5-2), passage (S5-1) and spool and into port (A5).
Oil supplied to port (P2) flows through neutral passage (L1), load check valve (S9-2), passage (S9-1), spool and passage (8) and joins at port (A5). Return oil from port (B5) returns through spool to tank passage (Ta).

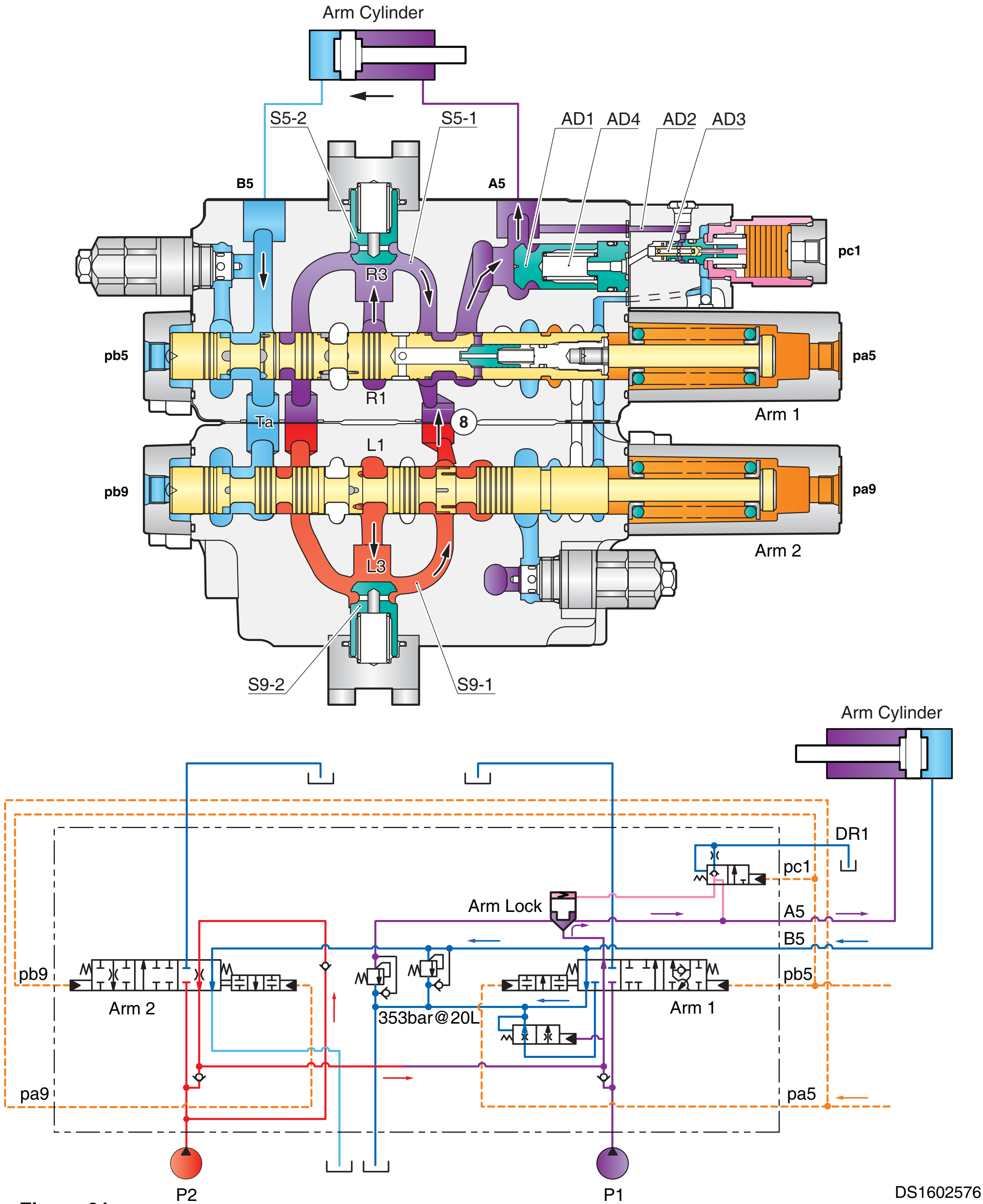


Figure 21

Parallel Orifice for Arm

The orifice, that is installed in parallel passage for arm 1, controls arm speed when operating in a combined operation. Oil supplied from parallel passage (L3) of arm 1 pushes open poppet (S5-3).

It then flows through orifice (Lc8) of variable orifice spool, and then is connected to passage (L5). From here, flow of orifice (Lc8) can be varied by increasing or decreasing pressure against pilot poppet (Pc3).

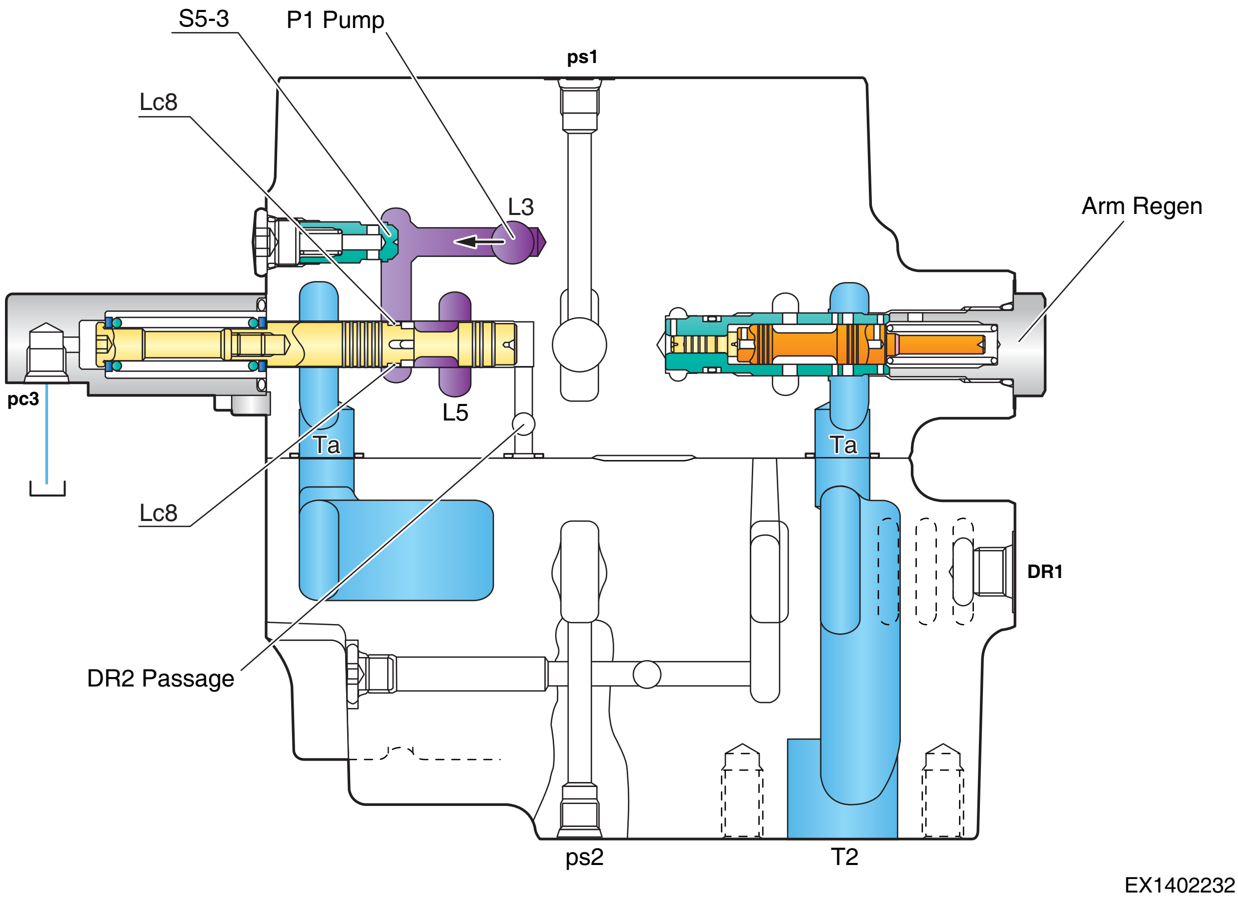


Figure 22

Relief Valve

1. Main relief valve

   Oil supplied to port (P1) flows through poppet (RP). Oil supplied to port (P2) flows through poppet (LP) and passage (3). They join at the main relief valve. The highest pressure of pump (P1 and P2) is controlled by reaction of main relief valve.

2. Overload relief valve

   The overload relief valve, that is installed in each cylinder port of boom 1, arm 1 and heel, prevents pressure of actuator from increasing extremely high from outside forces. This relief valve, when pressure of cylinder port is negative, has a function to prevent cavitation by drawing oil from tank.

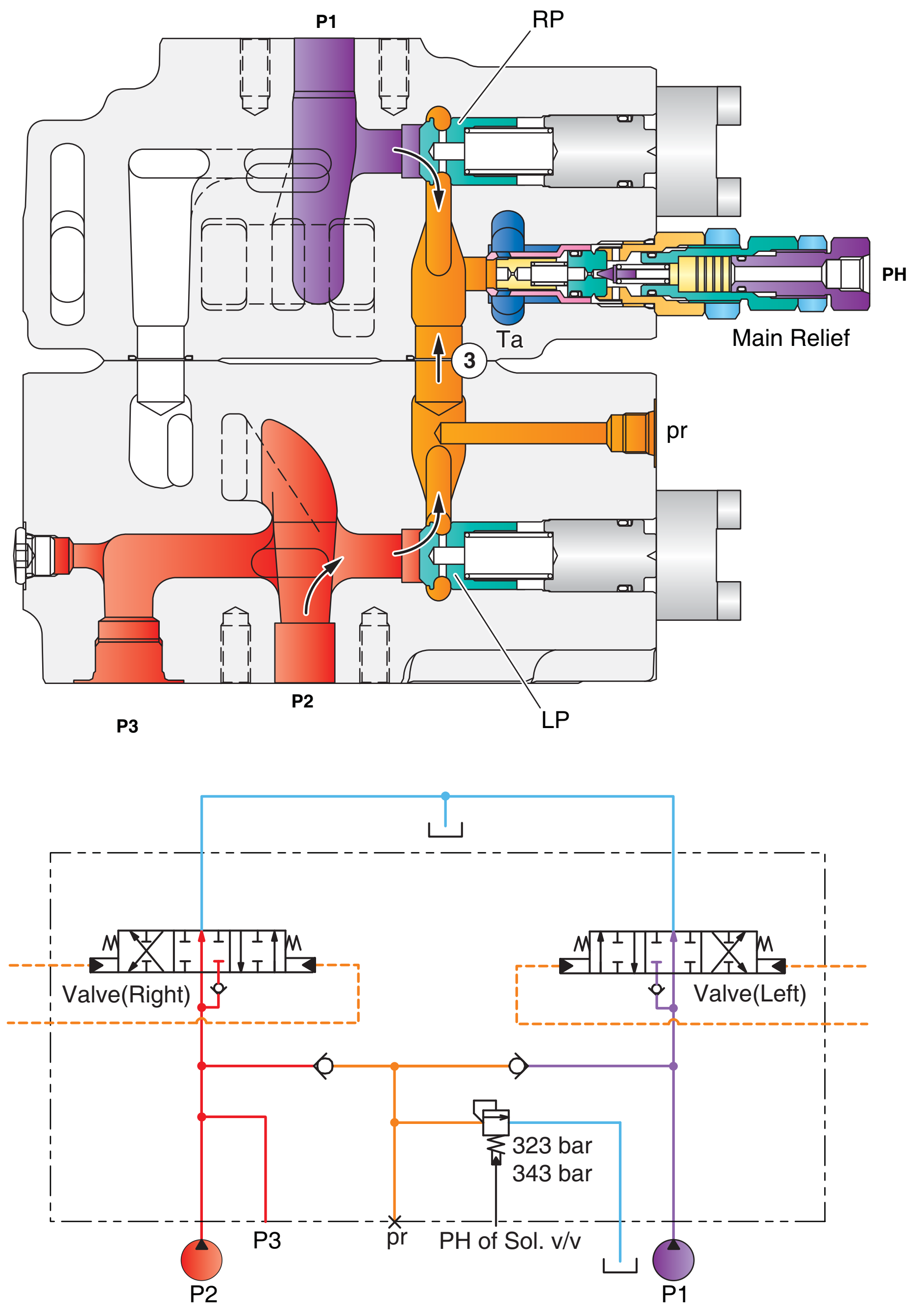


Figure 23

Compound Operation

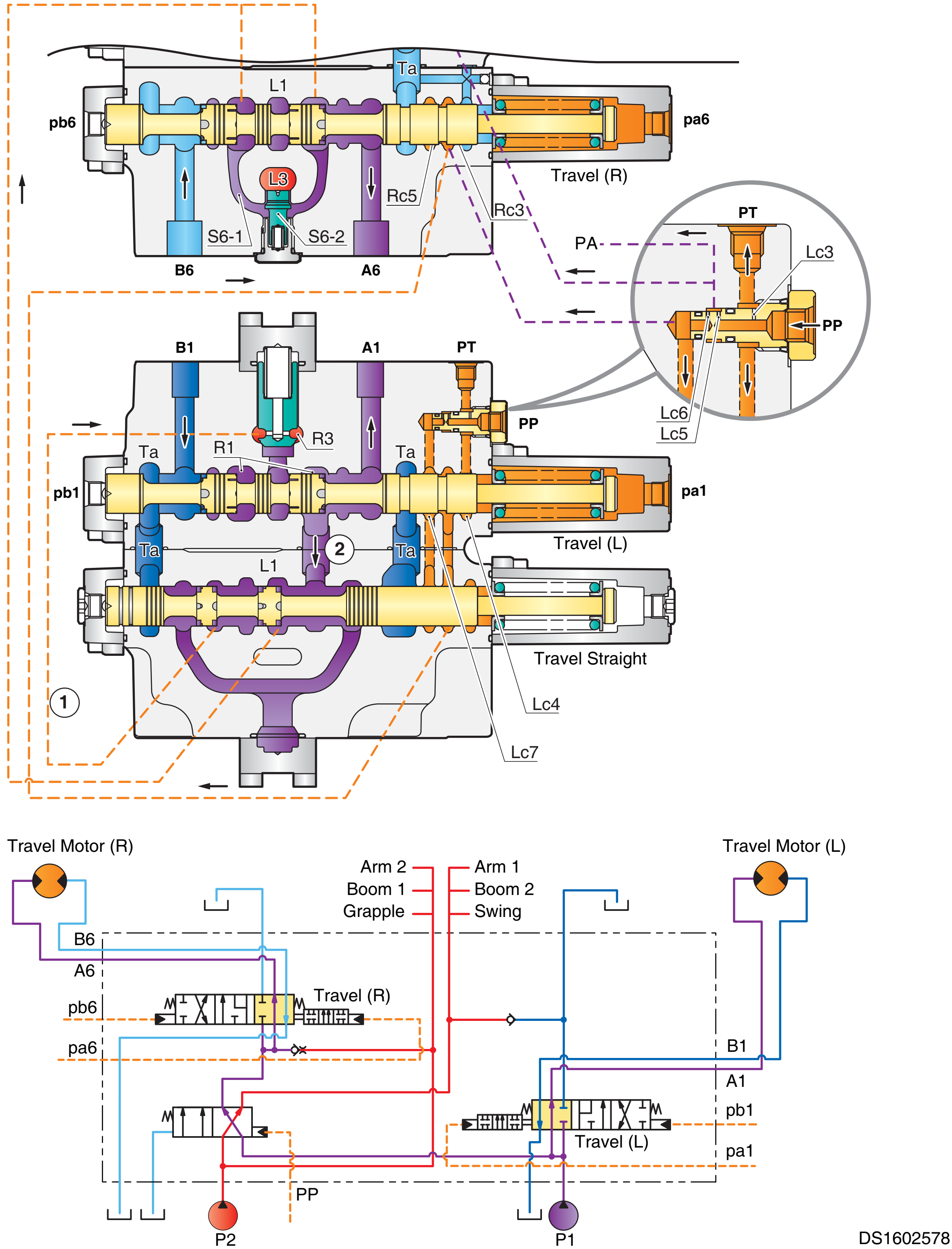
Travel Compound Operation

In the event of operating another function when the traveling left or right (when advancing, backing, or pivot turning) or operating for travel operation during the operation other than traveling, the oil supplied from the port (PP) is cut off from the tank passage (Ta) in the signal land part of the section other than the travel shifted from the land (Lc4), (Lc7), (Rc3), and (Rc5), and the pressure of the signal passage is increased to the relief set pressure of the oil origin for signal.

Because of the increase of the signal pressure, the spool before traveling is shifted to cause an increase of pressure in ports (PT and PA).

When the straight travel spool is shifted, the oil supplied from port (P1) flows to left travel from neutral passage (R1) while oil supplied to port (P2) flows into travel after passing through passage (2), straight travel spool head, and neutral passage (L1) flowing into the parallel passage (R3) after passing the straight travel spool head, and passage (1).

If the load pressure of section other than traveling is higher than the travel load pressure, some of the oil supplied from port (P2) pushes and opens poppet (S6-2), and it merged into the passage (S6-1) after passing the orifice of the poppet.
The operation is made by oil supplied from travel port (P1), and work device other than traveling is operated by the oil supplied from the port (P2), and projection is prevented when operating with travel operation and other work device.



Ta
L1
pb6
pa6
Travel (R)
L3
Rc5
Rc3
S6-1
S6-2
B6
A6
PA
PT
Lc3
PP
B1
A1
PT
PP
R3
R1
Ta
Ta
pb1
pa1
Travel (L)
Ta
Ta
2
L1
Travel Straight
1
Lc6
Lc5
Lc4
Lc7
Travel Motor (R)
Travel Motor (L)
Arm 2
Boom 1
Grapple
Arm 1
Boom 2
Swing
B6
A6
pb6
pa6
Travel (R)
B1
A1
pb1
pa1
Travel (L)
PP
P2
P1
DS1602578

Figure 24

Grapple Compound Operation

A priority control valve is installed in grapple. This valve controls oil flow entering grapple when operating during a combined operation with travel, boom 1, and arm 2 sections, on P2 side. If pressure at port (Pi4) is increased when operating grapple, piston (S7-6), piston (S7-5) and plug (S7-4) are pressed, and poppet assembly (S7-2) is seated on valve housing.

This causes oil flowing from parallel passage (L3) to open poppet (S7-3) in poppet assembly and flow into passage (S7-1). As a result, passage diameter is smaller during combined operation, than passage diameter during a single operation.

This smaller passage reduces flow of oil to port (A7, B7). Remaining oil flows through parallel passage (L3) and primarily flows to section being operated at P2 side during a combine operating procedure.

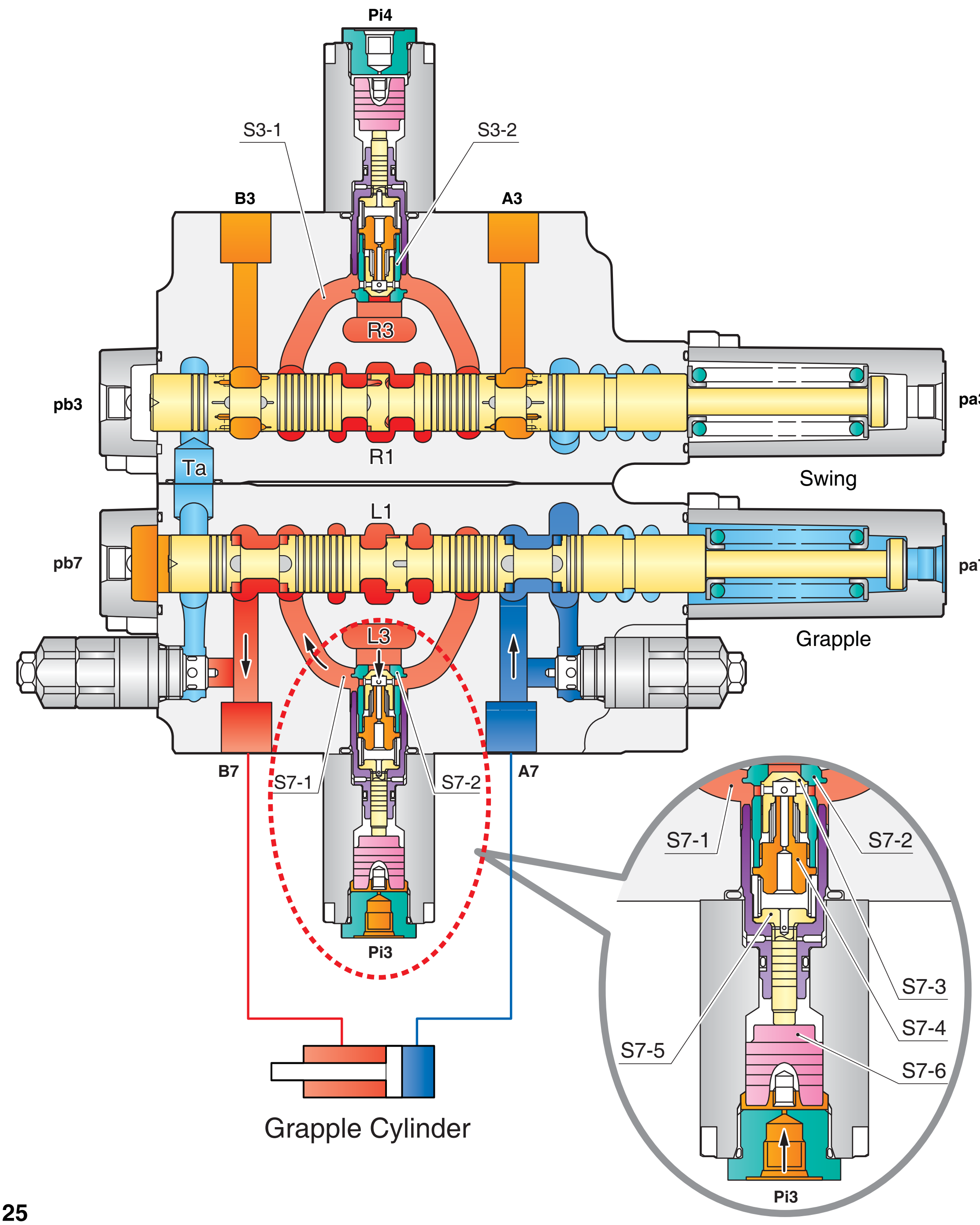


Figure 25

DS1602579

Swing Compound Operation

The valve's swing section is equipped with the control valve that adjusts the flux that flows into the swing when combined operating with the section (travel, boom 2, arm 1) of P1.

If port (Pi3) is pressurized when operating swing function, piston (S3-6) is pushed to have the poppet assembly (S3-2) to be pressed under the seat part of the valve housing through the piston (S3-5) and plug (S3-4). In this way, the oil in the parallel passage (R3) is flowing into the passage (S3-1) by pushing up the poppet (S3-3) inside the poppet assembly.

As a result, the passage at the time of compound operation is tightened more than when single operation that flux flowing into A3 (B3) is reduced, and the surplus flux is advanced to the section that P1 is simultaneously operated through the parallel passage (R3).

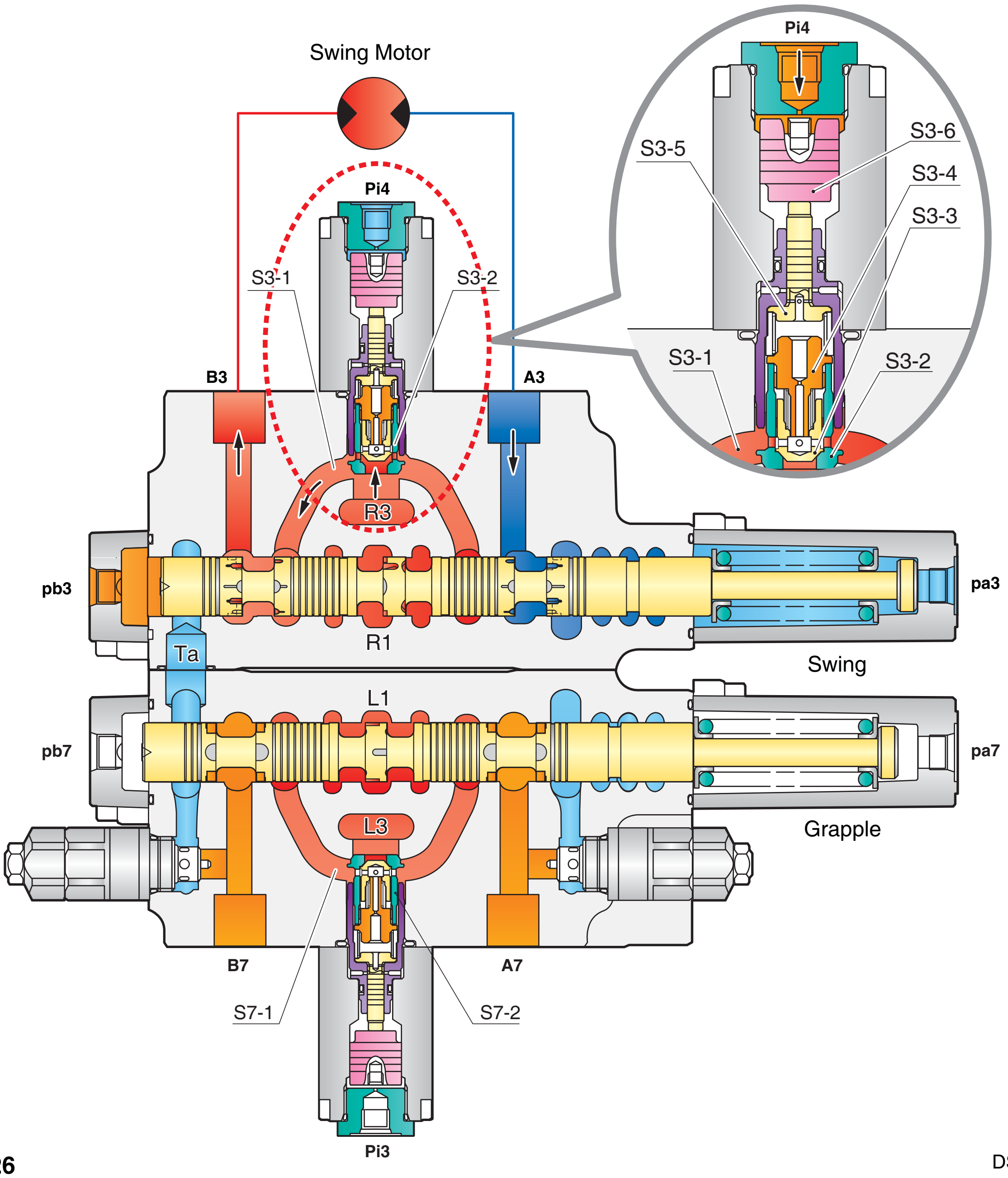


Figure 26

Antidrift Valve

The antidrift valve is installed on the cylinder port on the arm rod (boom head) for the natural antidrift of the arm (boom) cylinder. (For typical example, arm (A5) is shown.)

1. Neutral condition (maintaining port (A5))

   A. The holding pressure of port (A5) is sent through passages (a, b, and c), and into spring chamber (d) of poppet (1). Now pressurized oil flow, from port (A5) is cut off by seats (S1 and S2).

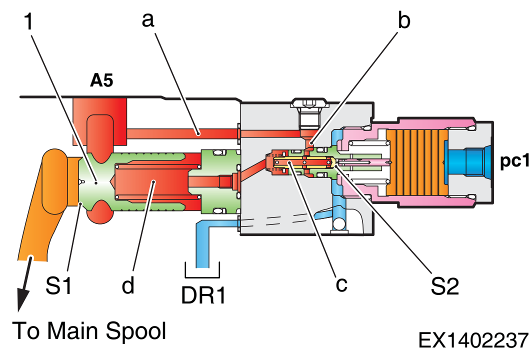


Figure 27

2. Oil passage cut off condition of the port (A5) and the spring chamber.

   A. If port pc1 is pressurized, piston (2) is moved and spool (3) reacts.

   B. Spool (3) activates poppet (4).

   C. Then by moving poppet (4), port (A5) and spring chamber (d) is cut off by part (T1).

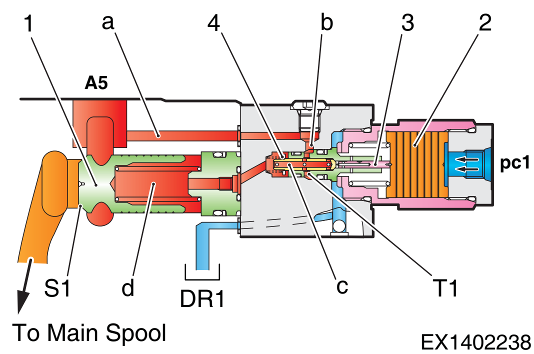


Figure 28

3. Main poppet operation condition.

   A. When the piston (2) starts, the spring chamber (d) passes from the passage (c) to the passage (e) and connect the oil passage by the part (T2) to the drain chamber (DR).

   B. The spring chamber (d) drains pressure and the main poppet (1) starts to unseat.

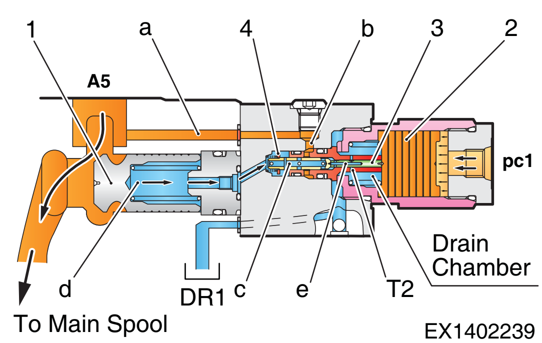


Figure 29

Main Relief Valve

1. The main relief valve is between neutral oil passage (HP, Figure 30) and low-pressure oil passage (LP). Pressurized oil flows into neutral oil passage (HP) through orifice in the main poppet (C) to fill internal cavity (D). Because of the difference in areas between (A and B), on which hydraulic pressure acts, main poppet (C) seats on sleeve (E).

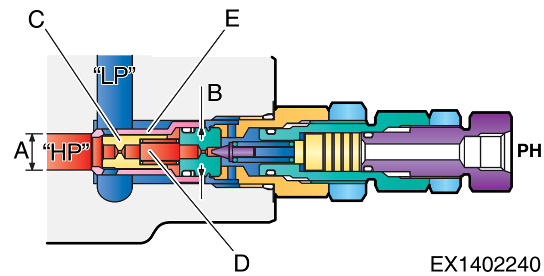


Figure 30

2. When pressure in neutral oil passage (HP) rises and exceeds relief valve setting, pilot poppet (F) opens. Pressurized oil flows through pilot poppet (F) into low-pressure oil passage (LP), passing through hole (G).

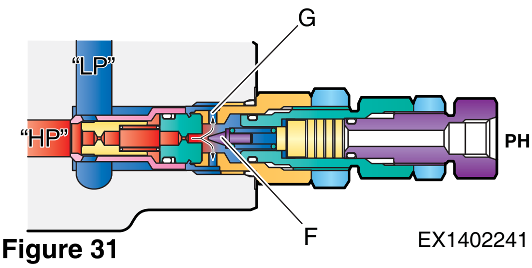


Figure 31

3. As pilot poppet (F) opens, pressure in internal cavity (D) lowers to move main poppet (C) so pressurized oil flows into neutral oil passage (HP) and directly into low-pressure oil passage (LP).

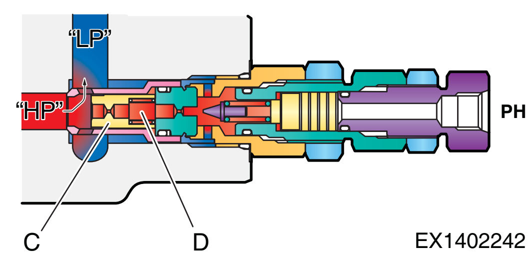


Figure 32

4. Pressure up operation

   If pressure is applied to pilot port "PH", piston (H) moves to the pressure setting position of plug (I) so the force of spring increases, thus increasing pressure in the neutral oil passage (HP).

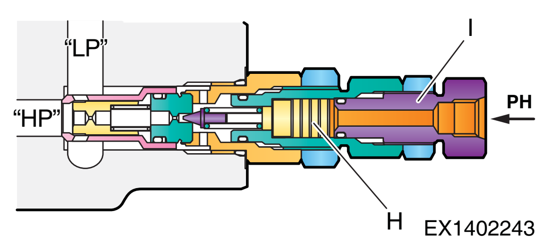


Figure 33

Overload Relief Valve

Operation

1. The overload relief valve is between cylinder port (HP) and low-pressure oil passage (LP). Pressurized oil at cylinder port (HP), flows through an orifice in piston (C), to fill internal cavity (G). Because of the difference in area between (A and B) on which the hydraulic pressure acts, main poppet (D) seats on sleeve (K).

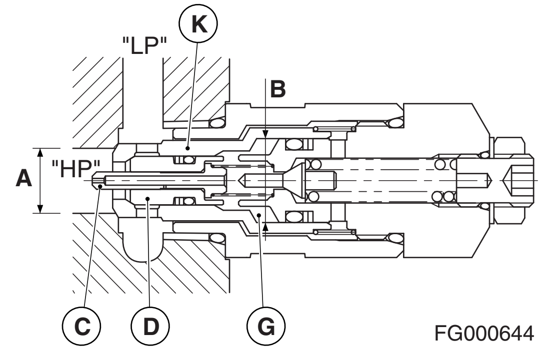


Figure 34

2. When pressure in cylinder port (HP) rises and exceeds the relief valve setting, pilot poppet (E) opens. Pressurized oil then flows through pilot poppet (E) into low-pressure oil passage (LP), passing through hole (H).

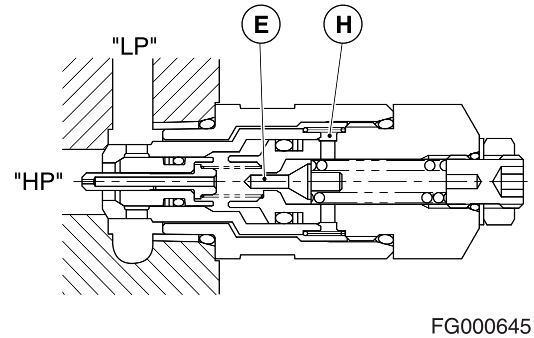


Figure 35

3. As pilot poppet (E) opens, pressurized oil flows through orifice (I) so pressure on back of piston (C) lowers to move piston (C). As a result, piston (C) seats on pilot poppet (E).

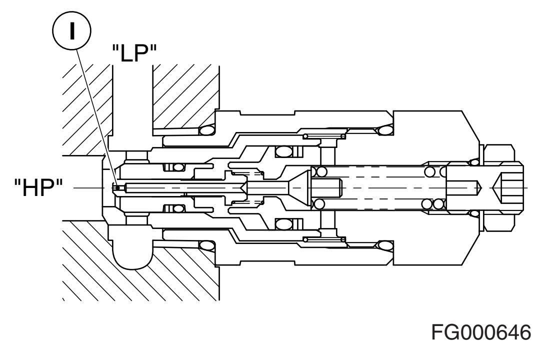


Figure 36

4. Pressurized oil in passage (HP) flows through orifice (F) in piston (C) so pressure on back of main poppet (D) moves main poppet (D). Pressurized oil then flows into passage (HP) and directly into passage (LP).

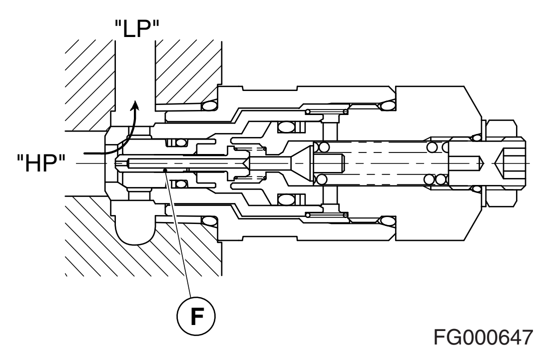


Figure 37

Absorption Operation

An anticavitation unit is installed in cylinder port (HP) to prevent the development of cavitation. If pressure at cylinder port (HP) becomes lower than that of oil passage (LP), sleeve (K) moves so oil is supplied from the low-pressure oil passage (LP) to cylinder port (HP) to eliminate cavitation.

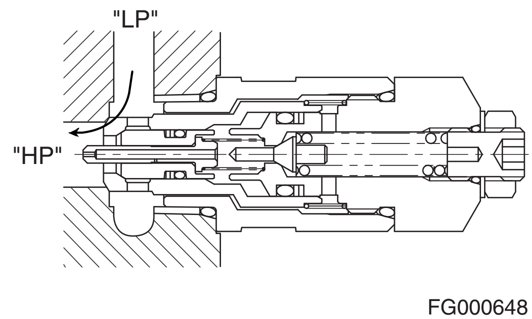


Figure 38

Low-pressure Relief Valve

1. Signal pressure

   Oil supplied from pump port (P1 (P2)) flows through neutral passage (L1 (R1)), low-pressure relief valve passage (L2 (R2)), and orifice (Lc1 (Rc1)) to tank passage (Ta).

   Now, pressure generated at passage (L2 (R2)) by orifice (Lc1 (Rc1)) moves to low-pressure relief signal port (Ps1 (Ps2)).

   If main spool of upper reaches of L2 (R2)) operates, signal pressure of Ps1 (Ps2) decreases because oil flowing to L2 (R2) decreases.

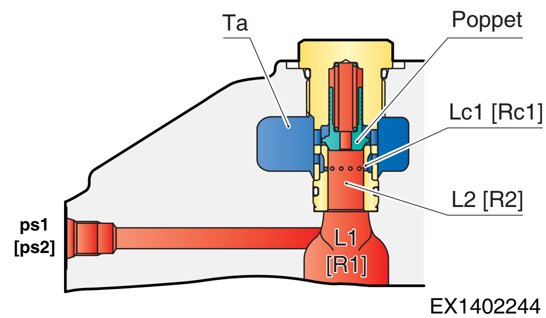


Figure 39

2. Operation of relief

   If excessive oil flows into passage (L2 (R2)), pressure generated at passage (L2 (R2)) by orifice (Lc1 (Rc1)) goes to back chamber of poppet, and poppet operates by the difference of pressurized area between passage and back chamber.

   By operation of this poppet, oil flows from passage through plug and drill hole to tank passage (Ta). By this action, generation of excessive pressure in low-pressure relief signal port is prevented.

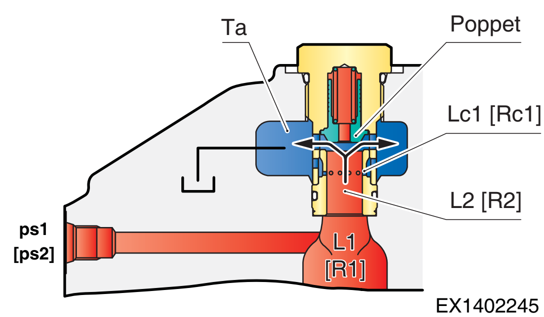


Figure 40

Cautions for Operation

1. Before operating machine, make sure that oil passages and hydraulic oil are clean.
2. Relief valve pressure should not be raised above specified pressure setting.
3. The difference between main relief valve setting pressure and overload relief valve setting pressure should not be over 2.0 MPa (19.9 bar (290 psi)).
4. Before operating machine, the hydraulic system must be fully warmed up. If machine is operated with cold hydraulic oil and valve, be careful of the following, to prevent spool sticking because of heat shock.

   NOTE: *Do not operate main relief valve or overload relief valve suddenly and continuously. Cycle oil through all actuators and warmed up cold hydraulic oil in the lines and components uniformly.*

   NOTE: *Slight or compound work should not be suddenly operated at cold weather because heat is developed partly at all the orifices.*

PRECAUTION

Lower the work equipment to the ground and stop engine.

Operate the control levers and pedals several times to release the remaining pressure in the hydraulic piping

Loosen the breather slowly to release the pressure inside the hydraulic tank.

Escaping fluid under pressure can penetrate the skin causing serious injury.

When pipes and hoses are disconnected, catch the oil with an oil pan.

Tools and Torques

Tool	Torque		
	N.m	kg.m	ft lb
Allen Wrench 4	14.7	1.5	10.8
Allen Wrench 5	8.8 ~ 10.8	0.9 ~ 1.1	6.5 ~ 8
Allen Wrench 6	15.7	1.6	11.6
Allen Wrench 8	39.2 ~ 44.1	4 ~ 4.5	28.9 ~ 32.5
Allen Wrench 14	166.7 ~ 176.5	17 ~ 18	123 ~ 130.2
Wrench 17	71.6	7.3	52.8
Wrench 22	39.2 ~ 44.1	4 ~ 4.5	28.9 ~ 32.5
Wrench 27	107.9	11	79.6
Wrench 32	107.9	11	79.6
Wrench 30	58.8 ~ 43.4	6 ~ 7	43.4 ~ 50.6
Wrench 36	215.7	22	159.1
Wrench 38	147.1 ~ 156.9	15 ~ 16	108.5 ~ 115.7
Bit Wrench 4			
Bit Wrench 4			
Loctite 271			

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Park on firm and level ground.
2. Lower front attachment to ground. (Figure 41).
3. Stop engine.

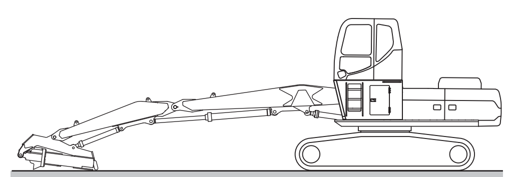


Figure 41 EX1300554

4. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 42)
5. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

6. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
7. Move safety lever to "LOCK" position. (Figure 42)
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Attach a maintenance warning tag on controls.
10. Turn battery disconnect switch to "OFF" position. (Figure 43)

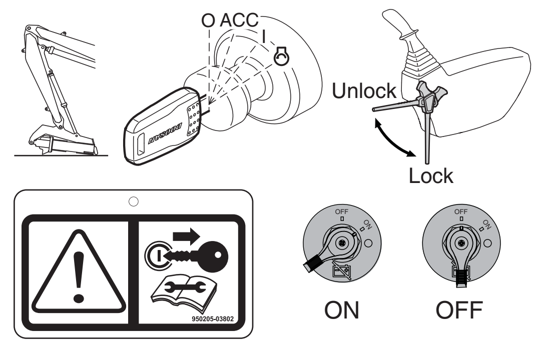


Figure 42

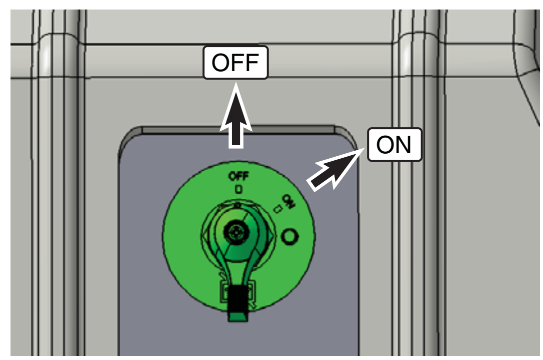
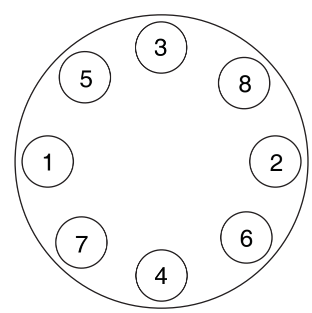


Figure 43
WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809
Figure 44

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

11. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.
    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

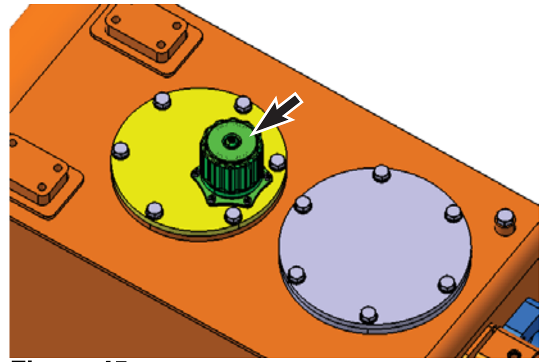
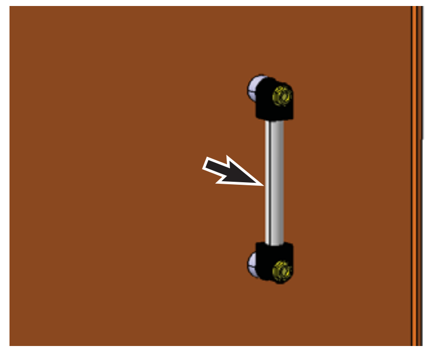


Figure 45 EX1404054

12. Oil drain method.

    NOTE: *Check the level on the oil level gauge before draining the oil.*



EX1402303

Figure 46

A. Remove cover (2 ea) on oil tank (bolt: 12 ea) and drain hydraulic oil using oil pump. (Figure 47)
   Also pump oil from the suction pipe.

   - Tool: 17 mm ( )
   - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

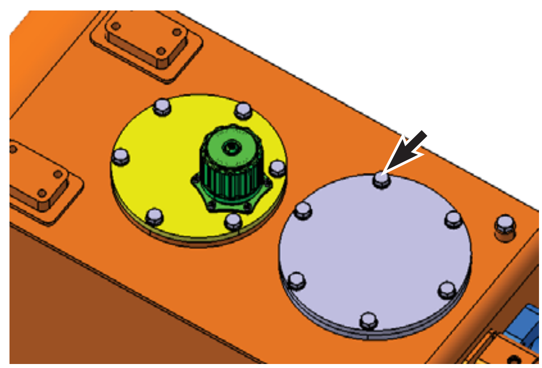
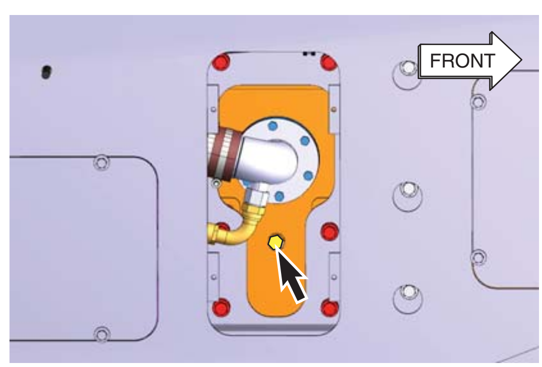


Figure 47 EX1404072

B. Drain hydraulic fluid using drain plug.
   (without oil pump) (Figure 48)

   - Tool: 27 mm ( )
   - Torque: 93.1 N.m (9.5 kg.m, 68.7 ft lb)
   - Hydraulic oil tank volume
     - Approximately: 195 L (52 U.S. gal)
     - Effective level: 131 L (35 U.S. gal)



DS1602639

Figure 48 Bottom of Main Frame

C. Plug the filter cap to location of suction filter.

Item	Part Number
Filter Cap	2188-1008

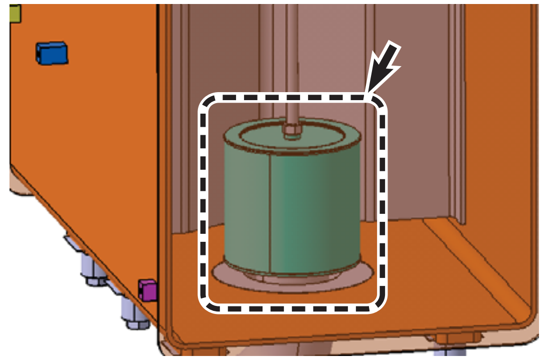
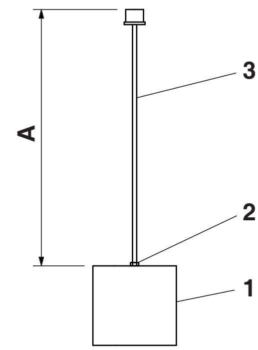


Figure 49 EX1402349

Reference Number	Description
1	Suction Filter
2	Nut
3	Rod

When installing

- Length (A): 650 mm
- Torque (2 nut): 49 N.m (5 kg.m, 36.2 ft lb)



EX1402872

Figure 50

13. Loosen the main control valve mounting bolts from main frame bracket. (bolt: 4 ea) (Figure 51)

NOTE: *Do not remove bolts completely to hold the position of control valve.*

- Tool: 24 mm ( )
- Torque: 264.6 N.m (27 kg.m, 195.2 ft lb)

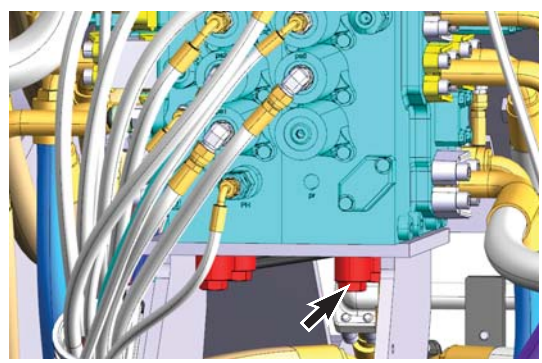


Figure 51 Bottom of Main Frame DS1602839

14. Open the engine cover and remove bolts and washers (1, Figure 52) (4 ea) with cover (2).

- Tool: 19 mm ( )
- Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
- Cover weight: 18 kg (40 lb)

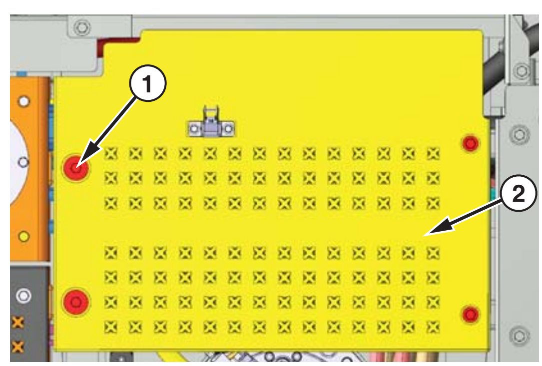


Figure 52 DS1602642

15. Disconnect the harness connector (2 ea).

NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

Port	Location
PT, PA	Left Side

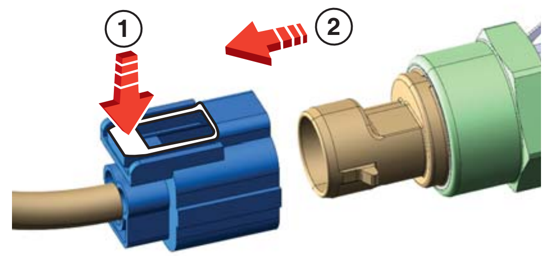


Figure 53

16. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 54

17. Remove hoses, pipes and adapters from control valve.

NOTE: *Attach identification tags to the removed hoses for reassembling.*
After disconnecting hoses from main control valve, plug them to prevent dirt or dust from entering. Disconnect the hoses from the bottom to top of control valve.

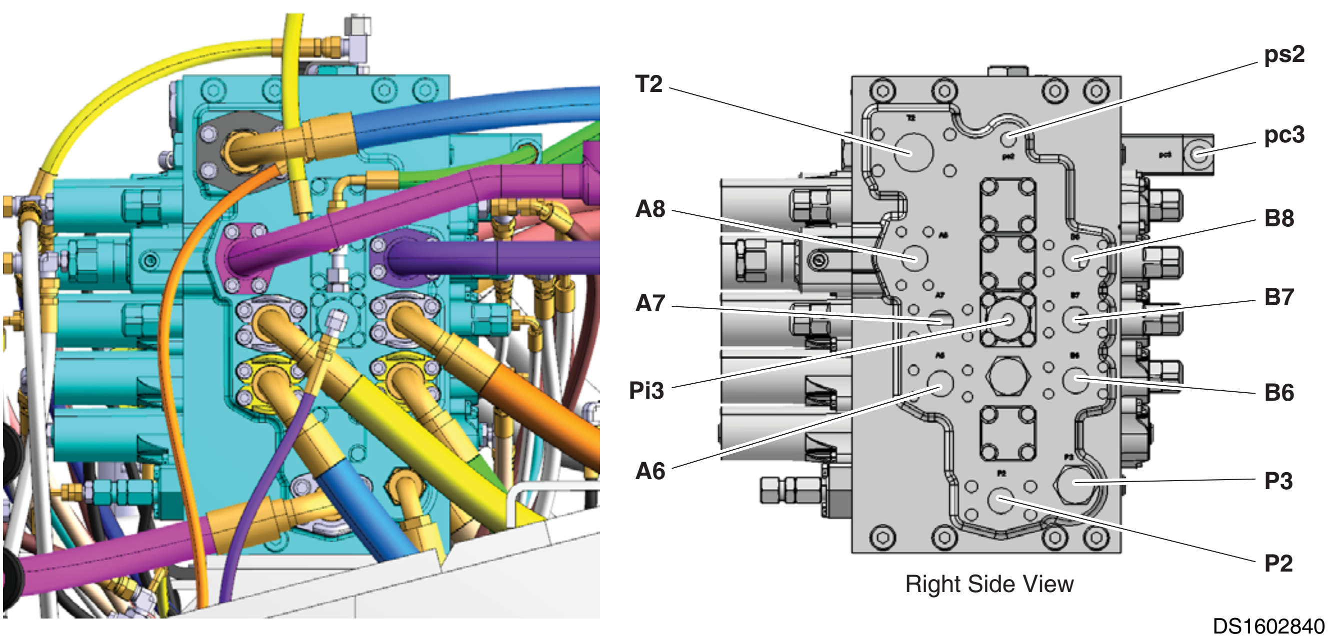


Figure 55

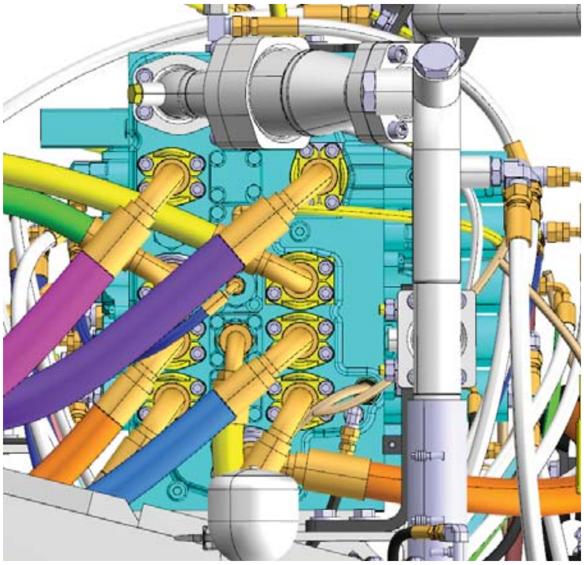
- Hoses and plugs ports

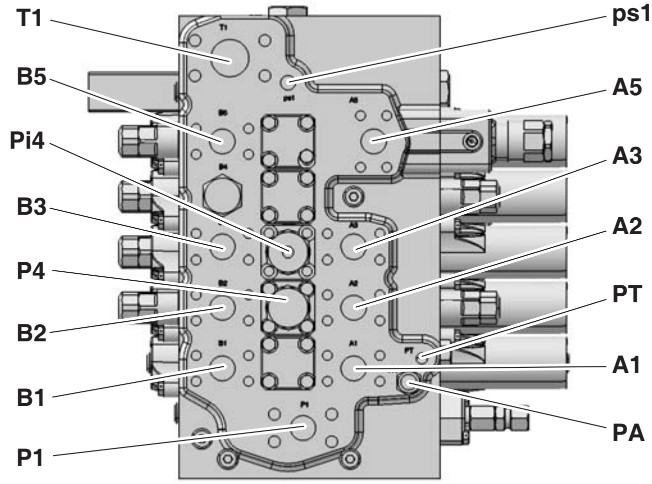
Port	Name	Plug/Flange Size (Hose)	(mm)	(mm)	Torque		
					N.m	kg.m	ft lb
T2	to Swing Device "C"	UNF 1 7/16"-12-2B	41		169.5	17.3	125
A6	to Center Joint "4" (Travel Motor RH Backward)	SAE 1", D25.4		8	63.7	6.5	47.0
A7	to Grapple Cylinder "Rod" (Grapple Extension)	SAE 1", D25.4		8	63.7	6.5	47.0
A8	to Boom Cylinder Head (Boom Up)	SAE 1", D25.4		8	63.7	6.5	47.0
B6	to Center Joint "3" (Travel Motor RH Forward)	SAE 1", D25.4		8	63.7	6.5	47.0
B7	to Grapple Cylinder "Tube" (Grapple Retraction)	SAE 1", D25.4		8	63.7	6.5	47.0
B8	to Boom Cylinder "Rod" (Boom Down)	SAE 1", D25.4		8	63.7	6.5	47.0
P2	from Main Pump "A2"	SAE 1", D25.4		10	107.9	11.0	79.6
P3	to Two Pump Flow Valve "A"	UNF 1 3/16"-12-2B	36		124.5	12.7	91.9
ps2	to Main Pump "(A2) X1"	UNF 9/16"-18-2B	19		25.5	2.6	18.8
pc3	Connect with "DR3" (to Oil Tank)	UNF 11/16"-16-2B	22		38.2	3.9	28.2
Pi3	from Joint Sub Assembly "B1"	UNF 9/16"-18-2B	19		25.5	2.6	18.8

- Fitting

Port	Name	Size		(mm)	(mm)	Torque		
		A	B (C)			N.m	kg.m	ft lb
T2	Flange	SAE 1 1/2", D38.1	UNF 1 7/16"-12		10	107.9	11.0	79.6
P3	Adapter	PF 3/4"	UNF 1 3/16"-12	36		156.9	16.0	115.7
pc3		PF 1/4"	UNF 11/16"-16	19		34.3	3.5	25.3
ps2, Pi3	Elbow	PF 1/4"	UNF 9/16-18	19		34.3	3.5	25.3
T2	O-ring	DS2856005 (1 1/2", ID:47.6, OD:54.6, 1B)	S8030165 (4D F-16)					
P3		S8000241 (1B P24)	S8030125 (4D F-12)					
A6, A7, A8, B6, B7, B8, P2		DS2856003 (1", ID:33.2, OD:40.2, 1B)						
pc3		S8000115 (4D P11)	S8030061 (1B F-06)					
ps2, Pi3		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)					

* A: Opposite side of hose, B (C): Hose side





Left Side View

DS1602841

Figure 56

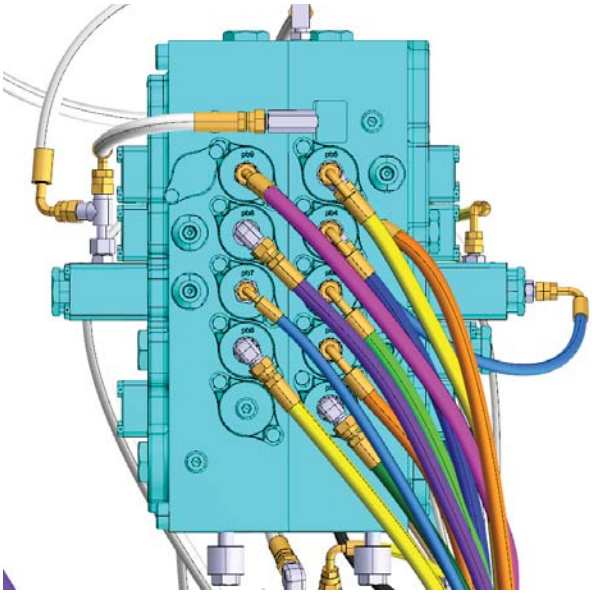
- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	(mm)	Torque		
					N.m	kg.m	ft lb
T1	from Oil Cooler	SAE 1 1/2", D38.1		10	107.9	11.0	79.6
A1	to Center Joint "2" (Travel Motor LH Backward)	SAE 1", D25.4		8	63.7	6.5	47.0
A2	to Heel Cylinder "Head" (Heel Rack OUT)	SAE 1", D25.4		8	63.7	6.5	47.0
A3	to Swing Device "B" (Left Swing)	SAE 1", D25.4		8	63.7	6.5	47.0
A5	to Stick Cylinder "Rod" (Arm Crowd)	SAE 1", D25.4		8	63.7	6.5	47.0
B1	to Center Joint "1" (Travel Motor LH Forward)	SAE 1", D25.4		8	63.7	6.5	47.0
B2	to Heel Cylinder "Rod" (Heel Rack IN)	SAE 1", D25.4		8	63.7	6.5	47.0
B3	to Swing Device "A" (Right Swing)	SAE 1", D25.4		8	63.7	6.5	47.0
B5	to Stick Cylinder "head" (Arm Dump)	SAE 1", D25.4		8	63.7	6.5	47.0
P1	from Main Pump "A1"	SAE 1", D25.4		10	107.9	11.0	79.6
P4	from Two Pump Flow Valve "B"	UNF 1 3/16"-12-2B	36		124.5	12.7	91.9
PA	to Swing Device "SH"	UNF 9/16"-18-2B	19		25.5	2.6	18.8
PT	Pressure Sensor	PF 1/4"	24		39.2	4.0	28.9
Pi4	Connect with "pb4"	UNF 9/16"-18-2B	19		25.5	2.6	18.2
ps1	to Main Pump "(A1) X1"	UNF 9/16"-18-2B	19		25.5	2.6	18.8

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
P4	Adapter	PF 3/4"	UNF 1 3/16"-12	36	156.9	16.0	115.7
PA, ps1	Elbow	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
Pi4	Adapter	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
PT	Reducer	PF 1/4"	PF 1/4"	19	39.2	4.0	28.9
P4	O-ring	S8000241 (1B P24)	S8030125 (4D F-12)				
T1		DS2856005 (1 1/2", ID:47.6, OD:54.6, 1B)	2180-1026D31 (ID:69.44, W:3.53, Class1)				
A1, A2, A3, A5, B1, B2, B3, B5, P1		DS2856003 (1", ID:33.2, OD:40.2, 1B)					
PA, Pi4, ps1		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				
PT		S8000115 (4D P11)					

* A: Opposite side of hose, B (C): Hose side



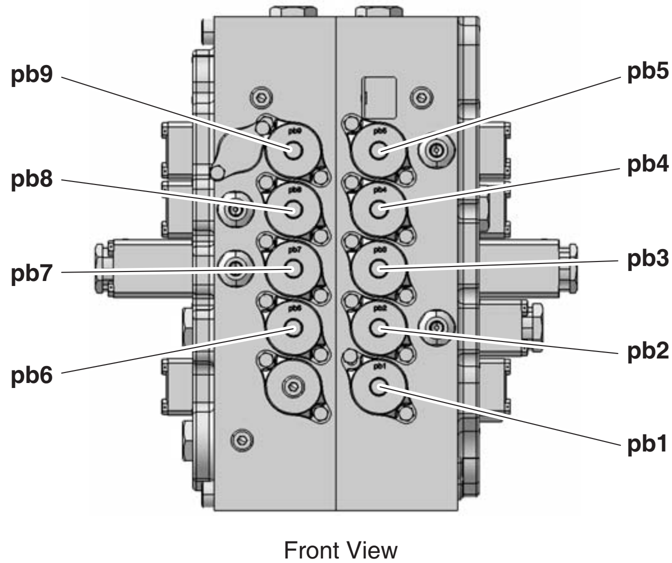


Figure 57

DS1602842

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
pb1	from Cabin Riser Sub Assembly "B6" (from Pedal Valve "2")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb2	from Joint Sub Assembly "B7" (from Joystick Valve (RH) "1")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb3	from Joint Sub Assembly "B8" (from Joystick Valve (LH) "3")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb4	Connect with "Pi4"	UNF 9/16"-18-2B	19	25.5	2.6	18.2
	Connect with "pa8"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb5	from Joint Sub Assembly "B2"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	from Two Pump Shift Valve (Heel) "P"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb6	from Cabin Riser Sub Assembly "B8" (from Pedal Valve "4")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb7	from Cabin Riser Sub Assembly "B15" (from Grapple EPPR Valve "A")	UNF 9/16"-18-2B	19	25.5	2.6	18.2
pb8	from Joint Sub Assembly "B3" (from Joystick Valve (RH) "2")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pb9	from Two Pump Shift Valve "P"	UNF 11/16"-16-2B	22	38.2	3.9	28.2

• Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
pb1, pb6, pb8	Elbow	PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pb2, pb3, pb9	Adapter	PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pb4	Tee	PF 3/8"	UNF 9/16"-18, UNF 11/16"-16	22	44.1	4.5	32.5
pb5		PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pb7	Adapter	PF 3/8"	UNF 9/16"-18	22	44.1	4.5	32.5
pb1, pb2, pb3, pb6, pb8, pb9	O-ring	S8000145 (4D P14)	S8030061 (1B F-06)				
pb4		S8000145 (4D P14)	S8030061 (1B F-06), 2180-1216D11 (ID:7.65, W:1.78, 1B)				
pb5		S8000145 (4D P14)	S8030061 (1B F-06)				
pb7		S8000145 (4D P14)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

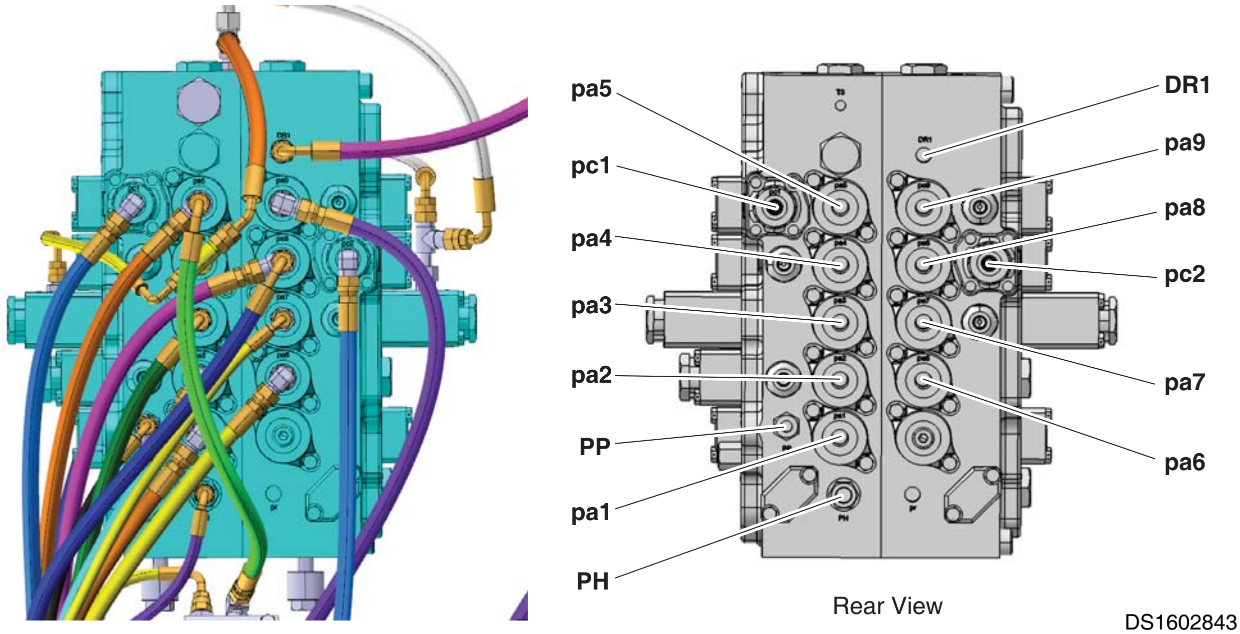


Figure 58

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
pa1	from Cabin Riser Sub Assembly "B5" (from Pedal Valve "1")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa2	from Joint Sub Assembly "B5" (from Joystick Valve (RH) "3")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa3	from Joint Sub Assembly "B6" ((from Joystick Valve (LH) "1")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa4	Connect with "DR4"	UNF 9/16"-18-2B	19	25.5	2.6	18.2
	Connect with "DR2"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa5	from Joint Sub Assembly "B4"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	from Two Pump Shift Valve (Heel) "PI"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa6	from Cabin Riser Sub Assembly "B7" (from Pedal Valve "3")	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa7	from Cabin Riser Sub Assembly "B16" (from Grapple EPPR Valve "B")	UNF 9/16"-18-2B	19	25.5	2.6	18.2
pa8	Connect with "pb4"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	from Joint Sub Assembly "B1"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pa9	from Two Pump Flow Valve "A"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pc1	from Joint Sub Assembly "B2"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
pc2	from Joint Sub Assembly "B3"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
DR1	to Oil Tank	UNF 11/16"-16-2B	22	38.2	3.9	28.2
PP	to Swing Device "PG"	UNF 9/16"-18-2B	19	25.5	2.6	18.2
	to Solenoid Valve "P1"	UNF 9/16"-18-2B	19	25.5	2.6	18.2
PH	to Solenoid Valve "PH"	UNF 9/16"-18-2B	19	25.5	2.6	18.2

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
pa1, pa2, pa6, pa9	Elbow	PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pa3, DR1	Adapter	PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pa7		PF 3/8"	UNF 9/16"-18	22	44.1	4.5	32.5
pa4	Tee	PF 3/8"	UNF 9/16"-18, UNF 11/16"-16	22	44.1	4.5	32.5
pa5, pa8		PF 3/8"	UNF 11/16"-16	22	44.1	4.5	32.5
pc1, pc2	Elbow	PF 1/4"	UNF 11/16"-16	19	34.3	3.5	25.3
PP	Tee	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
PH	Adapter	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
pa1, pa2, pa3, pa5, pa6, pa8, pa9, DR1	O-ring	S8000145 (4D P14)	S8030061 (1B F-06)				
pa4		S8000145 (4D P14)	S8030061 (1B F-06), 2180-1216D11 (ID:7.65, W:1.78, 1B)				
pa7		S8000145 (4D P14)	2180-1216D11 (ID:7.65, W:1.78, 1B)				
pc1, pc2		S8000115 (4D P11)	S8030061 (1B F-06)				
PP, PH		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

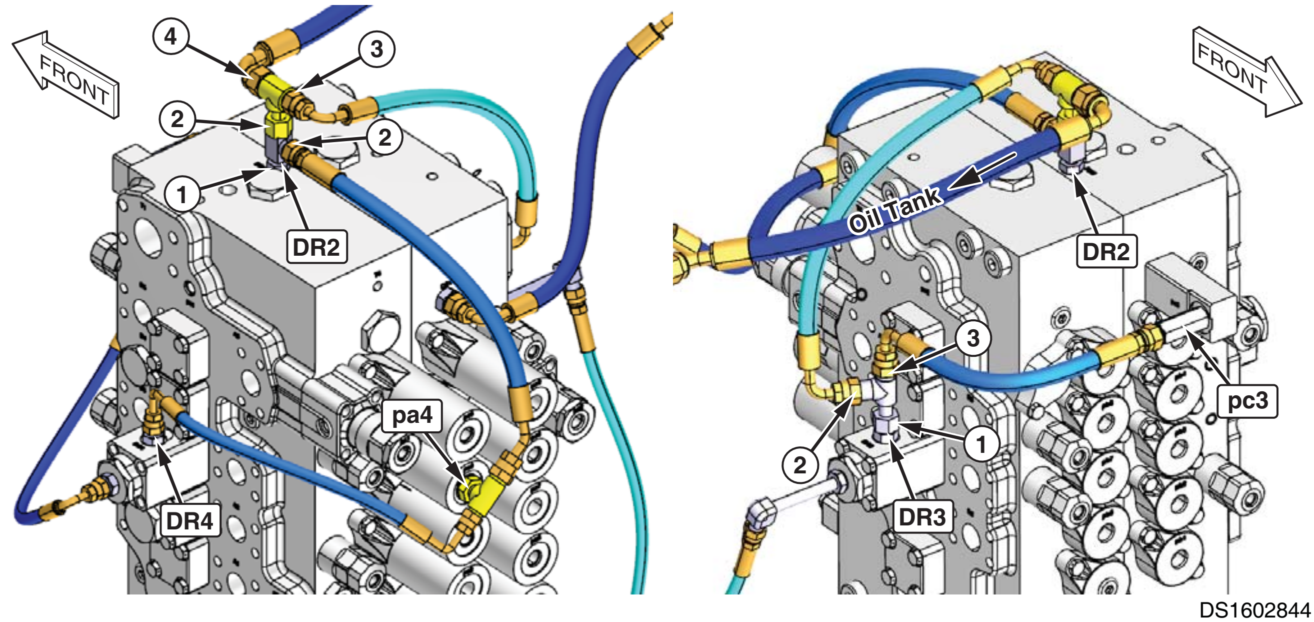


Figure 59

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
DR2	Connect with "DR3"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	Connect with "pa4"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	to Oil Tank	UNF 13/16"-16-2B	24	55.9	5.7	41.2
DR3	Connect with "DR2"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	Connect with "pc3"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
DR4	Connect with "pa4"	UNF 9/16"-18-2B	19	25.5	2.6	18.2

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
DR2	Tee	① PF 1/4"	② UNF 11/16"-16	19	34.3	3.5	25.3
		② UNF 11/16"-16	③ UNF 11/16"-16 ④ UNF 13/16"-16	22	38.2	3.9	28.2
DR3	Adapter	PF 1/4"	UNF 11/16"-16	19	34.3	3.5	25.3
	Tee	① UNF 11/16"-16	② UNF 11/16"-16 ③ UNF 11/16"-16	22	38.2	3.9	28.2
DR4	Adapter	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
DR2	O-ring	S8000115 (4D P11)	S8030061 (1B F-06), S8030081 (1B F-08)				
DR3		S8000115 (4D P11)	S8030061 (1B F-06)				
DR4		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

18. Install eyebolts (2 ea) to lift in threaded holes on top of control valve. (Figure 60)
    - Thread of hole: M10 x 1.5 (Depth 17 mm)
    - Control valve weight: about 193 kg (425 lb)

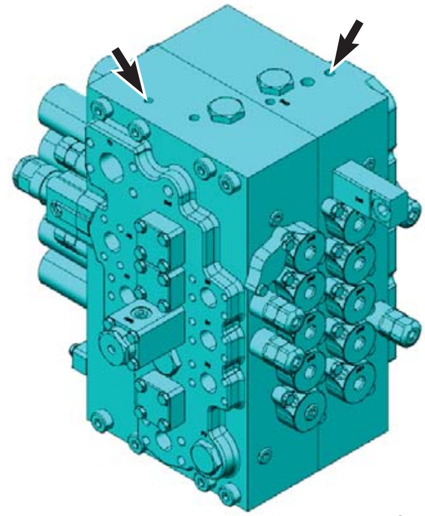

DS1602869

Figure 60

19. Remove main control valve mounting bolts and spacer from main frame bracket. (bolt: 4 ea) (Figure 61)
20. Lift the control valve by crane from frame slowly and carefully.

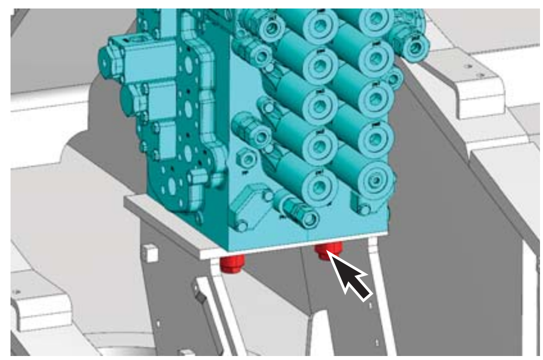

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Figure 61

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

NOTE: *First, assemble the bolts and spacer (4 ea) of main control valve mounting to main frame. (Figure 62)*

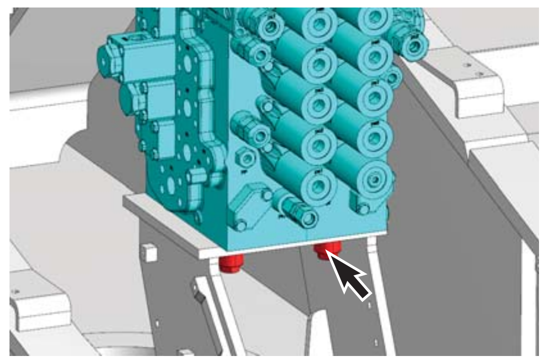


Figure 62

1. Perform installation in the reverse order to remove.

IMPORTANT

After completing the work, check the oil level. Start the engine and check for any oil leaks.

2. Be careful not to apply stress on control valve when attaching piping and hoses. Unnecessary stress can cause spools to bind and the control valve from functioning properly.
3. Tighten the assembling bolts alternately and evenly to the specified torque.
4. If welding procedures are being performed near the control valve, the valve could be damaged by weld spatter and heat. Use adequate shielding to protect valve.
5. Valve ports must be covered with caps, plugs or tape to protect them from dust and other foreign materials, until pipe laying work is started.

COMPLETING WORK

1. If the hydraulic oil in the oil tank was removed, refill the hydraulic oil tank.
2. Start the engine and run at low idle for about 5 minutes.
3. Operate the joystick lever and actuate the hydraulic cylinder 4 ~ 5 times very slowly, about 100 mm before the end of stroke.
4. Operate the rod of cylinder to the end of stroke to relieve the hydraulic piping.
   (The air breather of oil tank is actuated to bleed the air)

DISASSEMBLY

Caution on Disassembly

1. Stop engine when pressure of actuator is not indicated.

   It is dangerous to disassemble control valve while it is under pressure. High-pressure oil can squirt out or components can spring out. When partially disassembling control valve that is on machine, be careful to follow the following caution.

   WARNING

   AVOID DEATH OR SERIOUS INJURY

   Always relieve hydraulic pressure and fully lower bucket (or attachment) to the ground, before disassembly. Failure to follow instructions can cause sudden release of component parts or boom dropping, resulting in death or serious injury.

2. Vent pressurized air from hydraulic oil tank.
3. Clean all exterior surfaces of valve before to disassembly and protect it from dirt and foreign materials.
4. Match mark the disassembled parts to make sure of proper reassembling position.
5. Replace all sealing parts such as O-rings and backup rings with a new ones.
6. Do not replace spools, they are matched with valve housing and sleeve.

   NOTE: *The further part numbers of an assembly part are shown as (assembly part number - further part number).*

Sequence of Disassembly

Disassembly of Main Spool Part

No.	Item	Tool	Torque
74	Socket Bolt	Allen Wrench 8	4 ~ 4.5 kg.m
72	Plug	Allen Wrench 8	4 ~ 4.5 kg.m
91	Plug	Wrench 22	4 ~ 4.5 kg.m

1. Remove socket head bolt (74, two places on each section, width across flats: 8 mm) and cap (8, ten places).
2. Remove plug assembly (72, width across flats: 8 mm) and plug (91, width across flats: 22 mm) according to necessity.
3. Remove O-ring (7, one place on each section) from valve housing (1 and 13).
4. Remove all spool subassemblies from valve housing

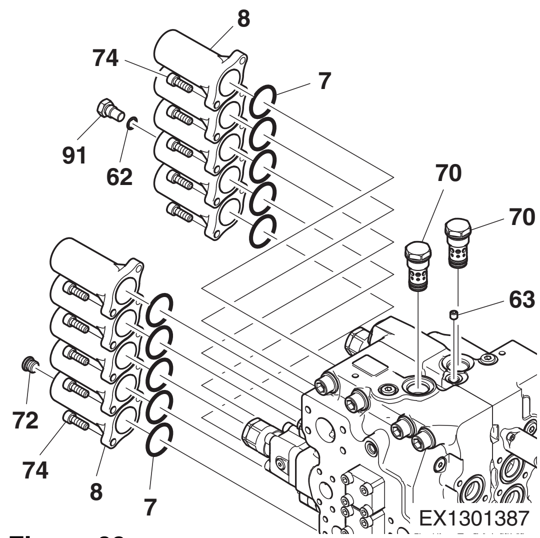


Figure 63

IMPORTANT

When removing spool, be careful not to damage it.

Attach label to each spool to install it in the correct position when reassembling.

5. Remove socket head bolt (74, two places on each section, width across flats: 8 mm) and cap (12, ten places).
6. Remove O-ring (7, one place on each section) from valve housing (1 and 13).
7. Disassembly of spool.

IMPORTANT

Work with spool gripped in vise with wood (see Figure 64) so as not to scratch outside diameter of spool.

Because Loctite is applied to threaded portion of spool end, heat outside surface of spool with industrial drier to release Loctite. Heat spool until spool end is easily loosened, and remove immediately after heating it to 200 - 250°C (392 - 482°F). If it overheated, change spring to new one.

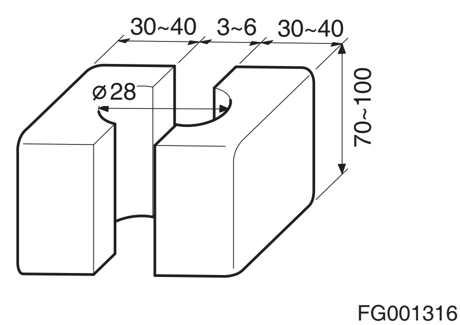


Figure 64

A. Remove spool end (width across flats: 8 mm), spring seat and spring from spool assembly (2-6 and 14-17).

NOTE: *There is a poppet, spring and plug in spool assembly. Do not disassemble unless absolutely necessary. If disassembly is necessary, heat spool outside surface to release Loctite in screw portion and remove plug. When reassembling, replace O-ring and backup ring to new ones.*

Disassembly of Arm 1 Para-turn Spool Part

No.	Item	Tool	Torque
78	Socket Bolt	Allen Wrench 5	0.9 ~ 1.1 kg.m
22	Spool End	Allen Wrench 5	1.9 ~ 2.2 kg.m

1. Remove socket head bolt (78, width across flats: 5 mm) and cap (18).
2. Remove O-ring (23) from cap (18).
3. Remove spool (19) from valve housing under subassembly conditions.
4. Disassembly of spool.

IMPORTANT

Work with spool gripped in vise with wood (see Figure 64), so as not to scratch outside diameter of spool.

Because Loctite is applied to threaded portion of spool end, heat outside surface of spool with industrial drier to release Loctite. Heat spool until spool end is easily loosened, and remove immediately after heating it to 200 - 250°C (392 - 482°F).

If it is overheated, replace spring with a new one.

A. Remove spool end (22, width across flats: 5 mm), spring seat (20) and spring (21) from spool (19).

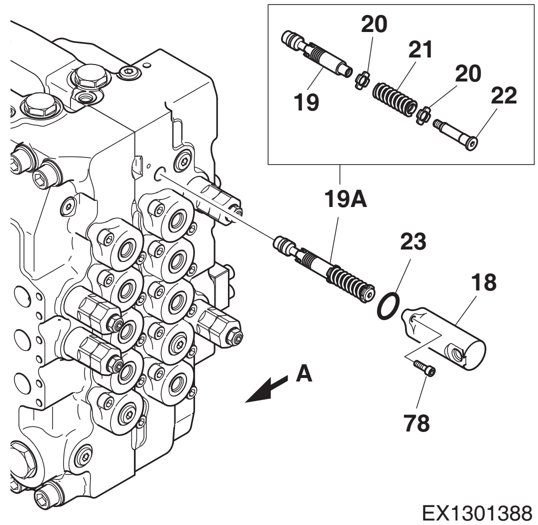


Figure 65

Disassembly of Arm Regeneration Release Valve Part

No.	Item	Tool	Torque
24	Plug	Wrench 5	11 kg.m

NOTE: *The part including assembly is shown (assembly number -part number).*

WARNING

AVOID DEATH OR SERIOUS INJURY

Always relieve hydraulic pressure and fully lower bucket (or attachment) to the ground, before disassembly. Failure to follow instructions can cause sudden release of component parts or boom dropping, resulting in death or serious injury.

1. Remove plug (24, width across flats: 32 mm) and O-ring (25).
2. Remove spring (26) and spool (27) from sleeve (28).
3. Remove sleeve (28) from valve housing.
4. Remove piston (29), O-ring (30) and backup ring (31) from sleeve (28).

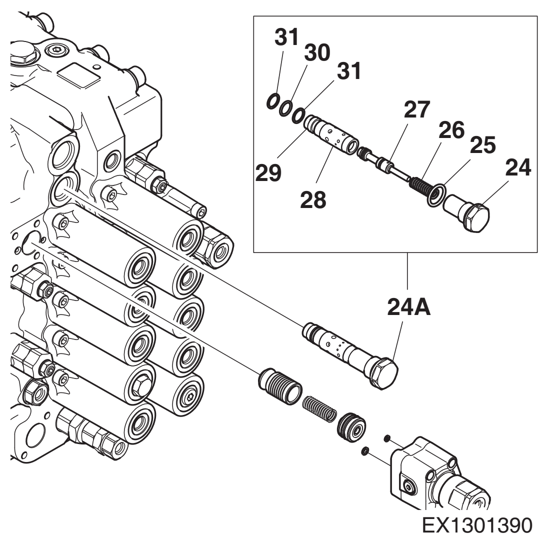


Figure 66

Disassembly of Load Check Valve Part

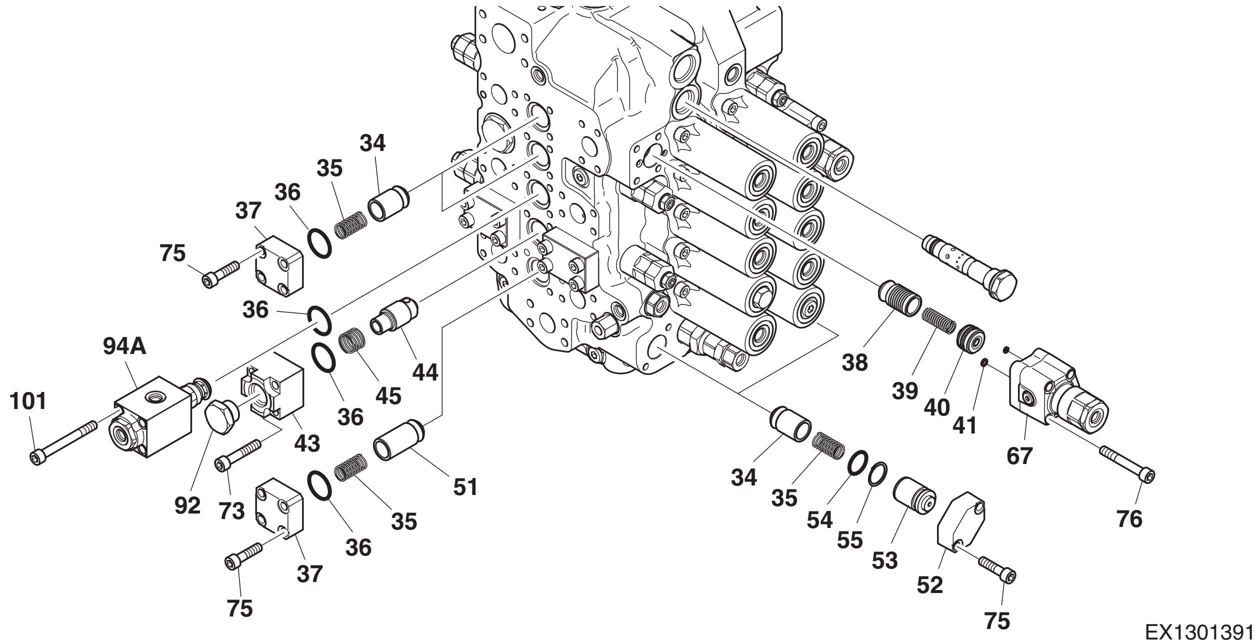


Figure 67

No.	Item	Tool	Torque
75	Socket Bolt	Allen Wrench 8	6.2 kg.m
73	Socket Bolt	Allen Wrench 8	6.2 kg.m
101	Socket Bolt	Allen Wrench 8	6.2 kg.m
46	Plug	Wrench 27	11 kg.m
72	Plug	Allen Wrench 8	7.7 kg.m
92	Plug	Wrench 36	22 kg.m
94	Plug	Wrench 36	22 kg.m

WARNING

AVOID DEATH OR SERIOUS INJURY

Always relieve hydraulic pressure and fully lower bucket (or attachment) to the ground, before disassembly. Failure to follow instructions can cause sudden release of component parts or boom dropping, resulting in death or serious injury.

1. Remove socket head bolt (75, four places on each section, width across flats: 8 mm) and flange (37, seven places).
2. Remove spring (35), poppet (34) (poppet (51)) and O-ring (36) from valve housing.

CAUTION

AVOID INJURY

Be careful, there is not a poppet and spring in travel straight valve section (Section H-H).

3. Remove socket head bolt (75, width across flats: 8 mm) and flange (52, two places).
4. Remove spacer (53) from valve housing. Remove O-ring (54) and backup ring (55) from spacer (53).
5. Remove spring (35) and poppet (34) from valve housing.
6. Remove plug (72, width across flats: 8 mm) (Section C-C).
7. Remove spring (33) and poppet (32) from valve housing.
8. Remove plug (72, width across flats: 8 mm) (Section L-L).
9. Remove spacer (57), spring (33) and poppet (32) from valve housing.
10. Remove plug (92, width across flats: 36 mm) (Section G-G).
11. Remove socket head bolt (73, four places, width across flats: 8 mm) and flange (43).
12. Remove spring (45), poppet (44) and O-ring (36) from valve housing.
13. Remove plug (46, width across flats: 27 mm) and O-ring (47).
14. Remove spring (48) and poppet (49) from valve housing.
15. Remove socket head bolt (101, four places, width across flats: 8 mm) from body (96, one places).
16. Remove body (96) from valve housing. Remove sleeve (99), piston (97), spring (98), poppet assembly (100), backup ring (103), and O-ring (104).
17. Remove O-ring (36).
18. Grip body (96) in vise. Remove plug (94), piston (95) and O-ring (102).

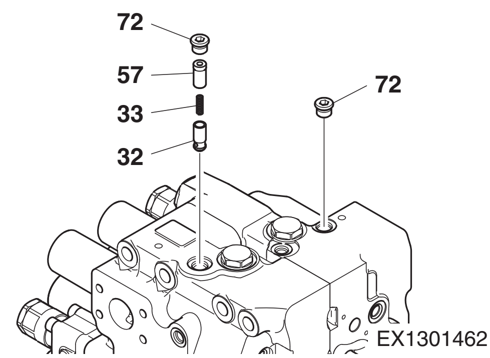


Figure 68

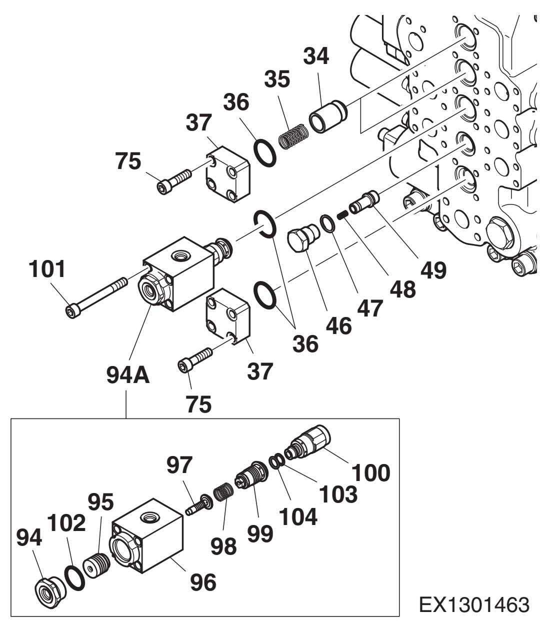


Figure 69

Disassembly of Antidrift Valve Part

No.	Item	Tool	Torque
67-3	Plug	Wrench 38	15 ~ 16 kg.m
67-14	Plug Assembly	Wrench 38	15 ~ 16 kg.m
67-15	Plug	Allen Wrench 4	1.5 kg.m
76	Socket Bolt	Allen Wrench 8	4 ~ 4.5 kg.m
78	Socket Bolt	Allen Wrench 5	0.9 ~ 1.1 kg.m

NOTE: *The part including the assembly is shown (assembly number-part number).*

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Always relieve hydraulic pressure and fully lower bucket (or attachment) to the ground, before disassembly. Failure to follow instructions can cause sudden release of component parts or boom dropping, resulting in death or serious injury.

1. Remove socket head bolt assembly (76, four places per section, width across flats: 8 mm) and antidrift valve assembly (67, two places).
2. Remove O-ring (41 and 42) from valve housing. Remove O-ring (40-4) from spacer assembly.
3. Screw socket head bolt (78, M6*1) into spacer, and remove spacer assembly (40) from valve housing.
4. Remove O-ring (40-2) and backup ring (40-3).
5. Remove spring (39) and poppet (38) from valve housing.
6. Disassembly of antidrift valve assembly
   - A. Remove plug assembly (67-14, width across flats: 38 mm) and O-ring.
   - B. Remove piston (67-4), spool (67-5), and spring (67-7).
   - C. Slowly remove plug (67-3, width across flats: 38 mm) and O-ring (67-13).
   - D. Remove sleeve (67-6) and poppet (67-2) from body. Remove O-ring (67-9 and 10) and backup ring (67-11 and 12) from outside diameter of sleeve.
   - E. Pull spring seat (67-16) and spring (67-8) out of inside hole.
   - F. Remove plug assembly (67-15) if necessary.

     NOTE: *Do not remove steel ball (67-18) because it is pressed in body.*

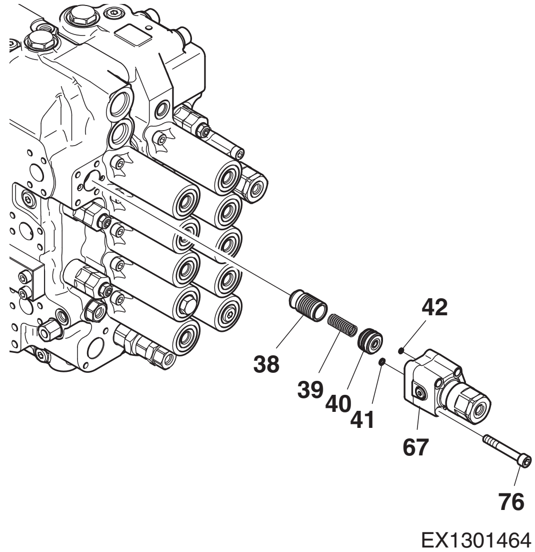


Figure 70

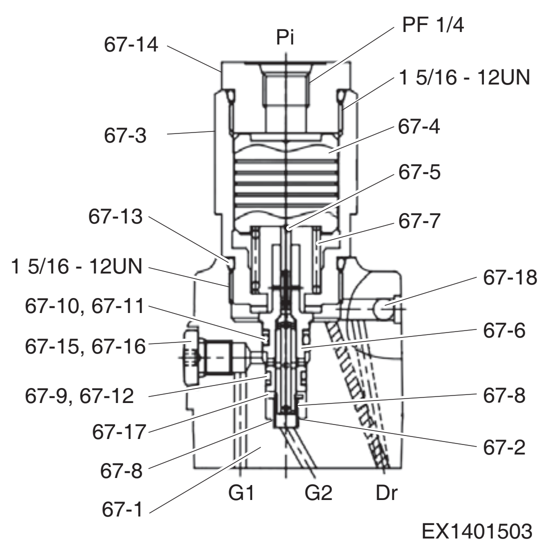


Figure 71

Disassembly of Relief Valve

WARNING

AVOID DEATH OR SERIOUS INJURY

Always relieve hydraulic pressure and fully lower bucket (or attachment) to the ground, before disassembly. Failure to follow instructions can cause sudden release of component parts or boom dropping, resulting in death or serious injury.

WARNING

AVOID DEATH OR SERIOUS INJURY

Do not loosen adjusting plug or change pressure setting.

No.	Item	Tool	Torque
68	Main Relief Valve	Wrench 32	8.8 kg.m
69	Overload Relief Valve	Wrench 32	8.8 kg.m
70	Foot Relief Valve	Wrench 32	11 kg.m

1. Remove overload relief valve (69, six places, width across flats: 32 mm).
2. Remove main relief valve (68, width across flats: 32 mm).
3. Remove relief valve assembly (70, two places, width across flats: 32 mm) and O-ring (70- 5 and 70-6).

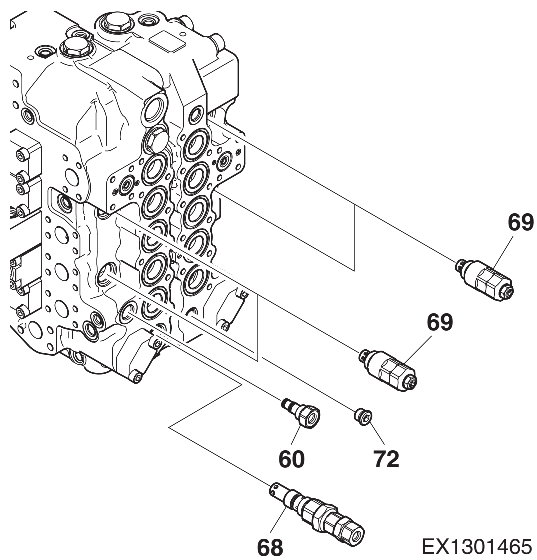


Figure 72

Disassembly of Other Plugs

No.	Item	Tool	Torque
60	Plug Assembly	Wrench 27	11 kg.m
61	Plug	Wrench 22	4 ~ 4.5 kg.m
63	Orifice Plug	Allen Wrench 5	1.6 kg.m
92	Plug Assembly	Wrench 36	22 kg.m
71	Plug Assembly	Allen Wrench 6	1.6 kg.m
72	Plug Assembly	Allen Wrench 8	7.7 kg.m

1. Remove plug assembly (60, width across flats: 27 mm) and O-ring (Section J-J).
2. Remove plug (61, width across flats: 22 mm) and O-ring (62) (Section K-K).

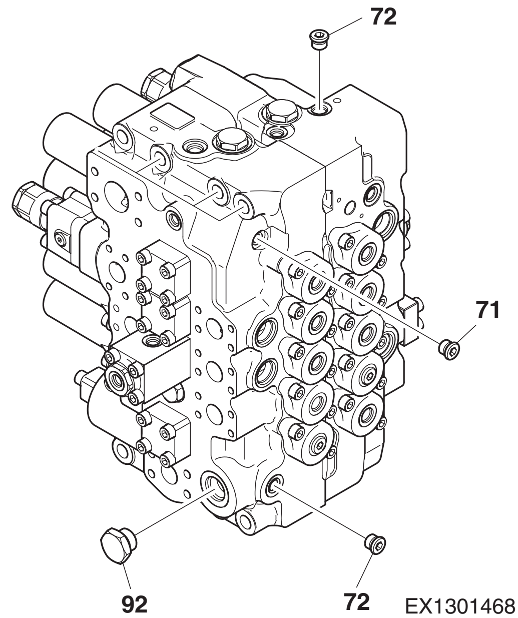


Figure 73

3. Remove orifice plug (63, width across flats: 5 mm) (Section A1-A1).
4. Remove plug assembly (92, width across flats: 36 mm) and O-ring.
5. Remove plug assembly (71, width across flats: 6 mm) and O-ring.
6. Remove plug assembly (72, width across flats: 8 mm) and O-ring.

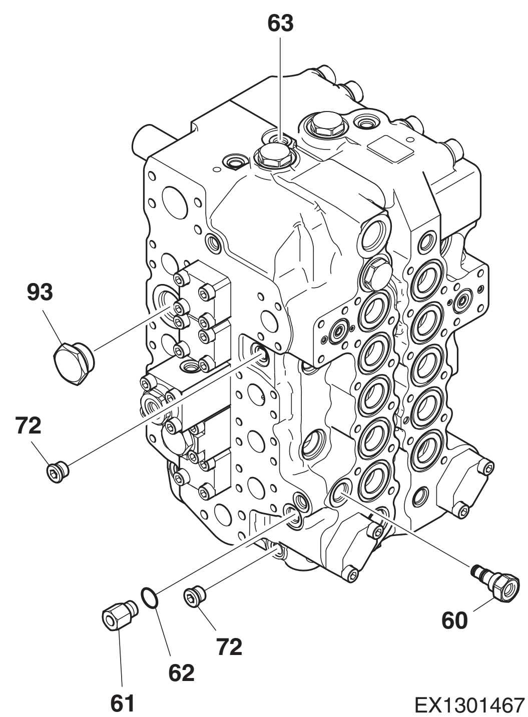


Figure 74

Disassembly of Valve Housing Bolt

No.	Item	Tool	Torque
77	Socket Bolt	Allen Wrench 14	17 ~ 18 kg.m

IMPORTANT

Do not disassemble combined bolt (77) if it is unnecessary.

If it is necessary to disassemble it, work by placing it horizontally on a workbench.

Prepare spare O-ring (65 and 66).

1. Remove socket head bolt (77, eight places, width across flats: 14 mm) and washer (81, eight places).

2. Remove O-ring (65 and 66) from valve housing mating surface.

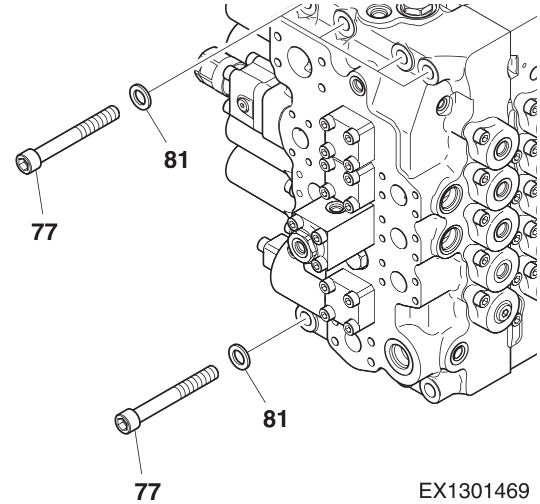


Figure 75

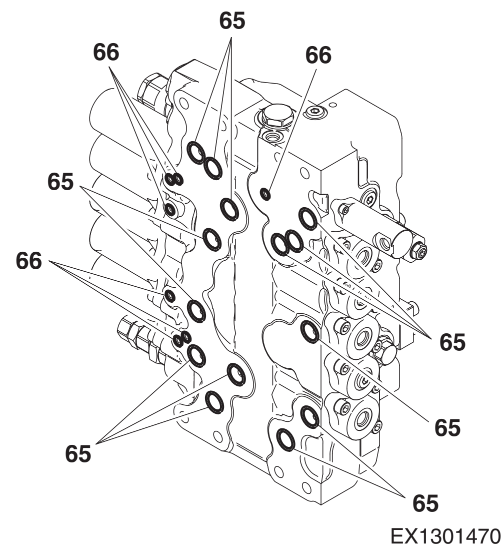


Figure 76

Disassembly of Main Relief Valve

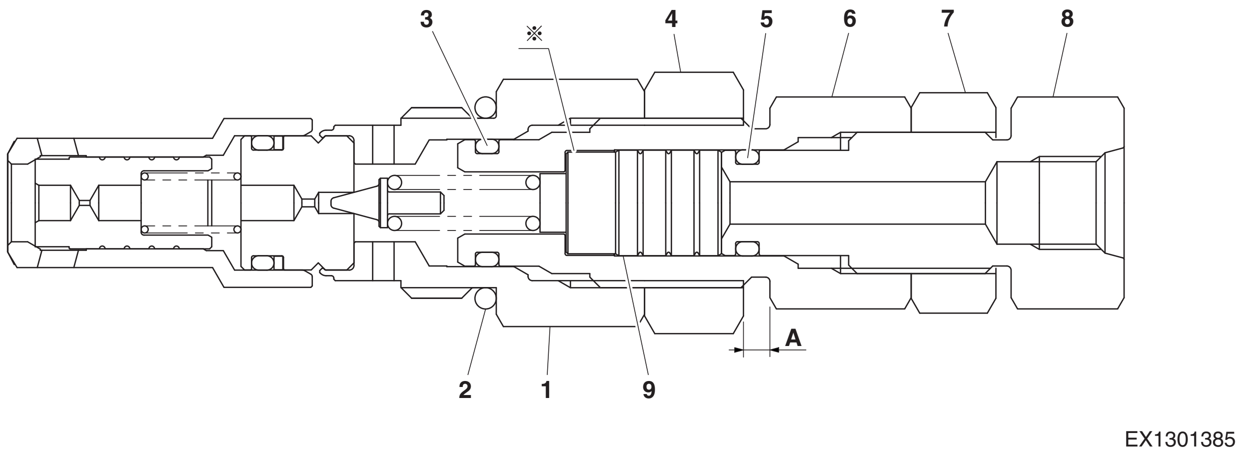


Figure 77

No.	Item	Tool	Torque
1	Plug	Wrench 32	8.8 kg.m
4	Nut	Wrench 36	8 ~ 9 kg.m
6	Plug	Wrench 27	11 kg.m
7	Nut	Wrench 30	6 ~ 7 kg.m
8	Plug	Wrench 27	Max. 2 kg.m

1. This relief valve must be replaced as an assembly. When replacing it, remove plug (1, width across flats: 32 mm), and O-ring (2). If oil is leaking from nut (4), remove nut (4) and plug (1), and replace O-ring (3). If oil is leaking from nut (7), remove nut (7) and plug (8), and replace O-ring (3).

Disassembly of Overload Relief Valve

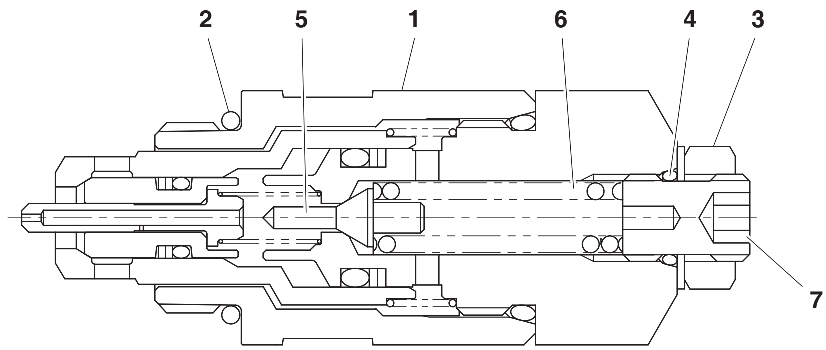


Figure 78

No.	Item	Tool	Torque
1	Cap	Wrench 31.75	8.8 kg.m
3	Locknut	Wrench 17	7.3 kg.m
7	Adjuster	Allen Wrench 6	

1. This relief valve must be replaced as an assembly. When replacing it, remove cap (1, width across flats: 32 mm) and O-ring (2). If oil is leaking from nut (4), remove nut (4) and plug (1), and replace O-ring (3). If oil is leaking from nut (7), remove nut (7) and plug (8), and replace O-ring (3).

   NOTE: *This relief valve must be replaced as an assembly. When replacing it, Remove cap (1, width across flats: 32 mm) and O-ring (2). If oil is leaking from adjusting kit (3), remove adjusting kit (3), and replace O-ring (4).*

CAUTION

AVOID INJURY

When disassembling adjuster kit, be careful not to let parts spring out or lose poppet because of spring force.

Instruction of Disassembly and Assembly of Low-pressure Relief Valve

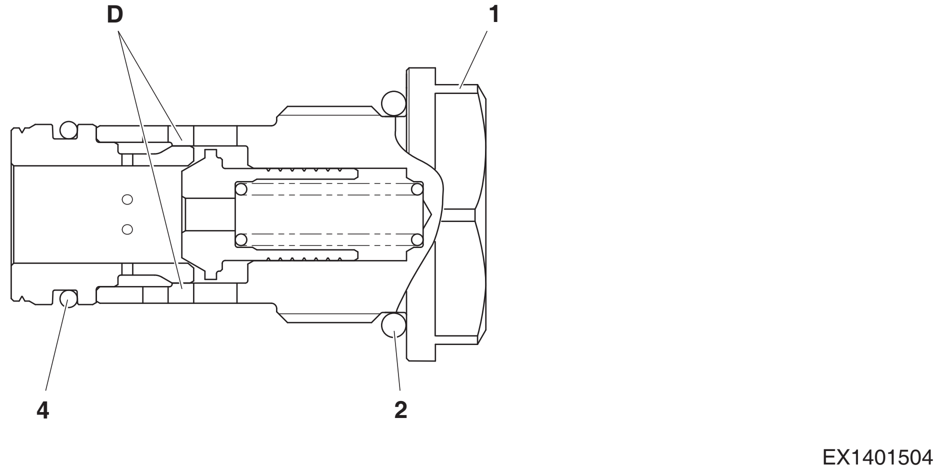


Figure 79

No.	Item	Tool	Torque
1	Plug	Wrench 32	8.8 kg.m
2	O-ring		
4	O-ring		

1. This unit has press install portion (D) and it must be replaced as a complete assembly.

CLEANING AND INSPECTION

For general cleaning and inspection procedures, refer to "General Maintenance Procedures" section.

Cleaning

Clean all parts thoroughly using a suitable cleaning fluid and dry them with moisture free compressed air. Put them on a clean paper or a vinyl for inspection.

Inspection

Inspect all parts for scratches, notches and other defects.

1. Inspect load check seat surface of valve housing for scratches, scores, dirt, notches and corrosion. Remove small scratches with oilstone.
2. Inspect exterior surface of spool for scratches and notches. Remove small scratches with oilstone.
3. Sliding parts must be moved lightly and foreign materials must be removed in all grooves and passages.
4. Replace any springs that are damaged, heavy deformed or worn.
5. If relief valve malfunction, inspect it using relief valve maintenance procedure.
6. Replace all O-rings and backup rings with new.
7. After disassembling cap or plug, check whether there are paint chips around body hole or plug. If paint chips penetrate into valve, they can cause malfunction or valve to leak.

REASSEMBLY

Caution on Assembly

Caution on Handling O-ring

1. Do not use O-ring which has any defect or scratches from handling.
2. Apply grease or hydraulic oil to installation portion of O-ring grooves and O-ring to ease installation.
3. Do not stretch O-ring beyond permanent set.
4. When installing O-ring, be careful not to twist it. (A twisted O-ring, is very difficult to return to its original shape after installing it. This could also cause a leak.)

Caution on Handling Spool

1. Rated torque must be kept because over torque of screw portion, can cause a malfunction of spool.
2. Be careful that each spool, spring and spool end must be reassembled like before disassembling.

Method of Painting the Adhesives (Screw Part and Arm Screw Part of Parts Requiring the Adhesiveness)

NOTE: *Male and female screw threads of parts which need to adhere.*

CAUTION

AVOID INJURY

When working with Loctite, work in a place that is well ventilated.

---

1. Cleaning (removal of grease)

   Remove grease with steam, acetate, etc. or clean with an alkali cleanser.

2. Dry

   Dry Loctite surface with moisture free air or naturally. If it is not completely dried, the effect of Loctite is weakened.

3. Primer painting

   Slightly spray Loctite Primer T effect promoter to Loctite surface and leave it for three or five minutes to dry.

4. Loctite application

   Lightly apply Loctite #274 or equivalent to two or three threads of spool female inlet. Now, be careful not to touch coated part to spring seat.

Sequence of Subassembly

IMPORTANT

Check number of each part, installation position and tools needed before reassembling.

Assembly of Spool (Main Spool)

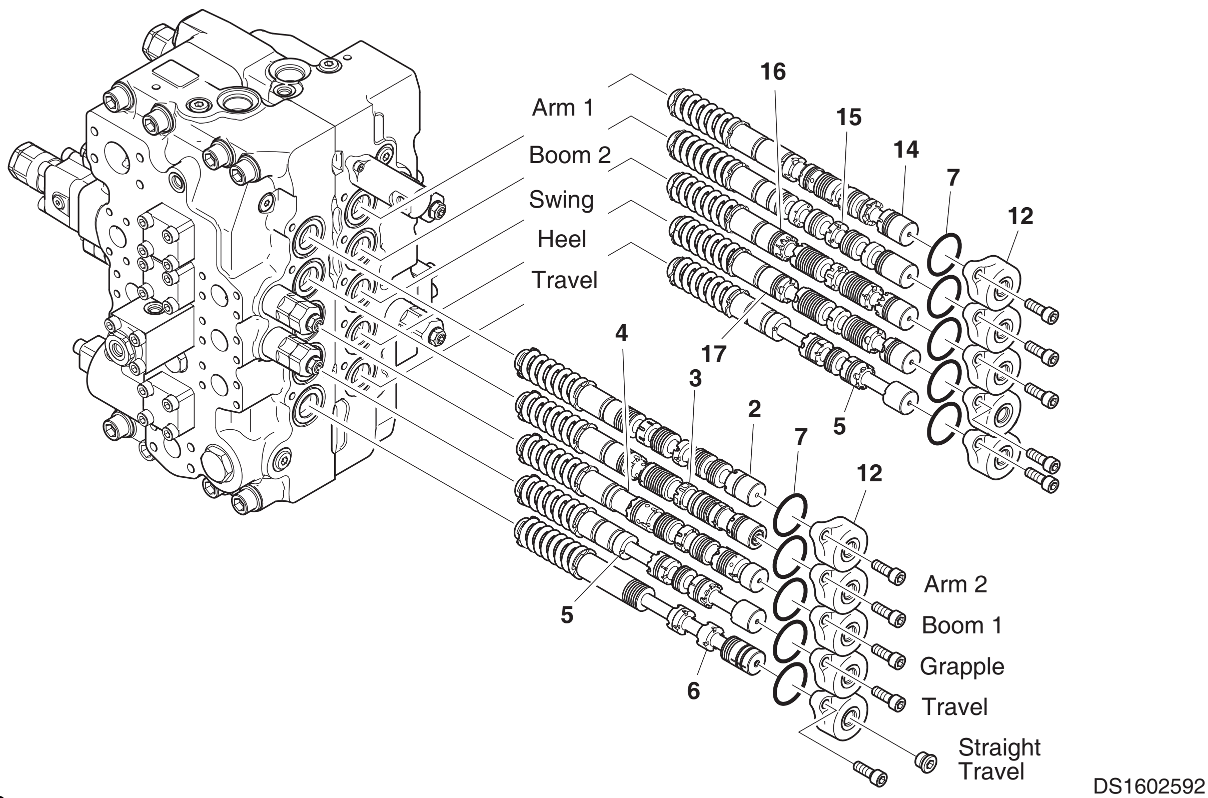


Figure 80

1. Apply Loctite to threaded portion of spool (2 ~ 6 and 14 ~ 17) and install spring seat, spring and spool end.
2. After gripping spool in vise with wood (that is used when disassembling it), tighten spool end. Tightening torque: 2.04 ~ 2.24 kg.m (15 ~ 16 ft lb). Bit Wrench 8.

IMPORTANT

Be careful not to get Loctite into spool by over applying it.

Be careful that spool operation does become deteriorated by over torquing spool end.

When reassembling it and A56, be careful because there are two different types of springs.

Assembly of Arm 1 Para-turn Spool

1. Apply Loctite to threaded portion of spool (19) and install spring seat (20), spring (21) and spool end (22).
2. After gripping spool in vise with wood (that is used when disassembling it), tighten spool end. Tightening torque: 1.94 ~ 2.24 kg.m (14 ~ 16 ft lb). Bit Wrench 5.

IMPORTANT

Be careful not to get Loctite into spool by over applying it.

Be careful that spool operation does become deteriorated by over torquing spool end.

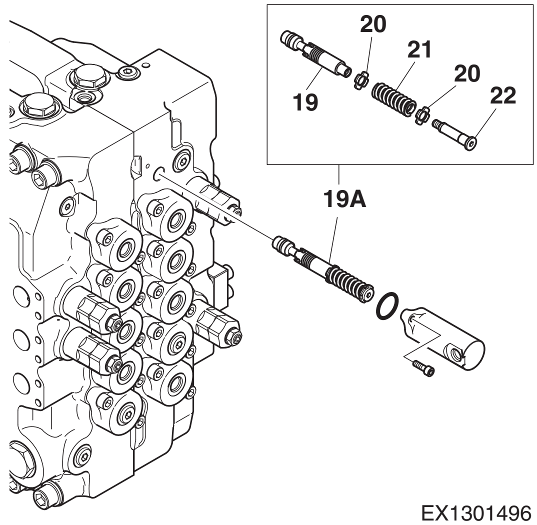


Figure 81

Assembly of Antidrift Valve

1. Install O-ring (67-9 and 67-10) and backup ring (67-11 and 67-12) in groove of sleeve (67-6).

IMPORTANT

Be careful of installation position of O-ring and backup ring.

If they are reversed, the O-ring will be damaged and drift speed of actuator can be increased.

2. Insert poppet (67-2) and spool (67-5) in sleeve hole.
3. Install spring seat (67-16) on small diameter of poppet end. Insert spring (67-8) and poppet assembly with sleeve into body (67-1).

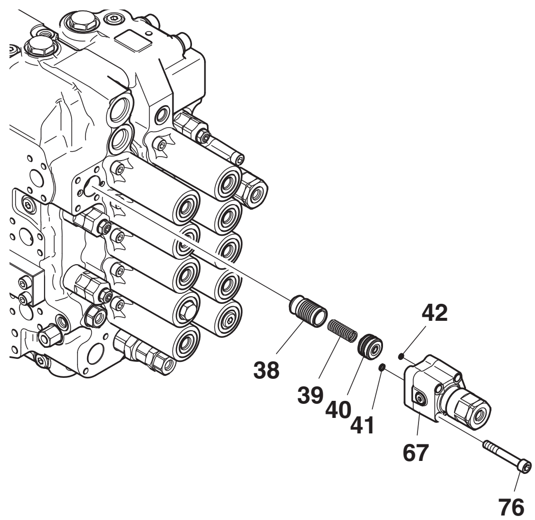


Figure 82

IMPORTANT

It Is better to apply grease to seat surface when installing spring and spring seat onto seat of poppet.

4. Install spring (67-7) and piston (67-4) in plug (67-3). Tightening torque: 15 ~ 16 kg.m (108 ~ 116 ft lb). Spanner 38.
5. Tighten plug assembly (67-14) with O-ring installed on plug (67-3). Tightening torque: 15 ~ 16 kg.m (108 ~ 116 ft lb). Spanner 38.
6. Install O-ring (67-13) on plug (67-3). Install it in body (67-1). Tightening torque: 15 ~ 16 kg.m (108 ~ 116 ft lb). Spanner 38.
7. Tighten plug assembly (67-15) with O-ring in body (67-1). Tightening torque: 1.4 ~ 1.8 kg.m (10 ~ 13 ft lb). Allen Wrench 4.

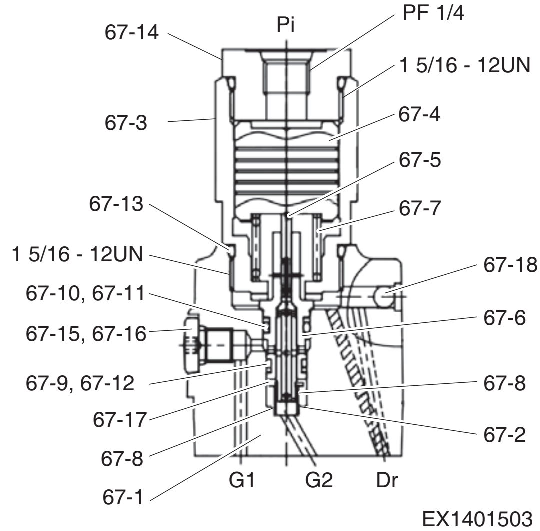


Figure 83

Assembly Sequence of Main Body of the Control Valve

WARNING

AVOID DEATH OR SERIOUS INJURY

Do not loosen adjusting plug or change pressure settings.

Assembly of Relief Valve

1. Install main relief valve (68). Tightening torque: 7.95 ~ 8.97 kg.m (58 ~ 65 ft lb). Wrench 32.
2. Install overload relief valve (69, six places) in each section. Tightening torque: 7.95 ~ 8.97 kg.m (58 ~ 65 ft lb). Wrench 32.
3. Install spring seat (68-7) on small diameter of poppet. Then insert spring (68-4) and them with sleeve to body (68-1). Tightening torque: 11 ~ 12 kg.m (76 ~ 83 ft lb). Wrench 27.

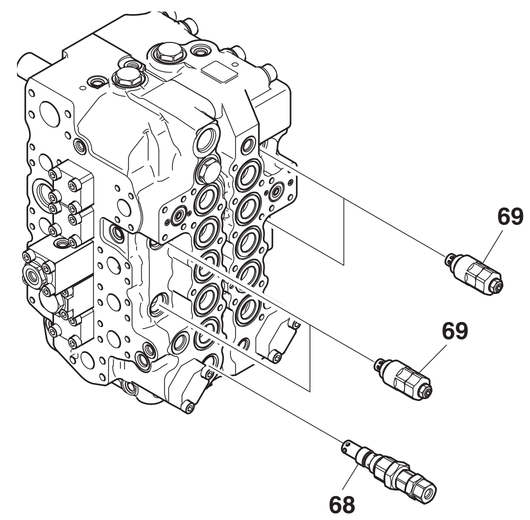


Figure 84

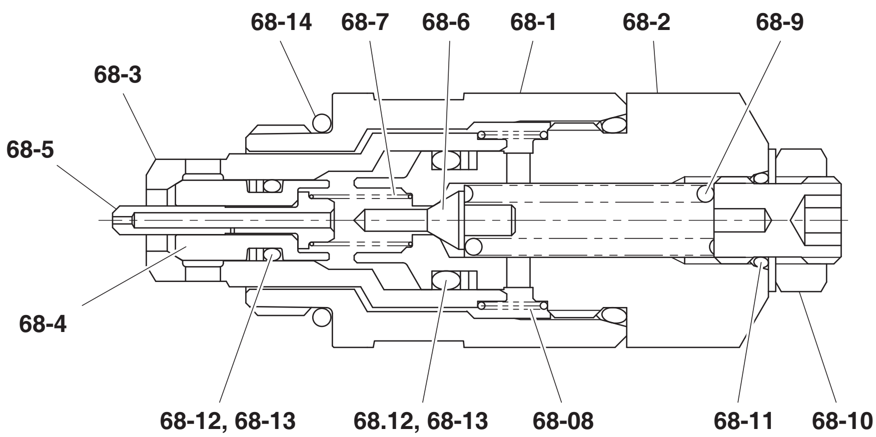


Figure 85

Assembly of Load Check Valve

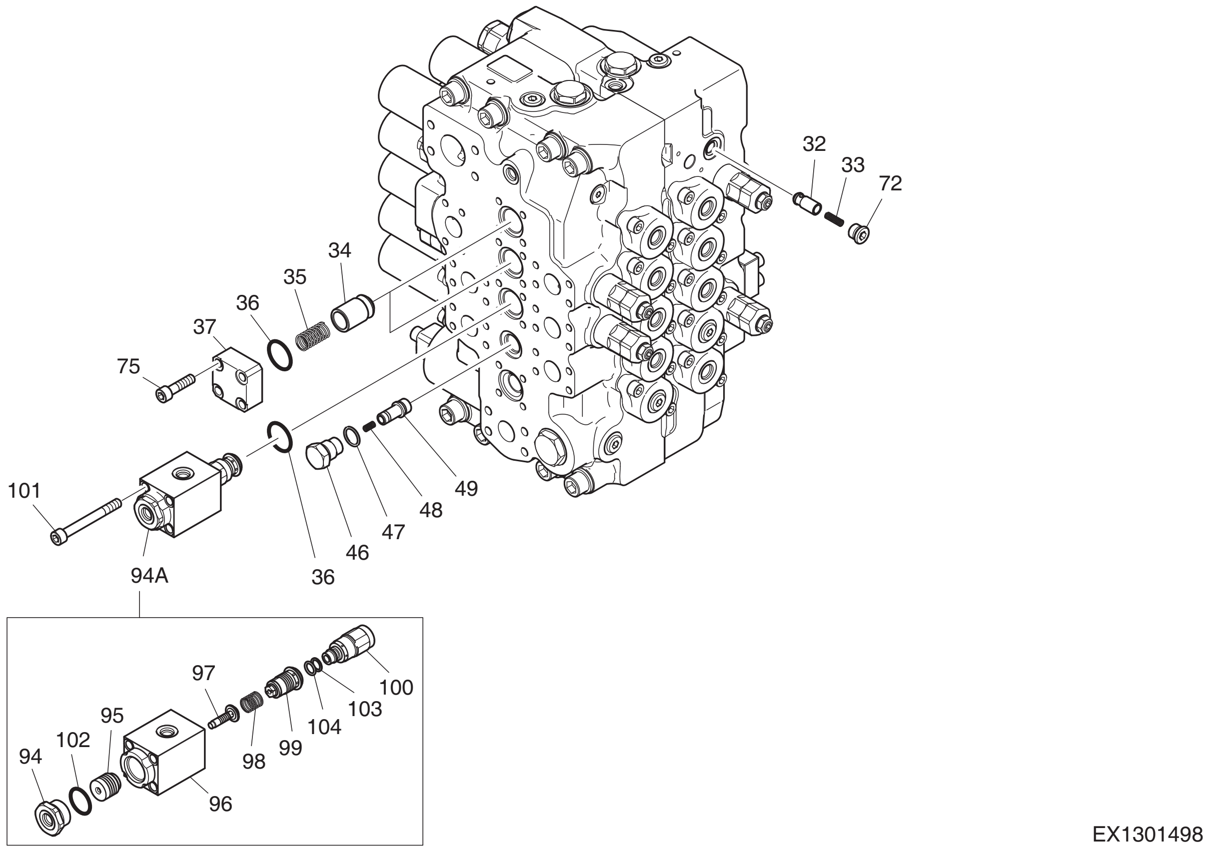


Figure 86

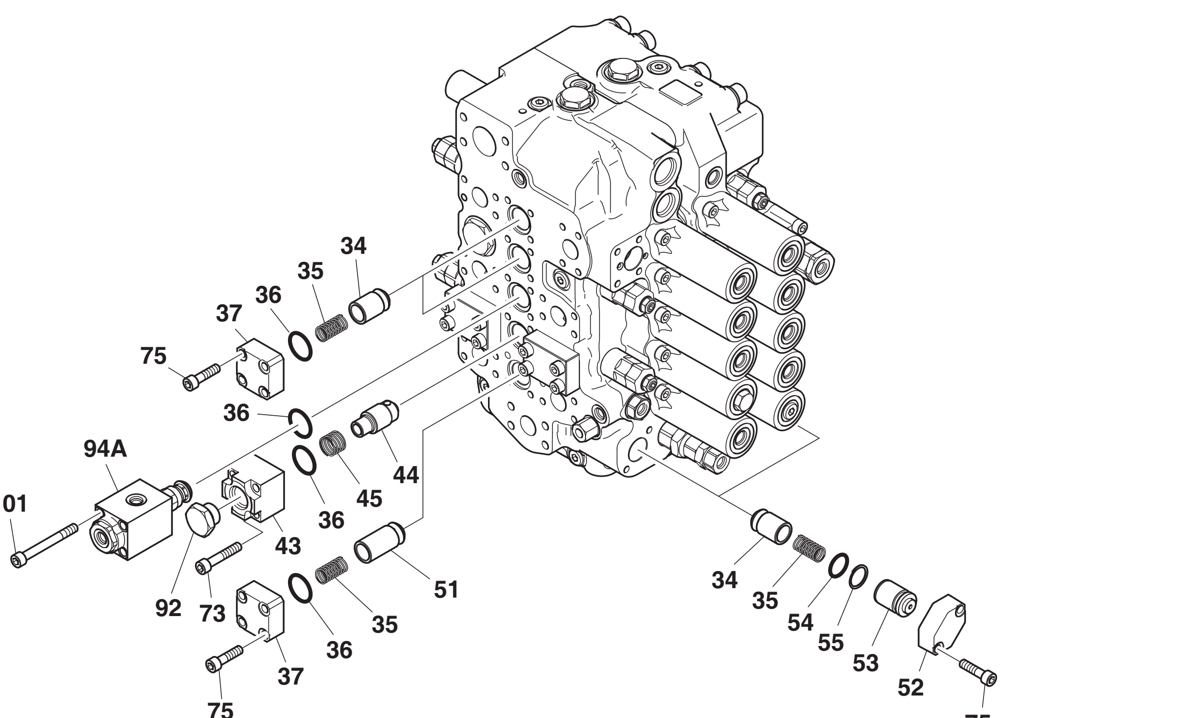


Figure 87

1. Install O-ring (36) on arm (1 and 2, section D-D), boom (1 and 2, section E-E) and swing section (Section F-F). Install poppet (34) and spring (35). Mount flange (37) and install socket head bolt (75). Tightening torque: 5.91 ~ 6.53 kg.m (43 ~ 47 ft lb). Allen Wrench 8.
2. Install O-ring (36) on travel section (Section H-H). Install poppet (51) and spring (35). Mount flange (37) and install socket head bolt (75). Tightening torque: 6 ~ 6.5 kg.m (43 ~ 47 ft lb). Allen Wrench 8.
3. Install O-ring (36) on travel straight section (Section H-H). Mount flange (37) and install socket head bolt (75). Tightening torque: 6 ~ 6.5 kg.m (43 ~ 47 ft lb).
Allen Wrench 8.
4. Install poppet (34) and spring (35) in common (Section I-I). Insert spacer (53) with O-ring (54) and backup ring (55). Tightening torque: 6 ~ 6.5 kg.m (43 ~ 47 ft lb).
Allen Wrench 8.

IMPORTANT

Be careful of installation position of O-ring and backup ring.

If they are reversed, the O-ring will be damaged and an oil leak can occur.

5. Install O-ring (36) on heel section (Section G-G). Install poppet (44) and spring (45). Mount flange (43) and install socket head bolt (73). Tightening torque: 6 ~ 6.5 kg.m (43 ~ 47 ft lb). Allen Wrench 8.
6. Tighten flange assembly (92) with O-ring. Tightening torque: 21 ~ 23 kg.m (151 ~ 167 ft lb). Wrench 36.
7. Insert poppet (49) and spring (48) in travel section (Section G-G). Install plug (46) with O-ring (47). Tightening torque: 10.91 ~ 11.93 kg.m (79 ~ 86 ft lb). Wrench 27.
8. Grapple section (Section F-F)
   A. Insert piston (95) and O-ring (102) on plug (94) and install in body (96). Tightening torque: 11 ~ 12 kg.m (76 ~ 83 ft lb). Wrench 36.
   B. Insert backup ring (103), O-ring (104), spring (98) and poppet assembly (100) in sleeve (99), and install it to body (96).
   C. Install O-ring (36) in valve housing and fasten body using socket head bolt (101). Tightening torque: 5.91 ~ 6.53 kg.m (43 ~ 47 ft lb). Allen Wrench 8.
9. Insert poppet (32) and spring (33) in arm 1 para turn part (Section C-C). Install plug assembly (72) with O-ring. Tightening torque: 7.44 ~ 8.06 kg.m (54 ~ 58 ft lb).
Allen Wrench 8.

10. Insert poppet (32), spring (33), and spacer (57) in arm 2 para turn part (Section L-L). Install plug assembly (72) with O-ring. Tightening torque: 7.44 ~ 8.06 kg.m (54 ~ 58 ft lb). Allen Wrench 8.

Assembly of Antidrift Valve

1. Install O-rings (41 and 42) on surfaces of antidrift valve assembly of arm 1 section (Section D-D) and boom 1 section (Section E-E).
2. Insert poppet (38) and spring (39). Install spacer assembly (40) with O-ring and backup ring.

IMPORTANT

Be careful of installation position of O-ring and backup ring.

If they are reversed, the O-ring will be damaged and an oil leak can occur.

Check installing of O-ring (40-4) on spacer assembly and be careful of installation direction.

3. Install antidrift valve assembly (67, two places) and socket head bolt. Tightening torque: 3.98 ~ 4.49 kg.m (29 ~ 32 ft lb). Allen Wrench 8.

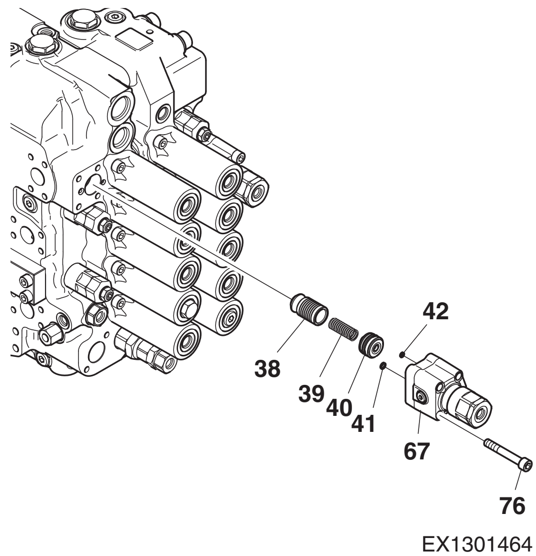


Figure 88

Assembly of Arm Regeneration Release Valve

1. Install O-ring (30) and backup ring (31, two places) on spool assembly (27).
2. Install piston (29) and spool (27) in sleeve. Insert sleeve in valve housing.
3. Install O-ring (25) on plug (27), insert spring (26) and install it in valve housing. Tightening torque: 11 ~ 12 kg.m (76 ~ 83 ft lb). Wrench 32.

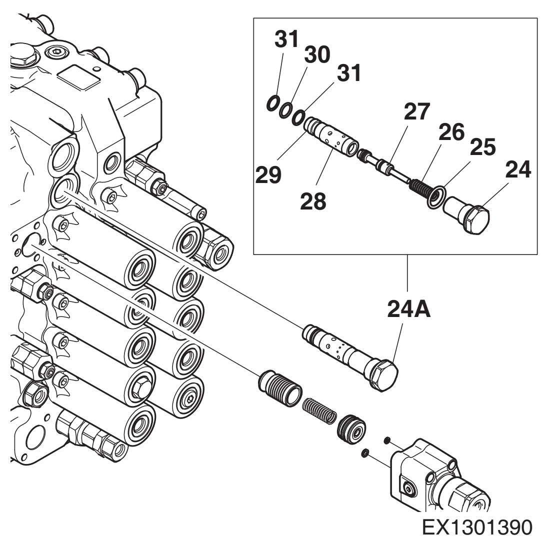


Figure 89

Assembly of Arm 1 Para-turn Spool

1. Install spool subassembly (19A) into valve housing.

IMPORTANT

After inserting spool, check to see if it slides easily.

2. Install O-ring (23) on cap (18) and fasten it in place with socket head bolt (78). Tightening torque: 0.90 ~ 1.10 kg.m (6.49 ~ 7.97 ft lb). Allen Wrench 5.

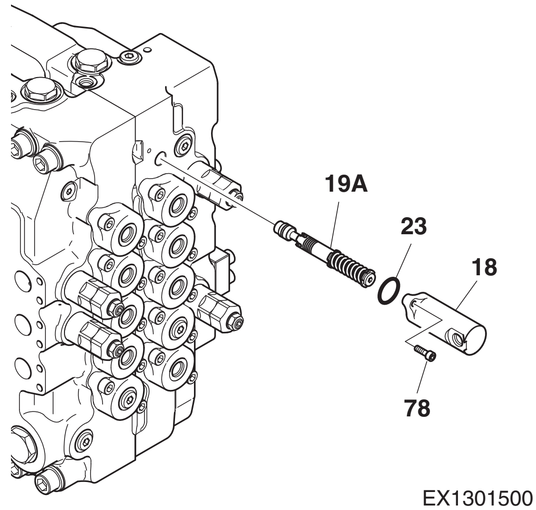


Figure 90

Assembly of Main Spool

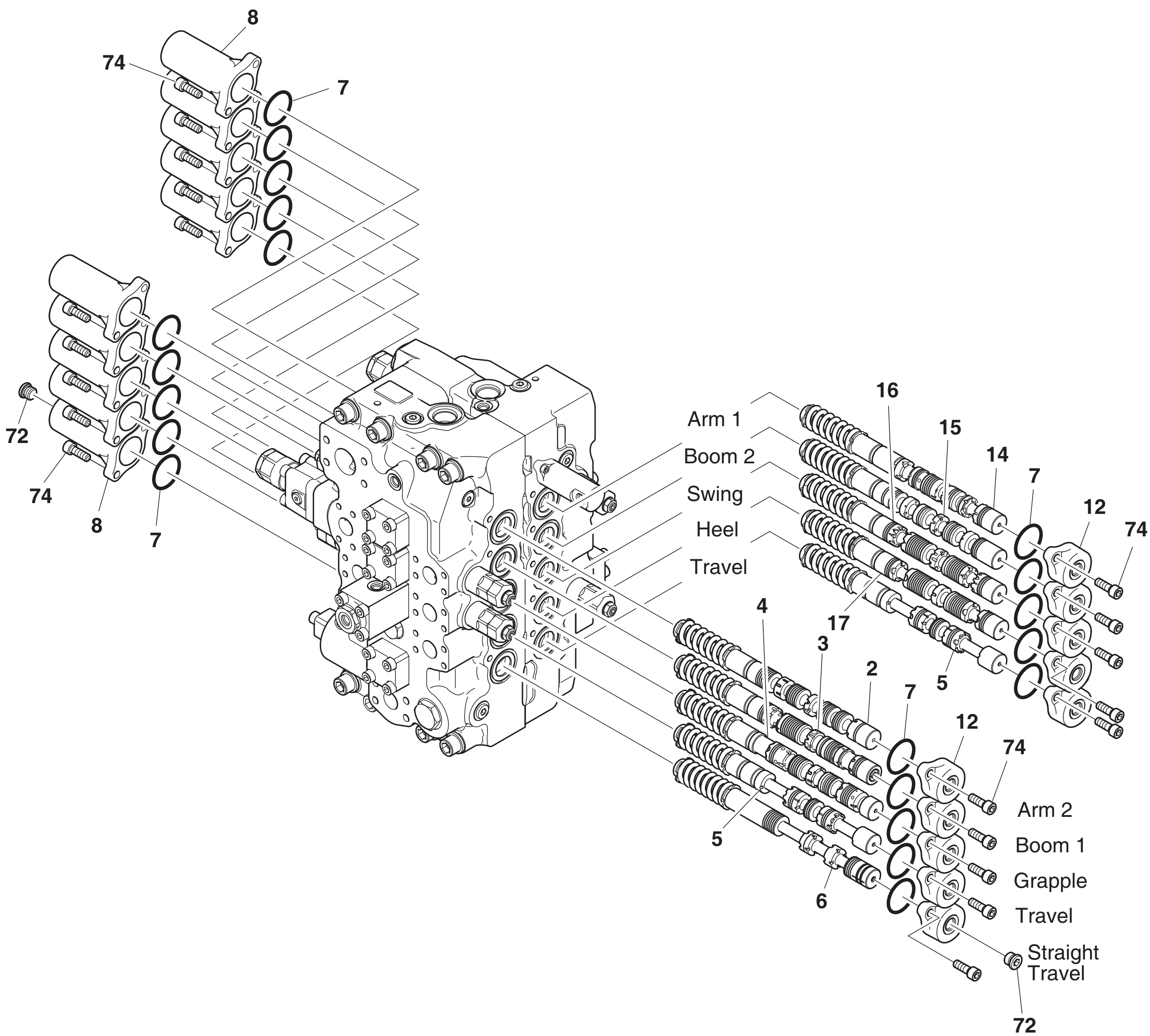


Figure 91

1. Install O-ring (7, twenty places) on mating surface of valve housing cap.
2. Install spool of subassembly condition (2-6 and 14-17) in same positions that they were remove from during disassembly

IMPORTANT

Align spool with hole and insert it slowly.

After inserting spool, check to see if it slides easily.

If spool is inserted when it is in a poor operating condition with a scratch, it can cause a improper operation of the spool.

3. Install cap (12, ten places) and fasten it in place with socket head bolt (74). Tightening torque: 3.98 ~ 4.49 kg.m (29 ~ 32 ft lb). Allen Wrench 8.
4. Install cap (8, ten places) and fasten it in place with socket head bolt (74). Tightening torque: 3.98 ~ 4.49 kg.m (29 ~ 32 ft lb). Allen Wrench 8.
5. Install O-ring on plug assembly (72) and tighten it to two sides of cap of travel straight section (Section H-H). Tightening torque: 3.98 ~ 4.49 kg.m (29 ~ 32 ft lb).
   Allen Wrench 8.

IMPORTANT

When tightening plug to cap, be careful not to over tighten. If it is over tighten, threads of cap can be damaged.

Assembly of Other Plugs

1. Install O-ring on plug assembly (60) and install. Tightening torque: 11 ~ 12 kg.m (76 ~ 83 ft lb). Wrench 27.
2. Install O-ring (62) on plug assembly (61) and install. Tightening torque: 4 ~ 4.5 kg.m (29 ~ 32 ft lb). Wrench 22.
3. Tighten orifice plug (63). Tightening torque: 1.4 ~ 1.8 kg.m (10 ~ 13 ft lb). Allen Wrench 5.
4. Install O-ring on plug assembly (92) and install. Tightening torque: 21 ~ 23 kg.m (151 ~ 167 ft lb). Wrench 36.
5. Install O-ring on plug assembly (71) and install. Tightening torque: 1.4 ~ 1.8 kg.m (10 ~ 13 ft lb). Allen Wrench 6.
6. Install O-ring on plug assembly (72) and install. Tightening torque: 7.5 ~ 8 kg.m (54 ~ 58 ft lb). Allen Wrench 8.

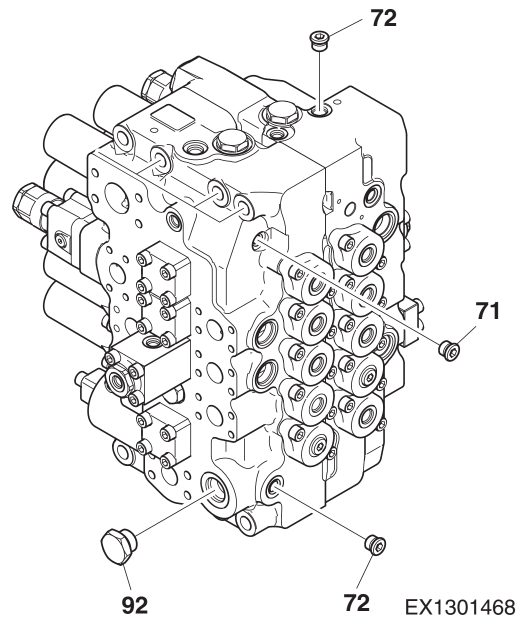


Figure 92

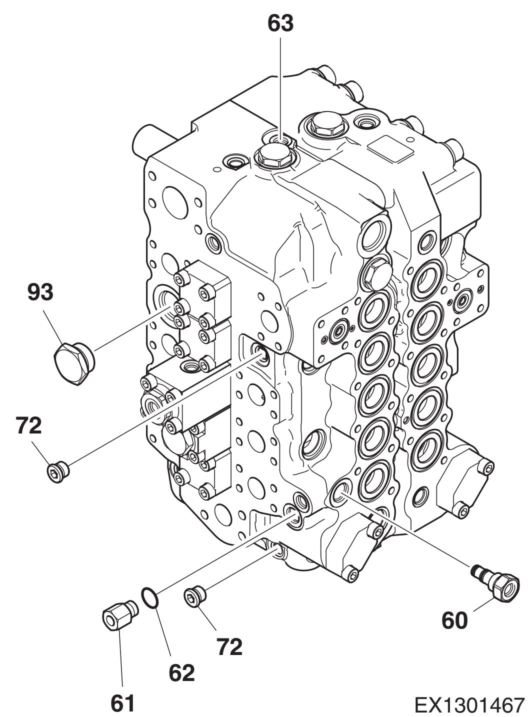


Figure 93

Maintenance of Relief Valves

Reassembly of Main Relief Valve

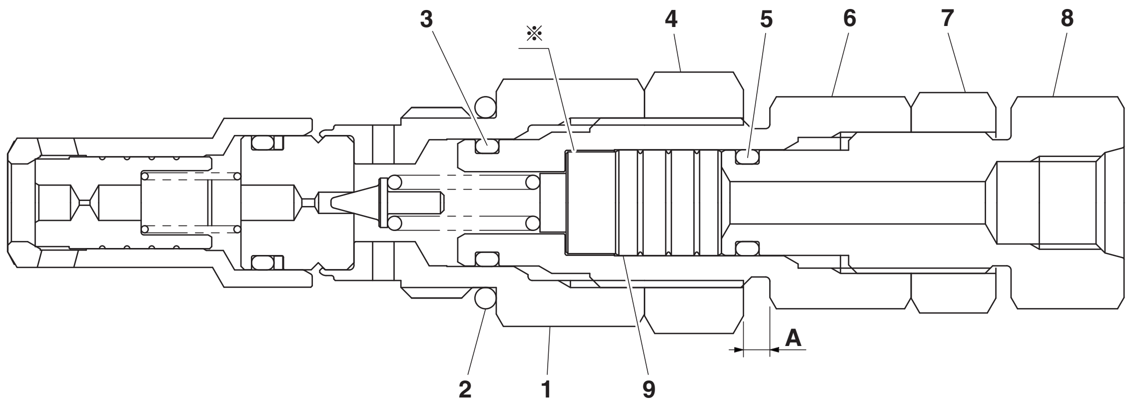


Figure 94

1. Check if there is dirt and paint chips around threads of plug (1, 6 and 8) and nut (4 and 7). Replace O-ring with new one. Clean installation portion of relief valve and valve housing. Install valve, and then tighten plug (1, width across flats: 32 mm). Tightening torque: 7.95 ~ 8.97 kg.m (58 ~ 65 ft lb). Wrench 32.

   NOTE: *The torque values are based on use of lubricated threads.*

   NOTE: *If relief valve was disassembled, adjust pressure by referring to "Adjustment of Valves" on page -91.*

Reassembly of Overload Relief Valve (69, Total of 8 Places)

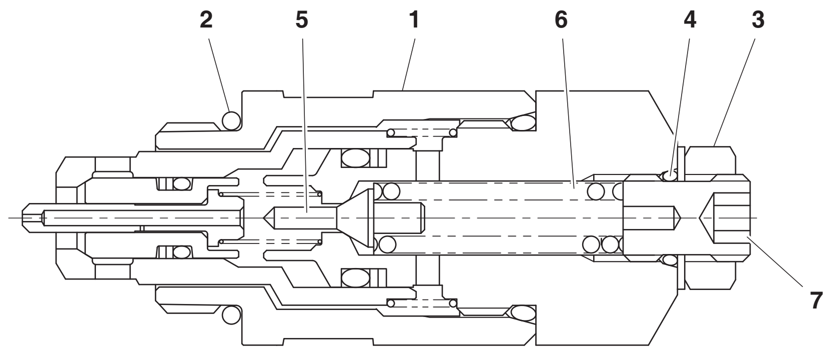


Figure 95

1. Check if there is dirt and paint chips around cap (1). Replace O-ring with new one. Clean installation portion of relief valve and valve housing. Install relief valve and tighten cap (1). Torque: 7.95 ~ 8.97 kg.m (58 ~ 65 ft lb). Wrench 32.

   NOTE: *The torque values are based on use of lubricated threads.*

   NOTE: *If relief valve was disassembled, adjust pressure by referring to "Adjustment of Valves" on page -93.*

CAUTION

AVOID INJURY

In the event of disassembling the adjustment kit, be careful for popping out of parts by the spring or the loss of the poppet.

Reassembly of Low-pressure Relief Valve (70, Total of 2 Places)

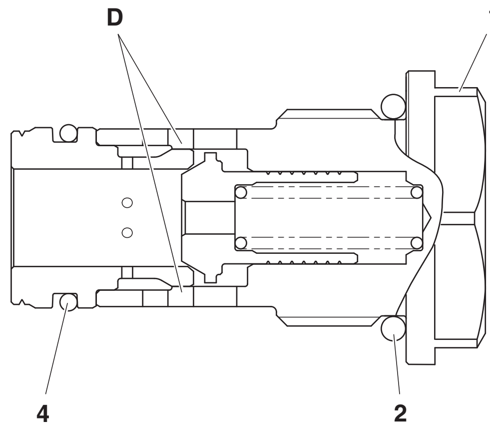


Figure 96

1. Check if there is dirt and paint chips around plug (1). Replace O-ring (3) with new one. Install new O-ring (4) on sleeve (2). Clean installation portion of relief valve and valve housing. Tighten plug (1, width across flats: 32 mm) of relief valve. Torque: 11 ~ 12 kg.m (76 ~ 83 ft lb). Wrench 32.

   NOTE: *The torque values are based on use of lubricated threads.*

IMPORTANT

Torque values must be measured when using lubricated threads.

TROUBLESHOOTING, TESTING AND ADJUSTMENT

Troubleshooting

Overall Control Valve

Problem	Possible Cause	Remedy
Spool does not move.	Oil temperature is abnormally increased.	Remove part with resistance of oil leakage within pipeline.
	Pollution of operation oil.	Replace operation oil and wash circuit at same time.
	Overly tighten pipe port joint.	Check Torque.
	Valve housing is skewed in loading.	Loosen and confirm loading bolt.
	Pressure is too high.	Check pressure of pump and cylinder port.
	Spool is bent.	Replace valve assembly.
	Return spring is damaged.	Replace damaged part.
	Spring or cap is not in line.	Loosen cap to release load.
	The temperature distribution in valve is inconsistent.	Warm up entire circuit.
	The valve is clogged by dust.	Remove (flushing) dust.
	The pilot pressure is insufficient.	Check pilot valve and pilot relief pressure.
Load is not maintained.	Oil is leaking from cylinder.	Check chamber part of cylinder.
	Oil is bypassed from spool.	Check groove of spool.
	Oil is leaking from overload relief valve.	Wash valve housing seat part and relief valve seat part.
	Oil is leaking from antidrift valve.	Disintegrate antidrift valve and wash seat part of each part. In event there is grooves on seat part, replace poppet or wrap poppet and seat part. In event of having malfunction in antidrift valve spool, spool and sleeve make pair that both shall be replaced.
When spool is shifted to up position from neutral, load is dropped.	The load check valve has dust.	Disintegrate check valve and wash.
	The poppet or seat part of check value has groove.	Replace poppet or wrap poppet and seat part.

Relief Valve

Problem	Possible Cause	Remedy
Press does not increase.	Main poppet, sleeve or pilot poppet are stuck open and valve seat part has dust.	Replace relief valve.
Unstable relief pressure.	The seat part of pilot poppet has groove.	
	Piston or main poppet gets stuck.	
Abnormal relief pressure.	Abrasion of seat part by dust.	
	Locking screw and adjustment equipment are loosened.	Reset pressure and tighten locking screw with regular Torque.
Oil leakage.	Damage to relief valve seat part.	Replace relief valve.
	Each part is stuck with dust.	
	The O-ring is worn out.	Replace adjustment equipment or O-ring of loading part.

Overall Oil Pressure

Problem	Possible Cause	Remedy
Oil pressure condition is bad or not operate at all.	Breakdown of pump.	Check pressure or replace pump.
	Breakdown of relief valve.	Replace relief valve.
	Breakdown of cylinders.	Repair or replace.
	Pump load pressure is significant.	Check circuit pressure.
	Valve has crevice.	Replace valve assembly.
	Spool does not make full stroke.	Check operation of spool.
	Tank surface is too low.	Add operation oil.
	Filter in circuit is clogged.	Wash or replace filter.
	Circuit pipeline is tightened.	Check pipeline.

Adjustment of Valves

Main Relief Valve

No.	Item	Tool	Torque
4	Locknut	Wrench 36	
7	Locknut	Wrench 30	
6	Plug	Wrench 27	2 kg.m
8	Plug	Wrench 27	

1. Connect an accurate pressure gauge to inlet port.
2. Start engine and maintain rated pump speed.
3. Shift control valve spool and read pressure gauge from stroke end of cylinder.

   NOTE: *Shift a spool that actuator pressure setting of the overload relief valve is higher than the pressure of the main relief valve.*
4. High-pressure adjustment (1st stage).
   - A. Loosen locknut (7) and tighten plug (8) until piston contacts step (* mark) of plug (6). Plug (8) must be torque below 2.0 kg.m (15 ft lb). While plug (8) is tightened, plug (6) should not be turned. Distance A must be more than 4.0 mm (0.16 in). Tighten locknut (7).
   - B. Loosen locknut (4) and turn adjusting plug (6) clockwise to raise relief pressure of preceding step. Turn adjusting plug (6) counterclockwise to lower relief pressure. One turn varies pressure by approximately 28.4 MPa (284 bar (4,120 psi)). Tighten locknut (4) after pressure has been adjusted.
5. Low-pressure adjustment (second stage)
   - A. Loosen locknut (7) and turn adjusting plug (8) counterclockwise to lower relief pressure at state of 4. One turn varies pressure by approximately 21.3 MPa (213 bar (3,090 psi)). Tighten locknut (7) after pressure has been adjusted.
6. Recheck pressure setting by raising pressure once more.

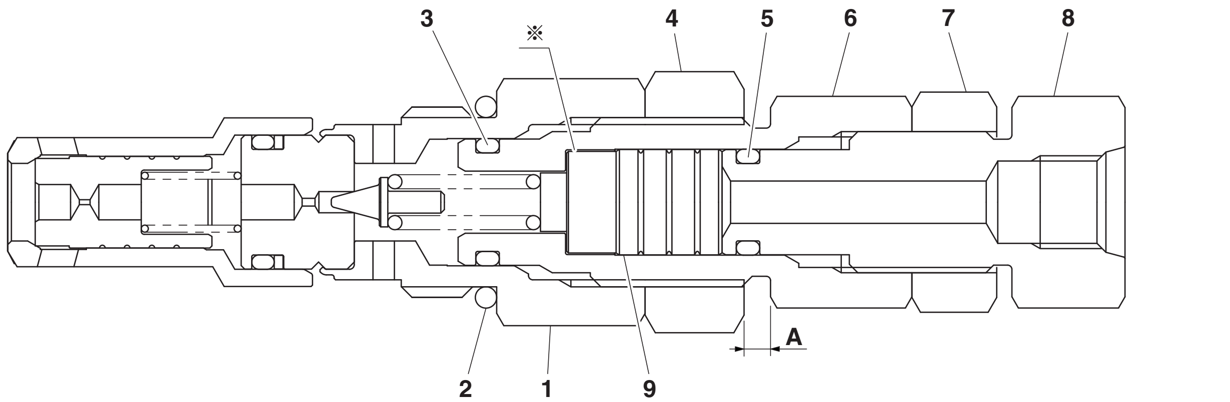


Figure 97

Reference Number	Description
1	Plug
2	O-ring
3	O-ring
4	Hex Nut
5	O-ring

Reference Number	Description
6	Plug
7	Hex Nut
8	Plug
9	Piston

Overload Relief Valve

No.	Item	Tool
3	Locknut	Wrench 17
7	Adjuster	Allen Wrench 14

IMPORTANT

If pressure of main relief valve is higher than the specified pressure for it, change main relief valve assembly setting without adjusting overload relief valve.

1. Shift control valve spool and read pressure gauge from stroke end of cylinder.
2. Loosen locknut (3) and turn adjusting plug clockwise to raise pressure. Item number (69: six places). One turn varies pressure by approximately 21.2 MPa (212 bar (3,075 psi)).
3. Tighten locknut (3) after pressure has been adjusted. Locknut (3) must be torqued to 2.8 ~ 3.2 kg.m (20 ~ 23 ft lb).
4. Recheck pressure setting by raising pressure once more.

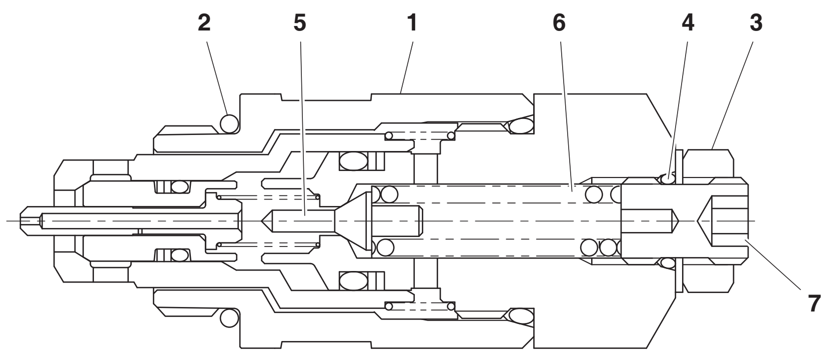


Figure 98

Reference Number	Description
1	Cap
2	O-ring
3	Locknut
4	O-ring

Reference Number	Description
5	Poppet
6	Spring
7	Adjuster

Swing Device

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Swing Device

GENERAL

Specification

Swing Motor

Type	Axial Piston
Displacement	132 cm^3/rev (0.005 ft^3/rev)
Crossover Relief Valve Setting	294 bar (300 kg/cm^2, 4,267 psi)
Max. Supply Flow	228 L/min (60 U.S. gal)
Motor Shaft Speed	1,725 rpm
Motor Shaft Torque	618 N.m (63 kg.m, 455 ft lb)
Accessory Valves	Swing Reactionless Valve
Weight	60 kg (132 lb)

Swing Reduction Gear

Drive Type	2 - Stage Planetary Gear
Reduction Ratio	21.58
Max. Output Speed	80 rpm
Max. Output Torque	13,336 N.m (1,360 kg.m, 9,819 ft lb)
Weight	181 kg (399 lb)
Oil Volume	5 L (1.3 U.S. gal)

Pinion Gear

Type	Spur Gear
Gear P.C.D	D 156 mm
No. of Teeth	13
Module	12

Parking Brake

Spool Cracking Pressure	12.7 bar (13 kg/cm^2, 185 psi)
Time Delay	5 sec

Overview

Swing device consists of a swing motor, swing reduction gear.

Swing motor includes mechanical parking valve, relief valve, makeup valve and time delay valve.

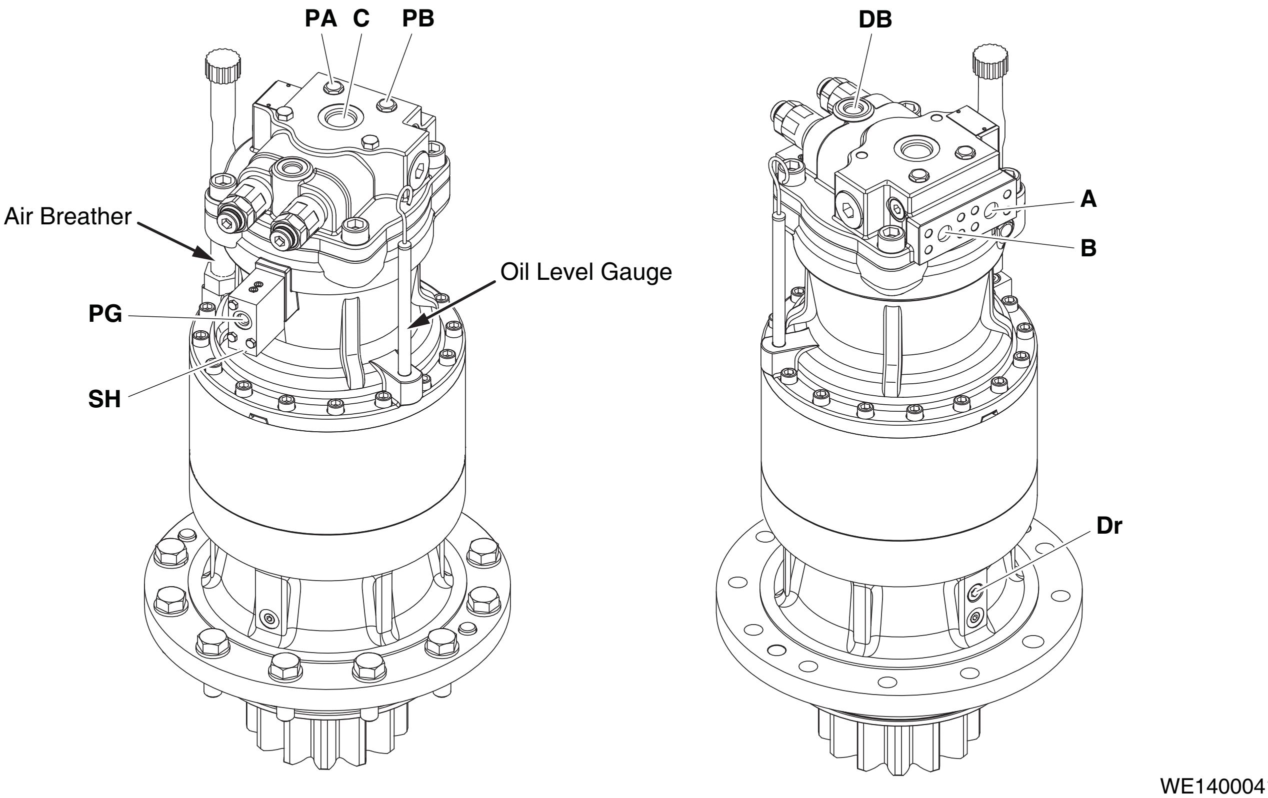


Figure 1

<table>
<tr><th>Port</th><th>Name</th><th>Size</th></tr>
<tr><td>A</td><td>High-pressure (Right)</td><td>22.2 x 47.6 Flange</td></tr>
<tr><td>B</td><td>High-pressure (Left)</td><td>22.2 x 47.6 Flange</td></tr>
<tr><td>C</td><td>Make Up</td><td>PF 1", O-ring</td></tr>
<tr><td>DB</td><td>Motor Drain</td><td>PF 1/2", O-ring</td></tr>
<tr><td>SH</td><td>Brake Signal</td><td rowspan="4">PF 1/4", O-ring</td></tr>
<tr><td>PG</td><td>Brake Release</td></tr>
<tr><td>Pa</td><td>Pressure Gauge</td></tr>
<tr><td>Pb</td><td>Pressure Gauge</td></tr>
<tr><td rowspan="2"></td><td>Air Breather</td><td>PT 1/2"</td></tr>
<tr><td>Oil Level Gauge</td><td>PT 1/4"</td></tr>
<tr><td>Dr</td><td>Oil Drain</td><td>PT 1/2"</td></tr>
</table>

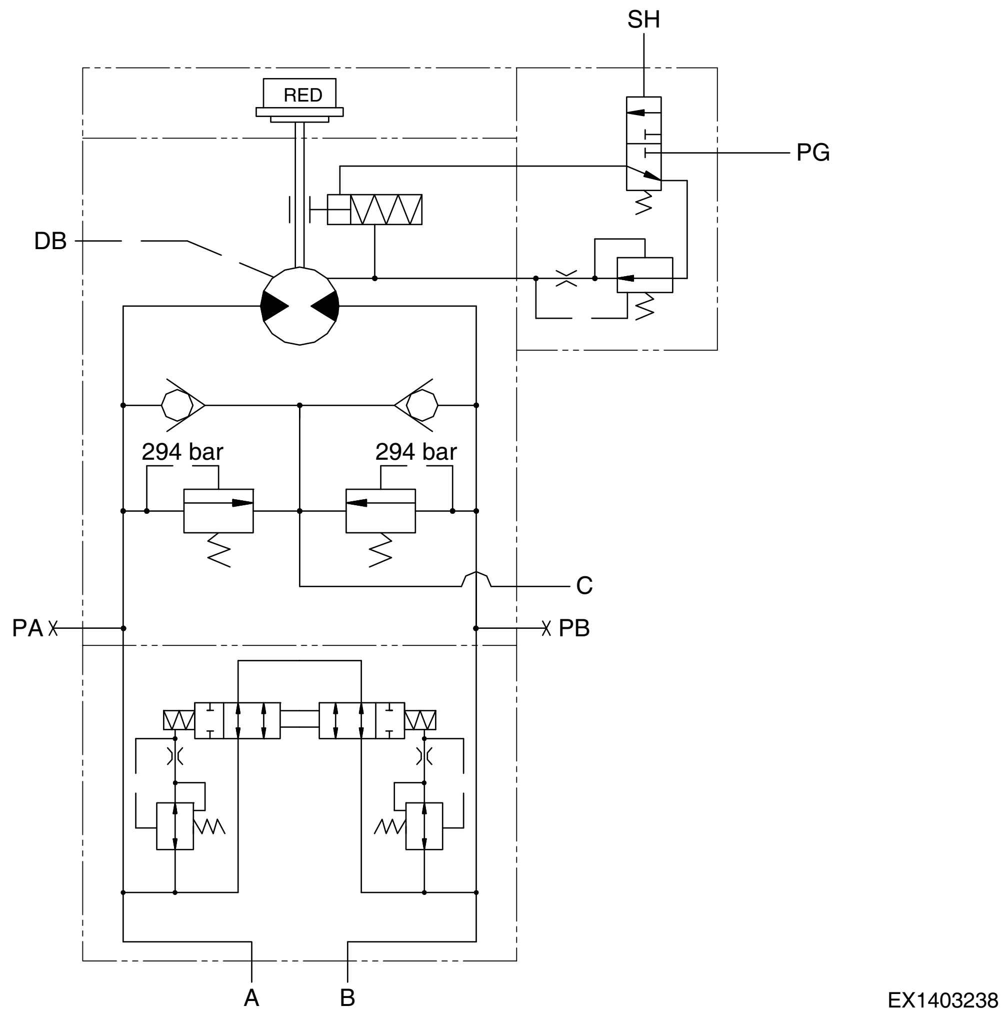


Figure 2

Parts List

Swing Motor

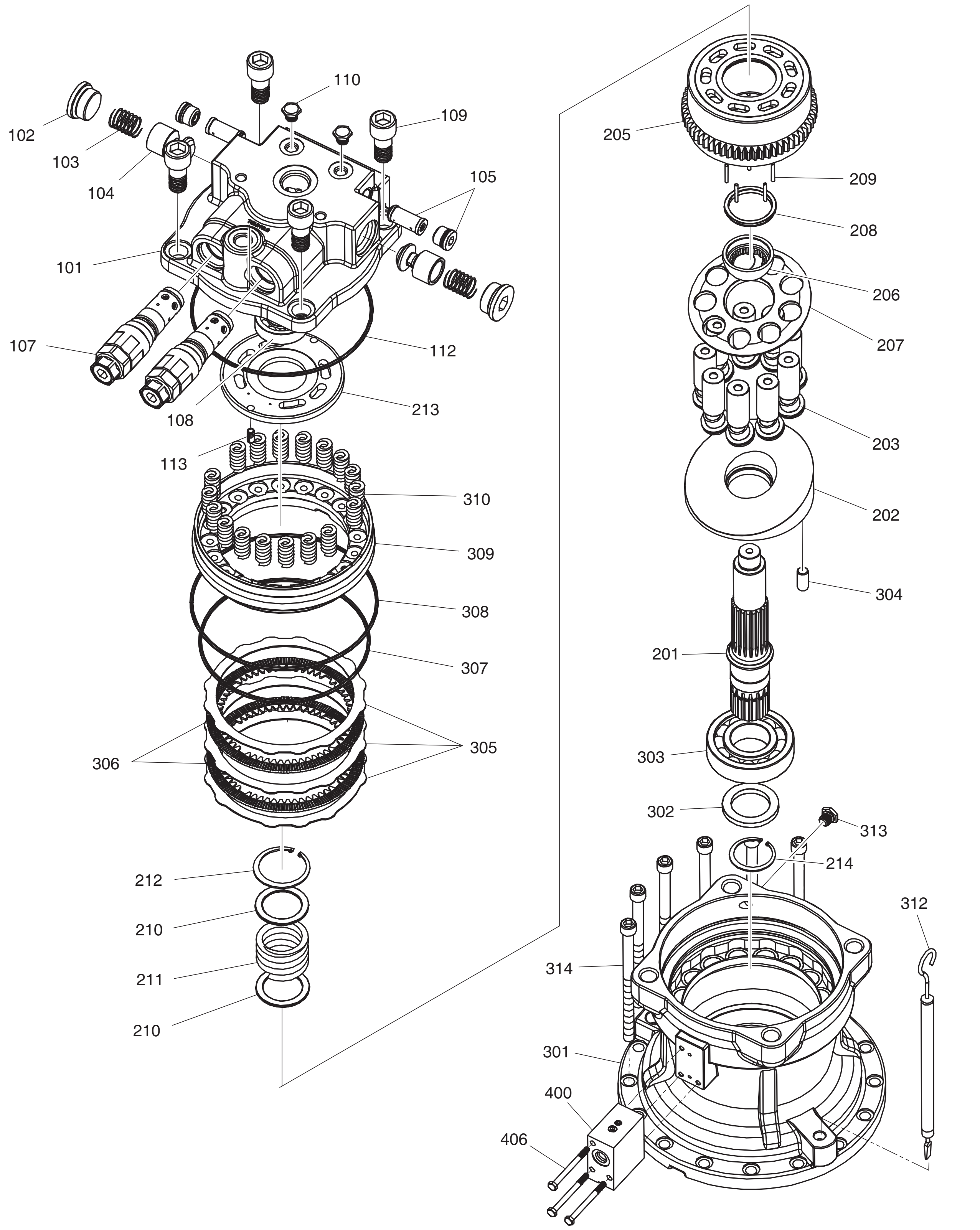


Figure 3

EX1403239

Reference Number	Description
101	Casing Valve
102	Plug
103	Spring
104	Plunger
105	Swing Reactionless Valve
107	Relief Valve
108	Ball Bearing
109	Socket Bolt
110	Plug
112	O-ring
113	Spring Pin
201	Drive Shaft
202	Swash Plate
203	Piston & Shoe Assembly
205	Cylinder Block
206	Thrust Ball
207	Retainer Plate
208	Collar
209	Roller
210	Washer

Reference Number	Description
211	Spring
212	Snap Ring
213	Timing Plate
214	Snap Ring
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
312	Level Gauge Assembly
313	Plug
314	Socket Bolt
400	Brake Valve
406	Hex Bolt
*	Seal Kit

*: 112, 302, 307, 308

Swing Reduction Gear

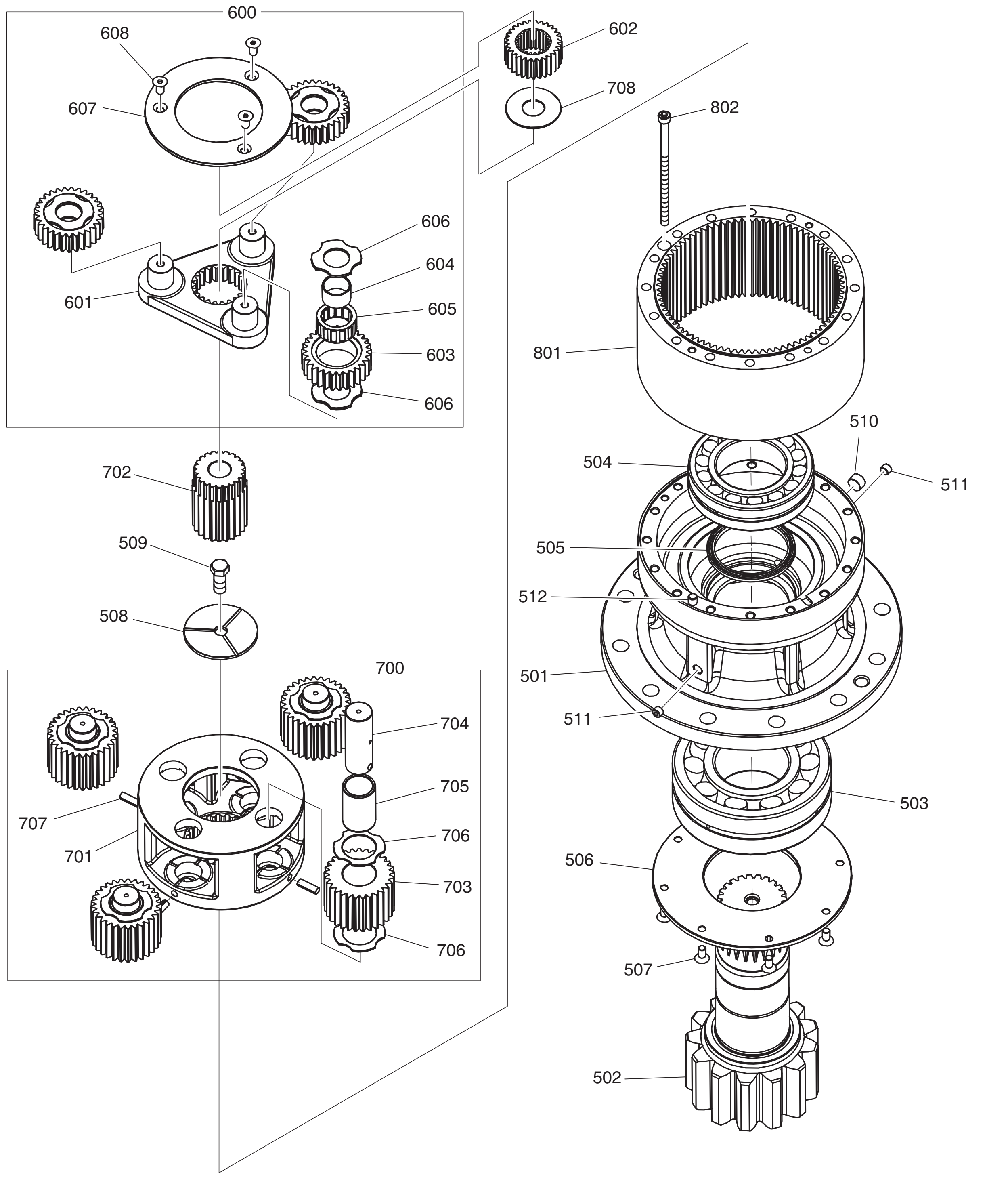


Figure 4

Reference Number	Description
501	Case
502	Pinion Shaft
503	Spherical Roller Bearing
504	Spherical Roller Bearing
505	Oil Seal
506	Cover
507	Screw
508	No.3 Thrust Washer
509	Hex Bolt
510	Plug
511	Plug
512	Pin
600	No.1 Carrier Assembly
601	No.1 Carrier
602	No.1 Sun Gear
603	No.1 Planetary Gear

Reference Number	Description
604	Inner Ring
605	Needle Bearing
606	No.1 Thrust Washer
607	Thrust Plate
608	Screw
700	No.2 Carrier Assembly
701	No.2 Carrier
702	No.2 Sun Gear
703	No.2 Planetary Gear
704	No.2 Pin
705	Bushing
706	No.2 Thrust Washer
707	Spring Pin
708	Thrust Washer
801	Ring Gear
802	Socket Bolt

Swing Device

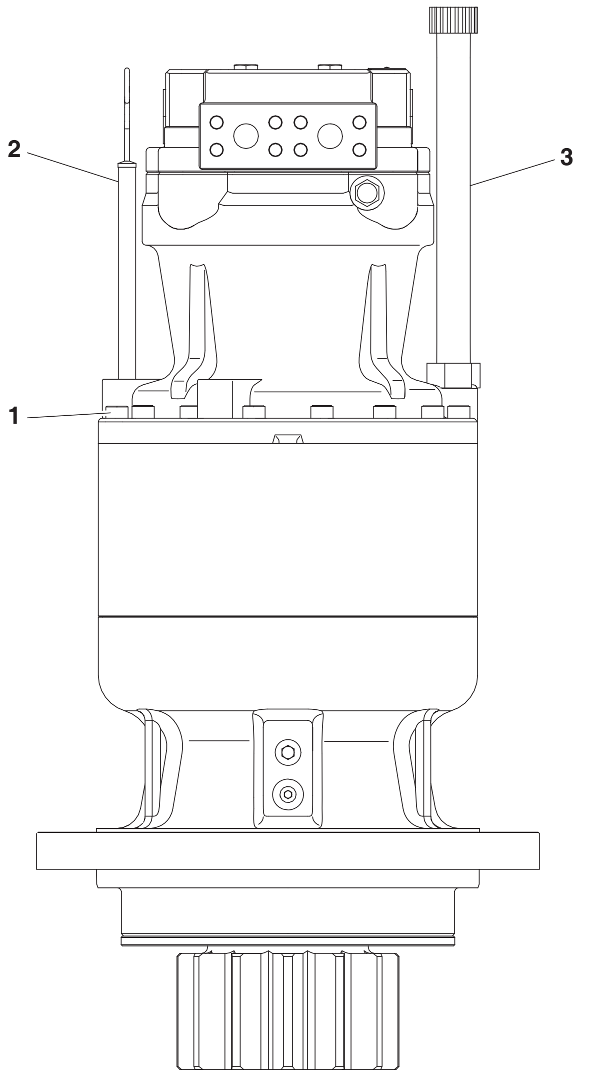


Figure 5

Reference Number	Description
1	Socket Bolt
2	Level Gage Assembly

Reference Number	Description
3	Air Breather Assembly

Theory of Operation

Hydraulic Motor

As shown in the figure below, the high-pressure oil entering the cylinder block through valve plate (112) inlet side port exerts pressure on the piston, generating axial force F. The force F is divided into the two vectors of force F1 which is perpendicular to the swash plate (103) and F2 which is perpendicular to the shaft, with the shoe (104-1) as the medium. With the piston and the medium, the force F2 is transmitted to the cylinder block (108) and generates rotational torque to the output shaft. On the cylinder block, 9 pistons are arranged equidistantly, and rotational torque is transmitted to the output shaft by the multiple pistons connected to the inlet side of the high-pressure oil in consequences.

Reversing the direction of oil flow will reverse the direction of rotation of the output shaft.

Theoretical output torque T is calculated with the formula below;

$$T = \frac{P \times q}{2 \times \pi}$$

P: effective differential pressure (kg/cm^2)

q: volume per rotation (cc/rev)

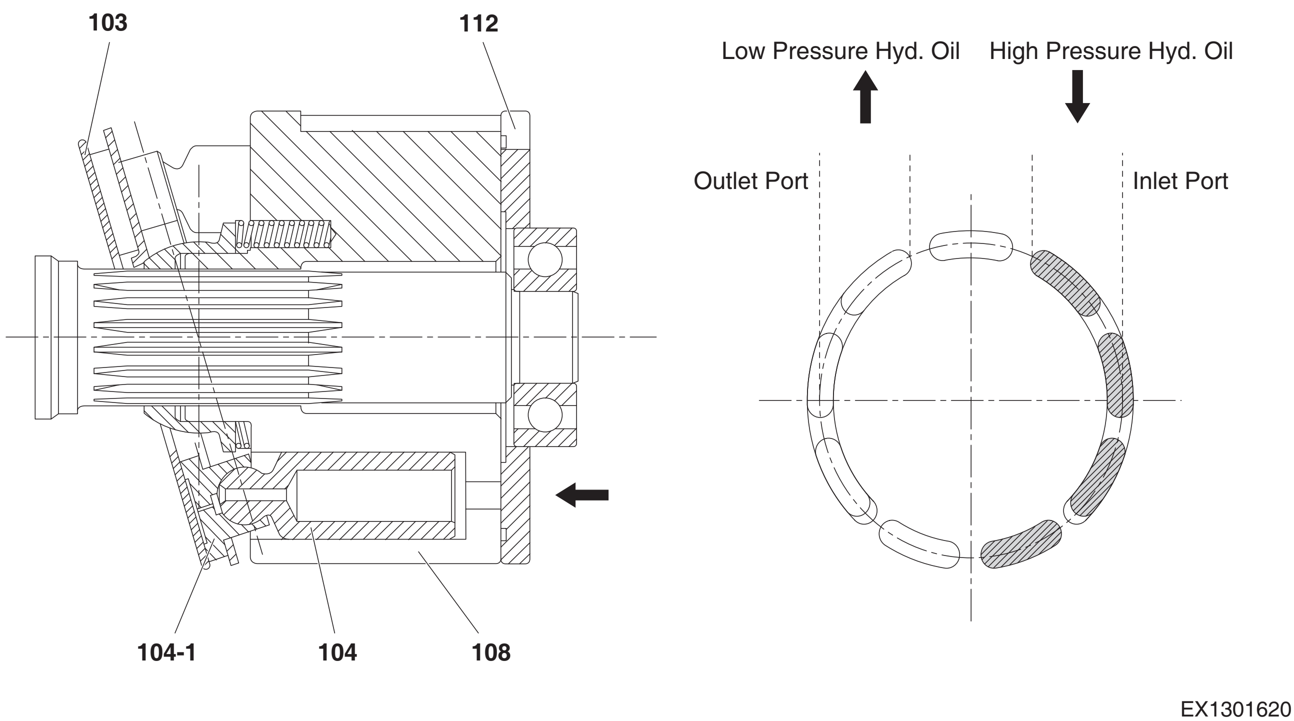


Figure 6 Operation Diagram of Motor

Valve Casing

1. Anticavitation check valve

   This motor has no valve which has counterbalance function, the motor may rotate exceeding the feed oil flow. To prevent cavitation, suck in deficient oil through the check valve.

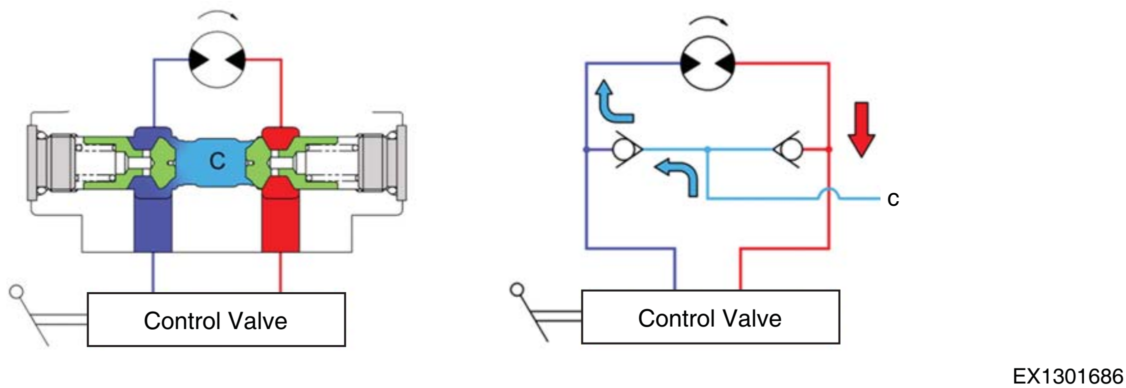


Figure 7

2. Relief valve

   Lets assume that port P is pressurized from the tank pressure. Initially, ports P and R are at tank pressure.

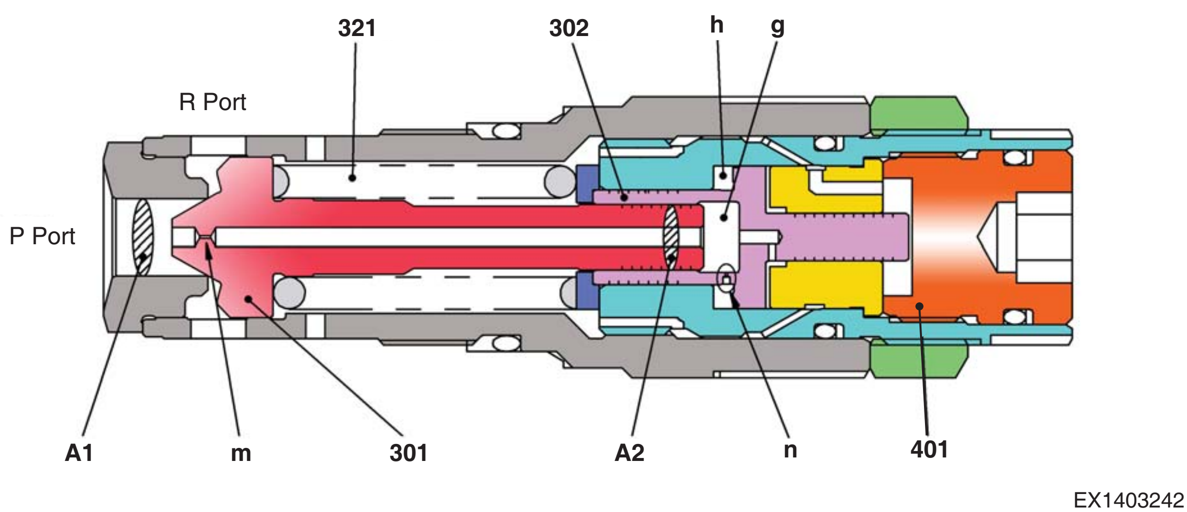


Figure 8

When the two forces; the force defined by the product of the area (A1) of plunger (301) receiving pressure and pressure P1; and the force defined by the product of spring (321) force (Fsp) and pressure-receiving area (A2) of plunger (301) by the pressure Pg in the chamber g; become the same, the relief valve starts to function.

Here, the Pg is the pressure in the chamber g which is pressurized by the oil through the orifice m, and when it reaches the pressure defined by the spring (321) pressing the piston (302), the piston starts to move to the left.

$$P1 \times A1 = F_{sp} + P_g \times A2$$

$$P1 = \frac{F_{sp} + P_g \times A2}{A1}$$

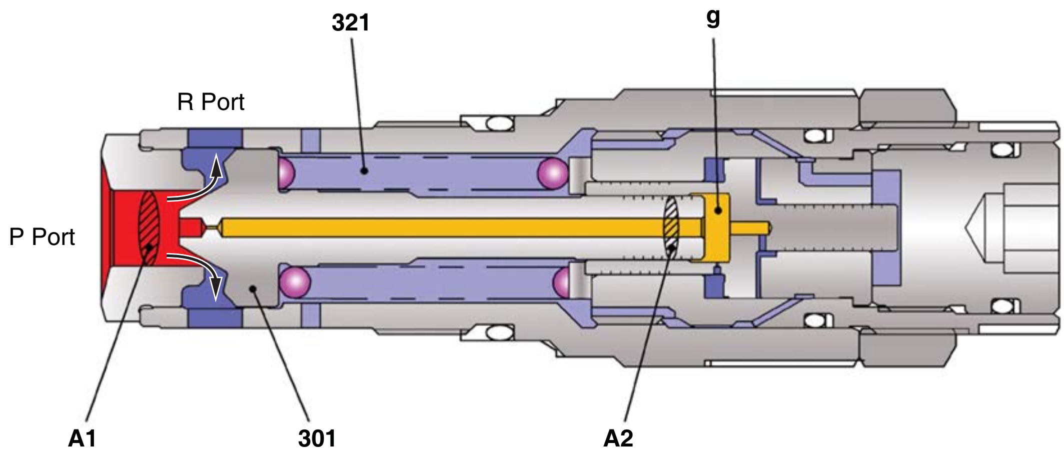


Figure 9

EX1301687

3. Chamber h acts as a damping chamber by the orifice (n) formed on the side of the piston (302).

   By this, the pressure in the chamber g increases smoothly until piston (302) reaches the end of the adjustment plug (401).

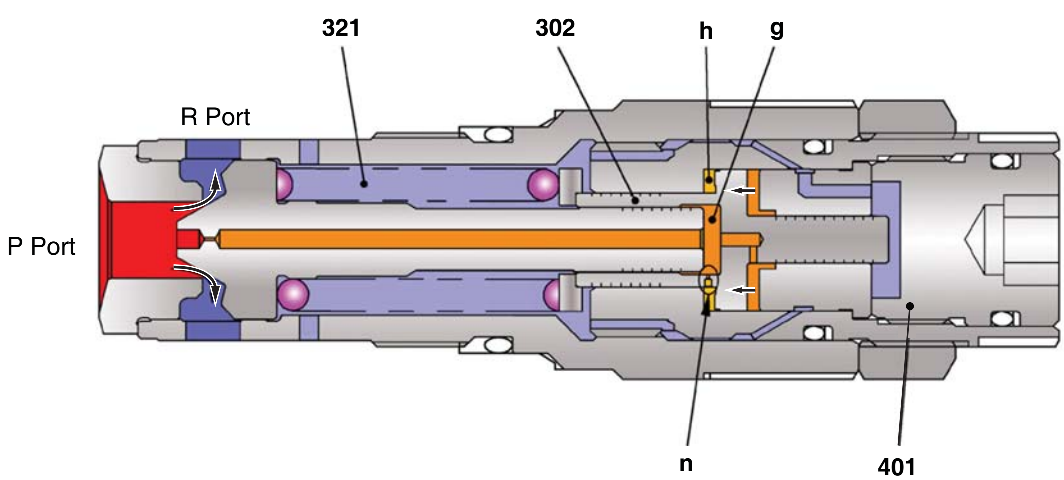


Figure 10

EX1403527

When the piston (302) reaches the end of the adjustment plug (401), it cannot move further to the left, thus, the pressure in chamber g becomes equal to Ps and the force of the spring (321) becomes Fsp' (Figure 11).

Consequently, the pressure P varies as illustrated in (Figure 11).

The pressure Ps at the final stage is expressed with the equation below;

$$P_s \times A1 = F_{sp'} + P_s \times A2$$

$$P_s = \frac{F_{sp'}}{A1 - A2}$$

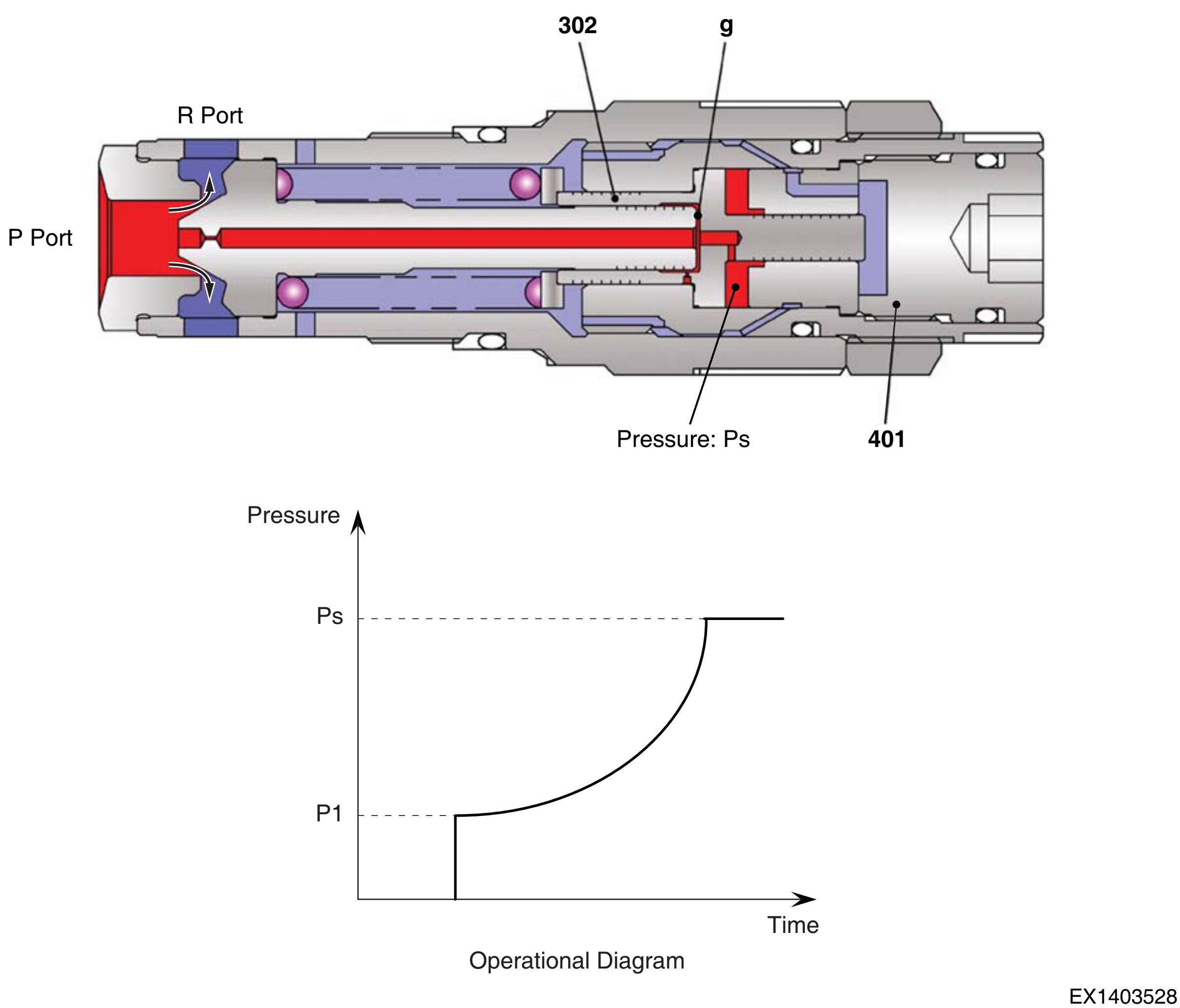


Figure 11 Relief Valve

4. Reactionless valve

When the direction switching valve of swing motor I switched, high-pressure oil is supplied to the port A (or port B) of the hydraulic motor. Then, the poppet of the reactionless valve moves to the right, blocks the bypass route and drives the rotating body (1, Figure 12).

Then, when the direction switching valve returns to neutral position, the ports at both sides of the hydraulic motor are blocked, but the rotating body would maintain its rotation because of inertia and the momentum of inertia is transmitted to the hydraulic motor through the reduction gear, generating brake pressure at the port B (or port A) which stops the rotating body and tries to reverse the direction of rotation.

By this brake pressure, the swing motor first stops and then tries to reverse its direction of rotation and the pressure at the port B tries to switch the poppet to the left, but the action is delayed by the orifice at the port A. Now, a bypass route is formed connecting the ports A and B through which the high-pressure oil flows from port B to the port A (2, Figure 12).

And, the poppet on the port B side moves to the left until it blocks the bypass route (3, Figure 12).

As described above, in the process of reverse pressure generation at the port B, the high-pressure oil is bypassed to the port A to prevent reverse rotation and stop the swing motor right away.

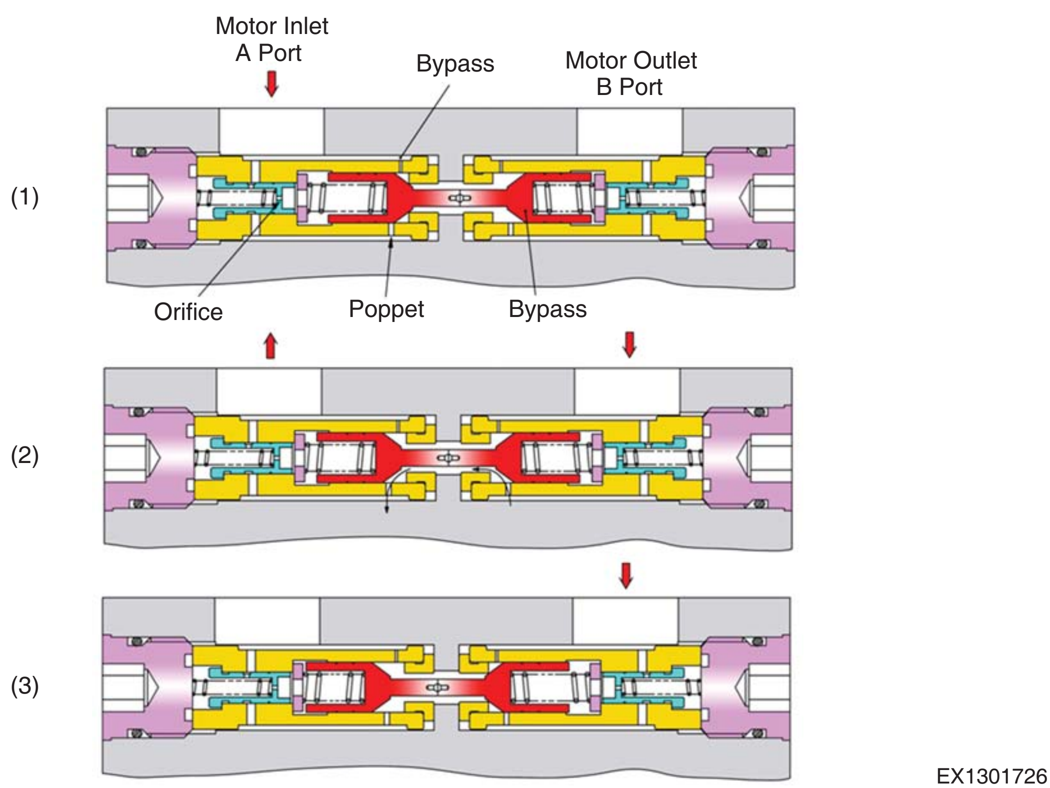


Figure 12 Principle of Operation of Reactionless Valve

Schematic of Operation of Reactionless Valve

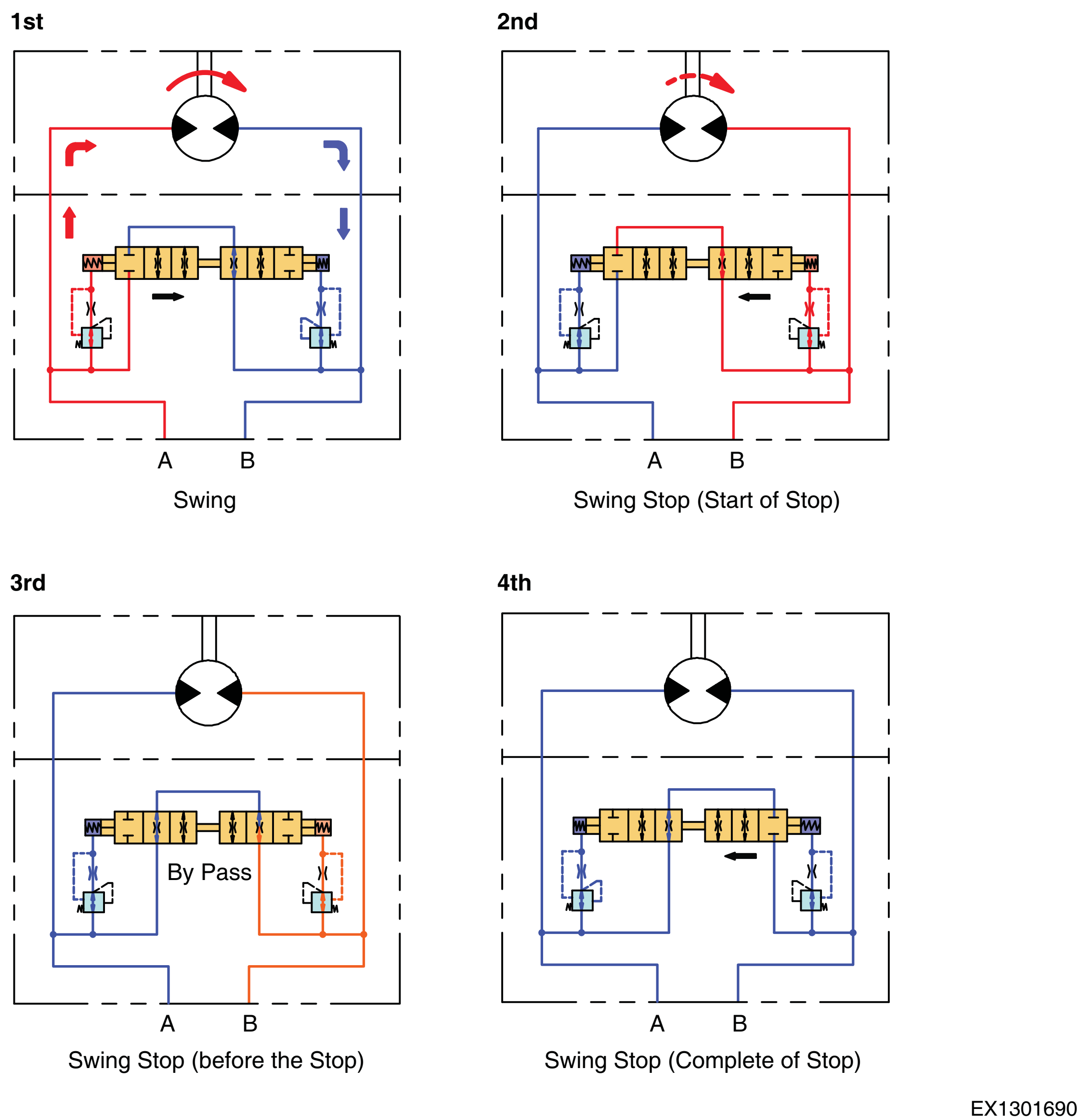


Figure 13

Brake Part

The cylinder block (108) is connected with the driveshaft (102) by spline joint, and rotation of the separation plate (110) in circumferential direction is restricted by the circular arc grooved on the casing (115). When the friction plate (109), engaged with the outer circumference of the cylinder with gears, is pressed to the casing (115) by the brake spring (118) with the separation plate (110) and brake piston (119) as the media. Friction force is generated between the friction plate and casing, separation plate and brake piston. This friction force restricts and brakes the driveshaft.

When brake release pressure is applied to the oil chamber formed between the brake piston and casing and this pressure overcomes the spring force, the brake piston moves and the friction plate is separated from the casing, and the brake is released.

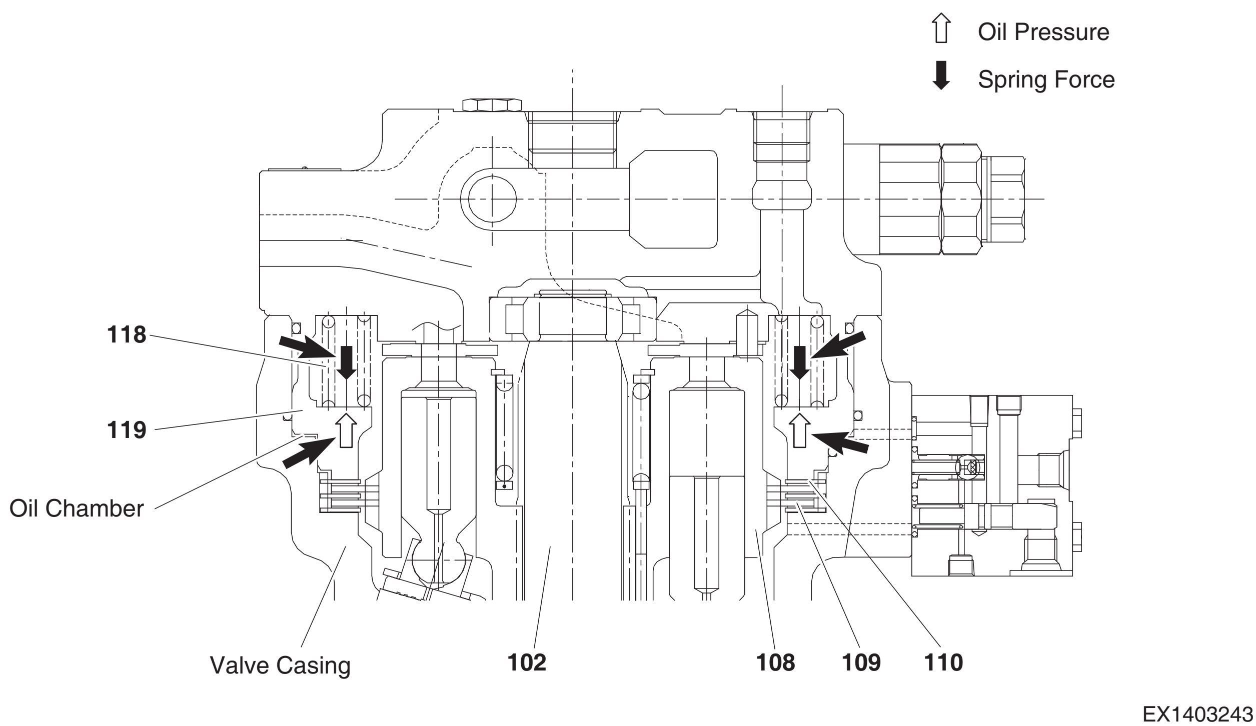


Figure 14 Operation Diagram of Brake

1. Parking brake operating

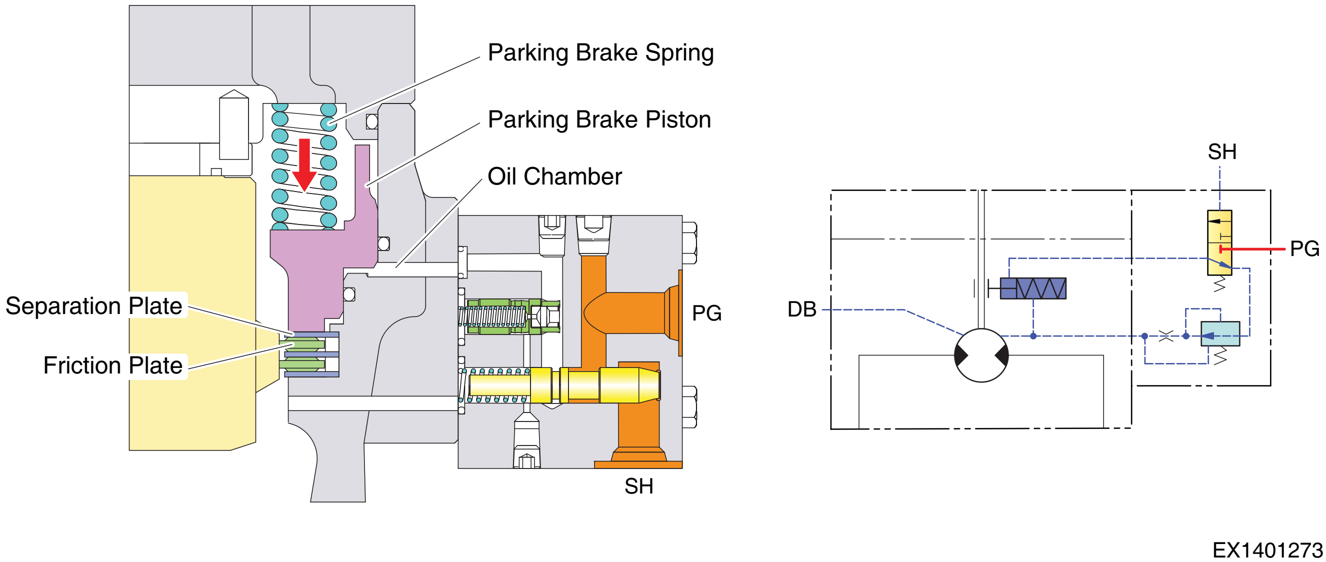


Figure 15

2. Parking brake release

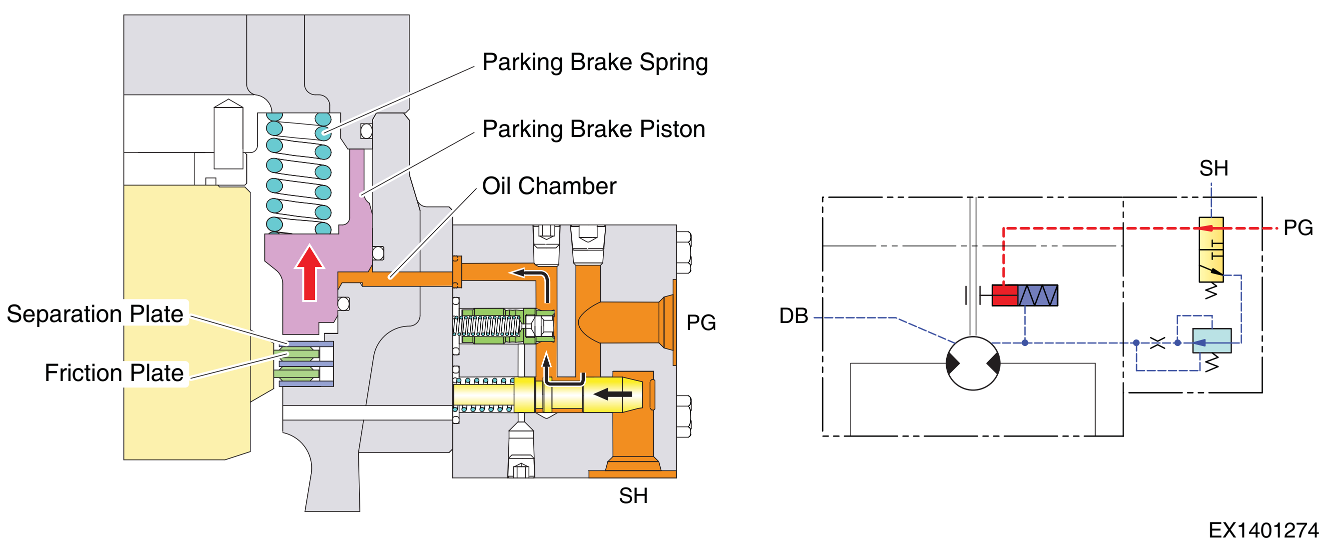


Figure 16

Cautions for Operation

Inspection

Please check the followings before installing a new motor:

1. Check if there is any part damaged or missing (during transportation).
2. Check if there is any loose joint.
3. Check that flange surfaces and the drain port cover are properly assembled and there is no dust or other particle in the motor.

Direction of Rotation

The relationship between the directions of oil flow and shaft rotation is presented in Figure 17 and Table.

The direction of rotation differs by the direction of the slope of casing.

Be careful for the direction of swing which is differentiated by the shape of casing and direction of flange.

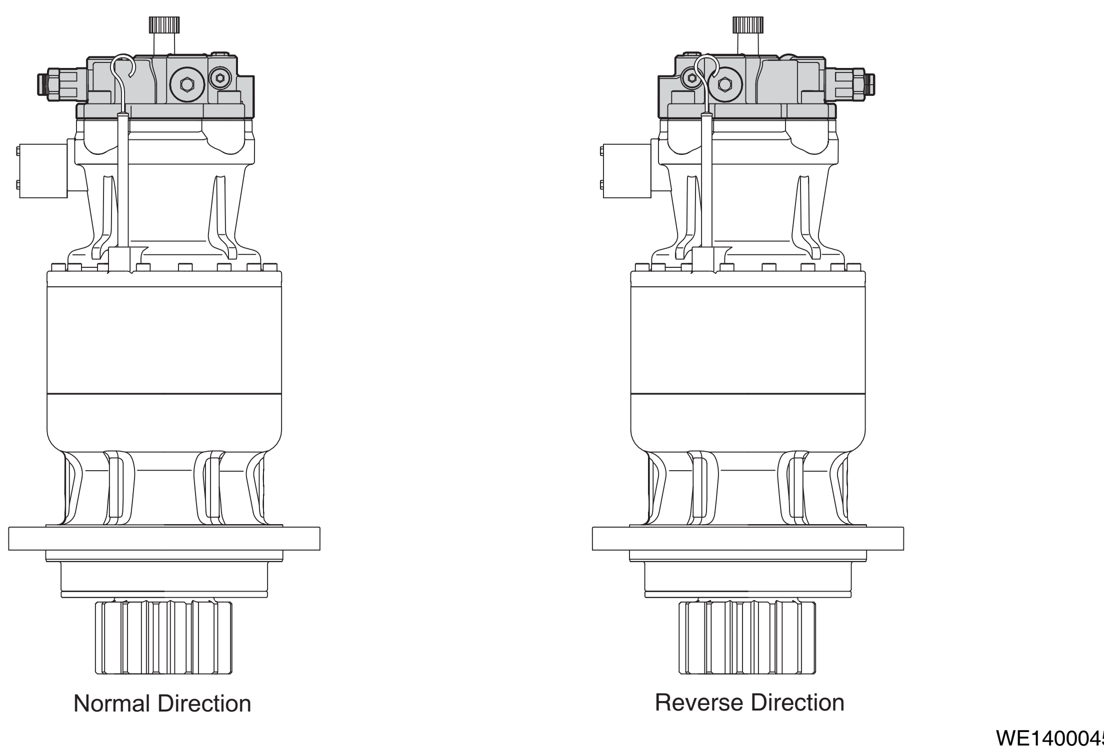


Figure 17

Classification	Inlet	Outlet	Direction of the Rotation of the Shaft Seen at the End of the Shaft
Normal Direction	A	B	Right (Clockwise)
Reverse Direction	B	A	Left (Counterclockwise)

External Load at the End of Shaft

In principle, the end of the motor shaft must be free of any external radial or thrust load.

Hydraulic Oil and Temperature Range

1. Oil type

   The recommended oil is mineral type hydraulic oil added with extreme pressure additive, foam suppressor, antioxidant, and desiccant, having high viscosity index.

2. Optimal viscosity and temperature range of hydraulic oil (Figure 18)

   Maximum viscosity range is 10 - 1000 cSt, however, recommended range is 10 - 200 cSt to obtain optimal efficiency.
   Temperature range is restricted between -25 - 100°C to protect oil seals and O-rings. The highest recommended temperature is 60°C or lower to prevent degeneration of the oil and seals.

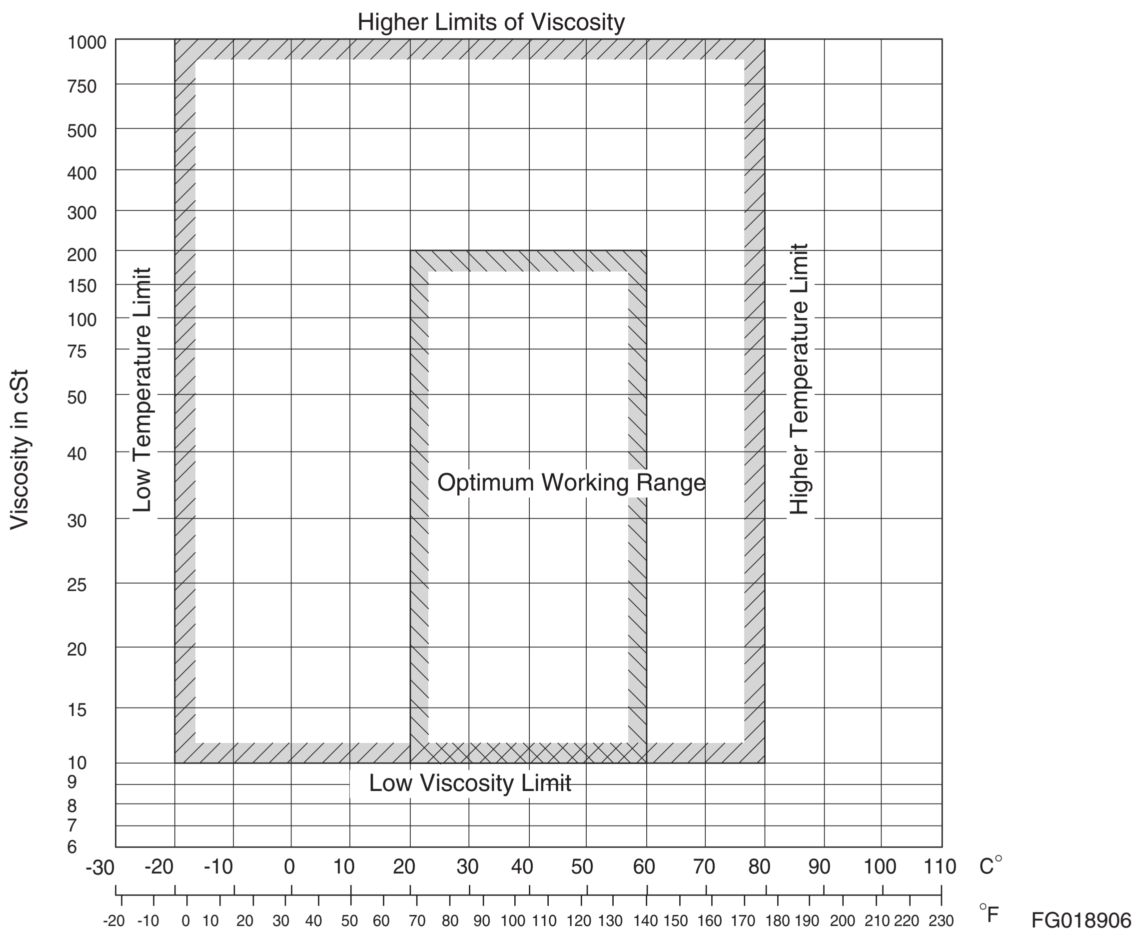


Figure 18 Optimum Viscosity and Temperature Range

3. Other types of oils than mineral oils

   Please contact us to use phosphoric acid ester, water-glycol, or fatty acid ester oils.

Installation and Piping

1. In principle, the motor shaft should face downward.
2. The deviation of centerline from the driven part must be 0.05 mm or less.
3. The tightening torque of the bolts used in mounting the motor to bracket must be according to the specifications on the outline drawings.
4. The casing must be always filled with oil.
   The position of the oil drain of the motor must be as shown in (Figure 19) to allow the casing be full of oil.
5. The maximum allowable pressure in the casing is 2 bar, so 2 bar or less is recommended.
6. Clean the pipeline and perform flushing.
7. Avoid excessive force at pipe joints.

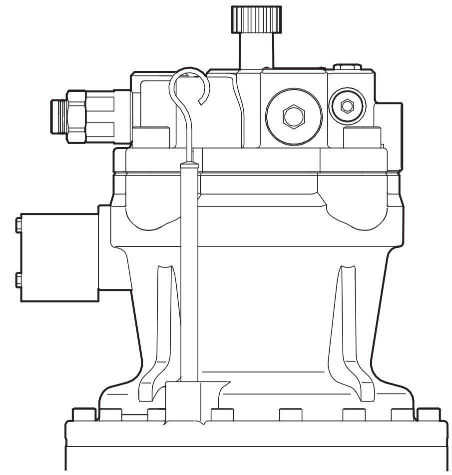
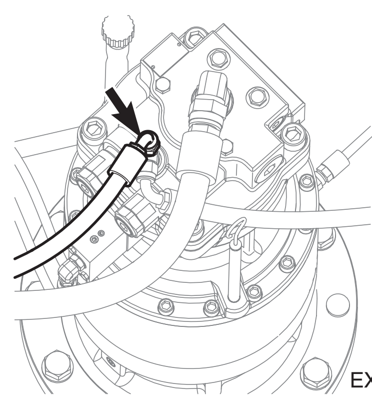


Figure 19 WE1400046

Oil Filling and Air Ventilation

1. starting operation, fill the casing with oil through drain port.

   In the hydraulic motor, there are high-speed sliding motion parts, such as bearing, piston, shoe and spherical bushing. If oil is not fully filled, these sliding parts can cause sticking or damage.
2. Air inside the hydraulic oil circuit or motor can cause malfunction or damage, thus, must be removed completely.



EX1403937

Figure 20

Instructions before Starting to Operate

1. Check if there is any loose joint or other trouble in the pipeline.
2. Check that direction of rotation is correct.
3. Check oil leaks from the hydraulic motor.
4. Check if abnormal vibration occurs during rotation or operating direction switching valve.
5. Check if the oil temperature rise too fast.
6. Check that actual pressure is about the same as the setting value.

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Park the machine on flat level ground.
2. Extend the boom and arm, as shown in Figure 21 and lower the boom until the attachment is 10 cm above the ground.
3. Stop the engine.

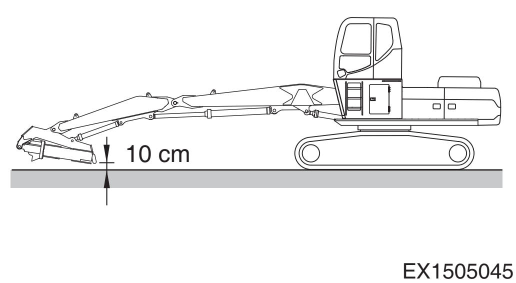


Figure 21

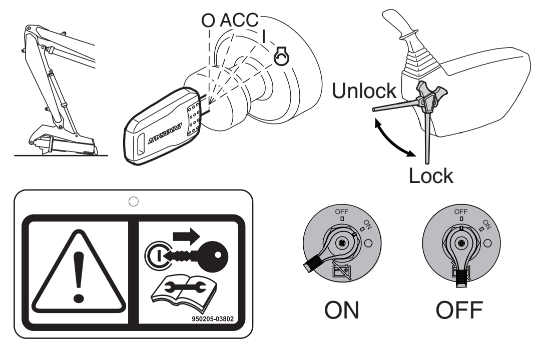
4. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 22)
5. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

6. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
7. Move safety lever to "LOCK" position. (Figure 22)
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Attach a maintenance warning tag on controls.
10. Turn battery disconnect switch to "OFF" position. (Figure 23)



EX1504829

Figure 22

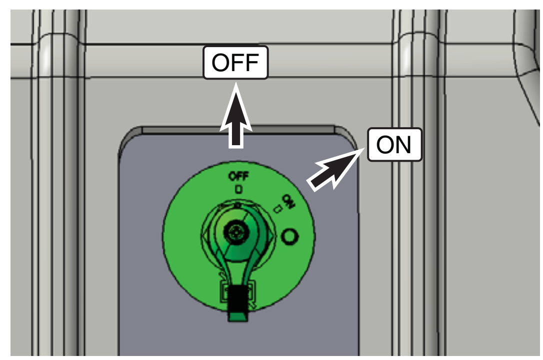
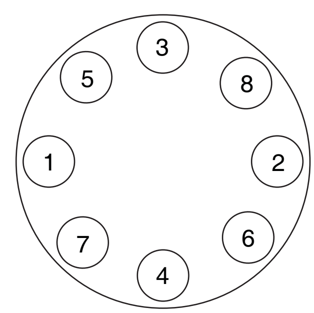


Figure 23 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 24

WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

11. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.

    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

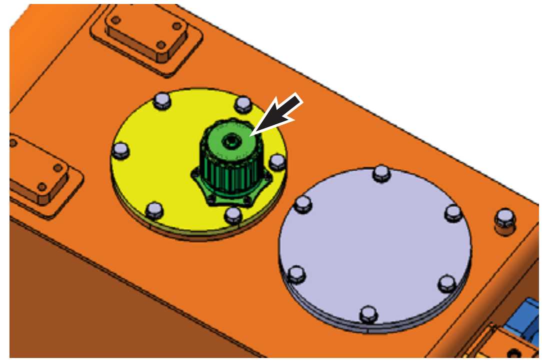


Figure 25 EX1404054

12. Open the engine cover and remove bolts and washers (1, Figure 26) (4 ea) with cover (2).

    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Cover weight: 18 kg (40 lb)

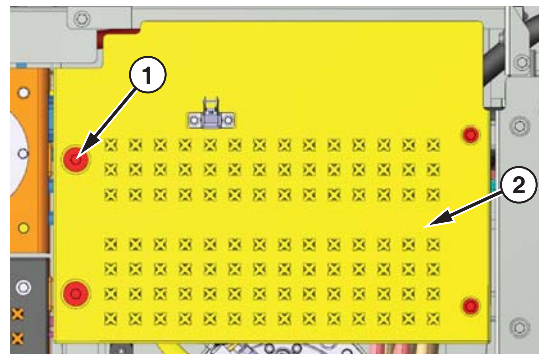


Figure 26 DS1602642

13. Disconnect harness from the swing device.

    NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
    If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

    And remove pressure sensor. (Figure 27)

    - Tool: 24 mm ( )
    - Torque: 39.2 N.m (4 kg.m, 28.9 ft lb)

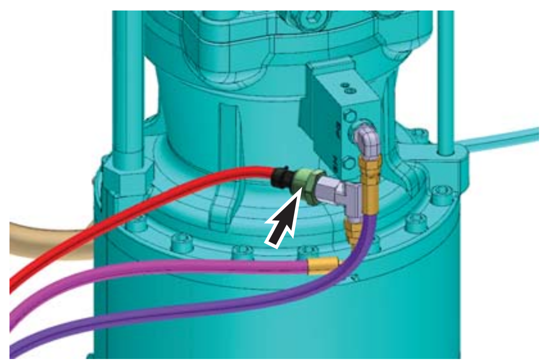
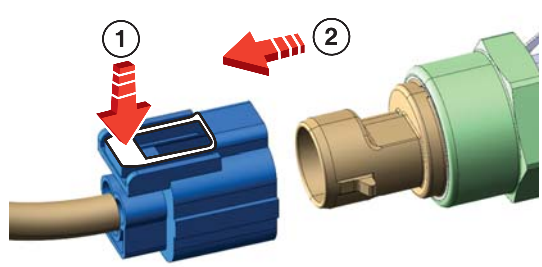


Figure 27 DS1602643

How to disconnect the harness connector.



DS1601120

Figure 28

14. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 29

15. Remove hoses and adapters from swing device.

NOTE: *Attach identification tags to the removed hoses for reassembling.*
After disconnecting hoses from swing device, plug them to prevent dirt or dust from entering.
Disconnect the hoses from the bottom to top of swing device.

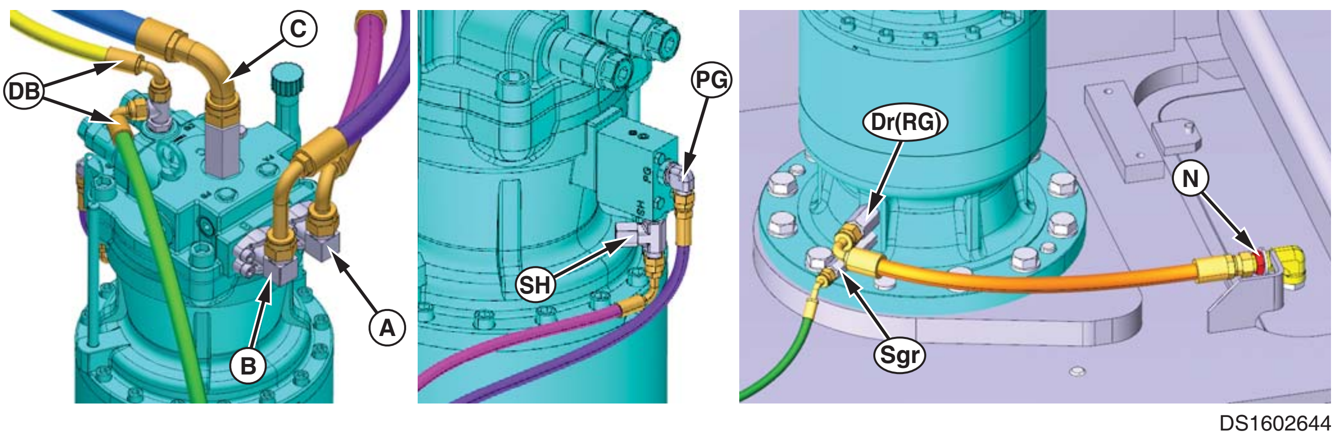


Figure 30

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
A	Main Port (from Main Control Valve "B3")	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
B	Main Port (from Main Control Valve "A3")	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
C	Make-up Port (from Main Control Valve "T2")	UNF 1 7/16"-12-2B	41	169.7	17.3	125.1
DB	Drain Port	UNF 13/16"-16-2B	24	55.9	5.7	41.2
PG	Brake Release Port (from Solenoid Valve "P1")	UNF 9/16"-18-2B	19	25.5	2.6	18.8
SH	Brake Release Signal (from Main Control Valve "PA")	UNF 9/16"-18-2B	19	25.5	2.6	18.8
	Pressure Sensor	PF 1/4"	27	39.2	4.0	28.9
Dr (RG)	Drain (Reduction Gear)	PF 1/2"	27	93.1	9.5	68.7
Sgr	Grease Inlet port	PF 1/4"	19	39.2	4.0	28.9
N	Nut	PF 1/2"	27	93.1	9.5	68.7

- Fitting

Port	Name	Size		(mm)	(mm)	Torque		
		A	B (C)			N.m	kg.m	ft lb
A, B	Elbow	SAE 3/4"	UNF 1 3/16"-12		8	56.9	5.8	42.0
C	Adapter	PF 1"	UNF 1 7/16"-12	41		215.7	22.0	159.1
DB	Tee	PF 1/2"	UNF 13/16"-16	27		107.9	11.0	79.6
PG	Elbow	PF 1/4"	UNF 9/16"-18	19		36.3	3.7	26.8
SH	Tee	PF 1/4"	PF 1/4", UNF 9/16"-18	19		36.3	3.7	26.8
Dr (RG)	Adapter	PT 1/2"	PF 1/2"	27		49.0	5.0	36.2
Sgr		PT 1/4"	PF 1/4"	19		19.6	2.0	14.5
A, B	O-ring	DS2856002 (3/4", ID:25.3, OD:32.3, 1B)	S8030125 (4D F-12)					
C		S8000291 (1B P29)	S8030125 (4D F-12)					
DB		S8000185 (4D P18)	S8030081 (1B F-08)					
PG		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)					
SH		S8000115 (4D P11)	S8000115 (4D P11), 2180-1216D11 (ID:7.65, W:1.78, 1B)					

* A: Opposite side of hose, B (C): Hose side

16. Install the eyebolts (M10 x 1.5 DP18) (Figure 31).
17. Attach a nylon sling onto the eyebolt.

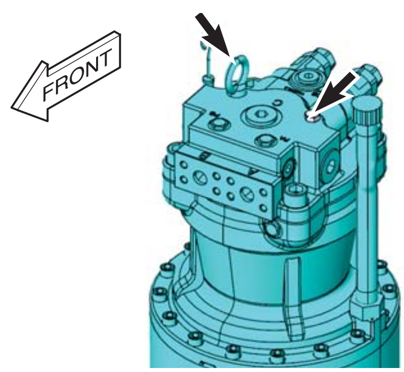


Figure 31 DS1602645

18. Remove bolts and washers (1, Figure 32) (11 ea).
    - Tool: 30 mm ( )
    - Torque: 539.4 N.m (55 kg.m, 397.8 ft lb)
19. Remove plugs (2, Figure 32) (2 ea).
20. Install the back bolt to the plug position to ensure that frame and swing device can be separated.
21. Hoist and remove swing device from the frame.

NOTE: *When hoisting the swing device one part of swing device will contact with the main frame. Hoist the swing device a little and push to the front side while hoisting slowly.*

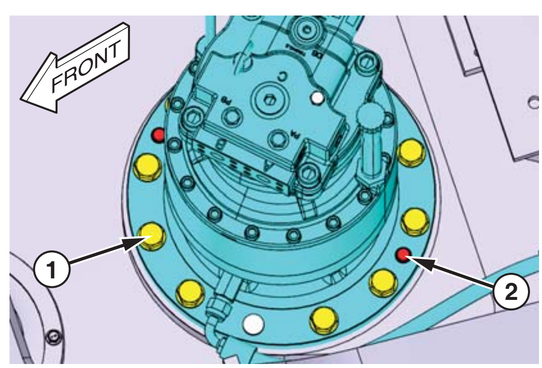


Figure 32 DS1602743

22. Wind wire rope around the swing device, lift it up with a crane and wash with flushing oil.

    After washing, dry with compressed air.

    - Weight: about 252 kg (556 lb)

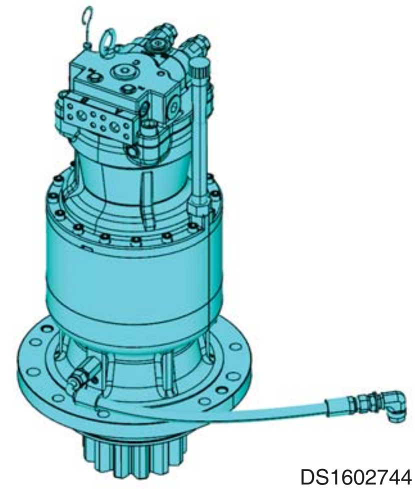


Figure 33

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

1. Perform installation in the reverse order to remove.
2. When installing the hoses, install the drain hose first.
3. When installing the swing device, slightly move the end of heel to align it with the swing bearing gear if the swing device does not fit the gear.

COMPLETING WORK

IMPORTANT

If the air is not vented from the system, it will cause damage to the swing motor and bearings.

NOTE: *Perform this only when oil has been drained from swing motor.*

1. Stop engine.
2. Disconnect drain hose and fill swing motor case with hydraulic oil.
3. Connect the drain hose.
4. Start engine and set throttle at "LOW IDLE" and swing 20° upper structure slowly 2 times to the left and right.

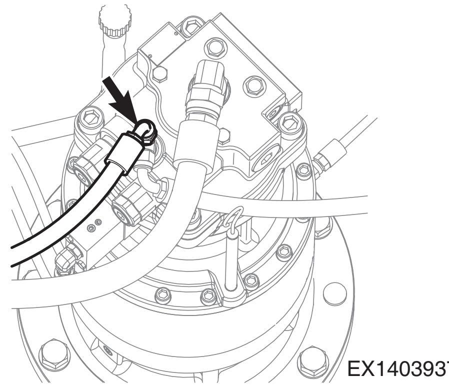


Figure 34

PRECAUTION

Tools for Disassembly and Assembly

Tables 1 and 2 and Figure 35 presents the tools required for disassembly and reassembly. Since different bolts and plugs are used in different types, check and prepare necessary tools.

Table 1

Name	Size	Application Part	Tool (mm)
Hex Bolt	M6	Brake Valve	 (10)
Hex Socket Head Bolt	M20	Valve Casing	 (17)
Plug	M30	RO Plug	 (14)
Hex Socket Head Bolt	M12	Casing	 (10)
Relief Valve	M33	Relief Valve	 (41)

Table 2

Specification / Tools		Size
Pliers	for stop ring	For ø45 shaft
	for lock ring	For ø62 hole
Driver		Flat tip, 2 pcs.
Steel Rod		Approximately 10 x 8 x 200. 1 pc.
Hammer		Plastic and metal hammers, 1 each
Torque Wrench		Torque adjustment range • for 100 ~ 450 kg.cm • for 400 ~ 1,800 kg.cm • for 1,200 ~ 4,800 kg.cm
Slide Hammer Bearing Pliers		-
Brake Piston Puller		See next page

Tightening Torque

Table 3 presents the tightening torque of the bolts used in the hydraulic motor. Observe the specified torque when tightening the bolts.

Table 3

Reference No.	Bolt Size	Type	Tightening Torque		
			N.m	kg.m	ft lb
102	M30	Ro Plug	220.6 ±24.5	22.5 ±2.5	162.7 ±18.1
107	M33	Relief Valve	176.5 ±9.8	18 ±1	130.2 ±7.2
109	M20	Hex Socket Head Bolt	431.5 ±64.7	44 ±6.6	318.3 ±47.7
314	M12	Hex Socket Head Bolt	98 ±2	10 ±0.2	72 ±1.4
406	M6	Hex Bolt	11.8 ±2	1.2 ±0.2	8.7 ±1.4

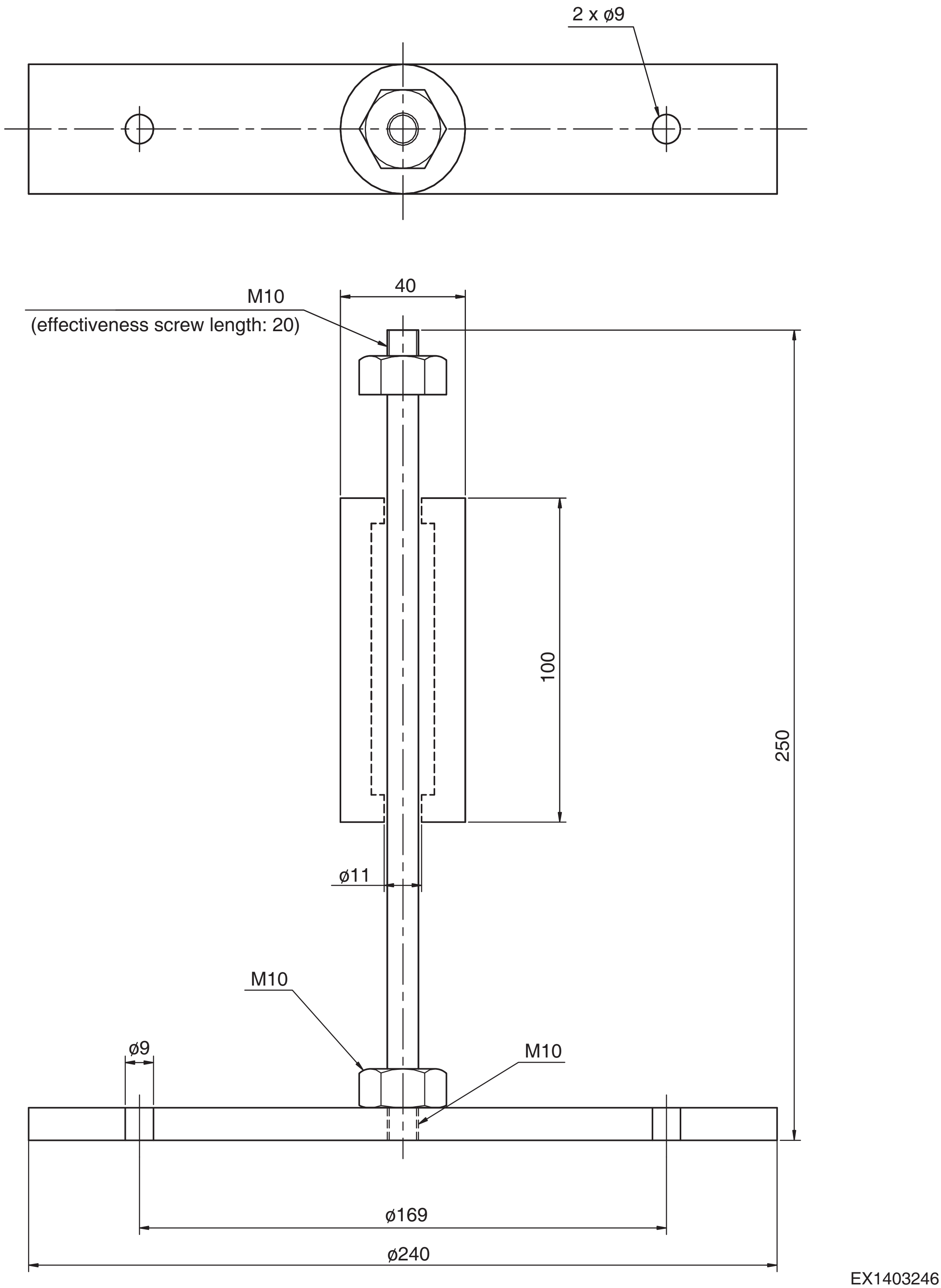


Figure 35 Tools for Brake Piston Disassembly

DISASSEMBLY

Swing Motor

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 parts list.

1. Wind the wire rope around motor, Lift up the motor with a crane and clean the motor with cleaning oil. After cleaning, dry with compressed air.
2. Drain the oil out of the casing (301).
3. Point the end of the driveshaft downward and fix it on a disassembly table for easy disassembling. Before disassembling make a match mark on motor casing (301) and valve casing (101).

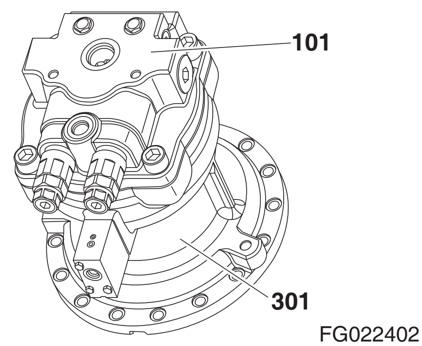


Figure 36

4. Remove bolts (406) (3 ea) with brake valve (400).
   - Tool: 10 mm ( )

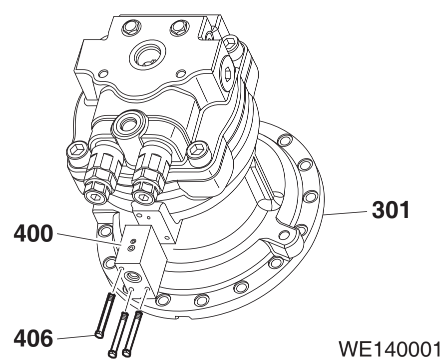


Figure 37

5. Remove relief valve (107) from valve casing (101).
   - Tool: 41 mm ( )

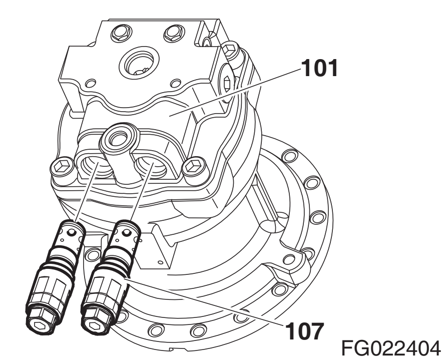


Figure 38

6. Remove RO plug (102) and take out spring (103) and plunger (104) from valve casing (101).

   - Tool: 14 mm ( )

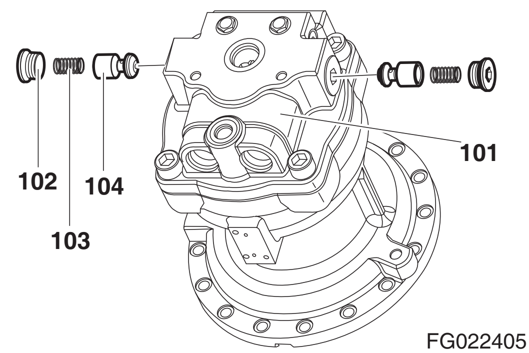


Figure 39

7. Remove swing reactionless valve assembly (105) from valve casing (101).

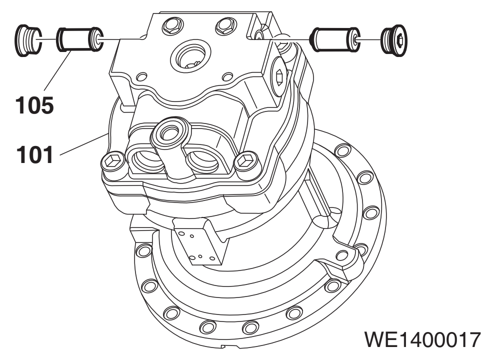


Figure 40

8. Remove hex socket bolts (109) and disassemble valve casing (101) from casing (301). When loosening bolts, the valve casing will be raised by brake springs (310).

   - Tool: 17 mm ( )

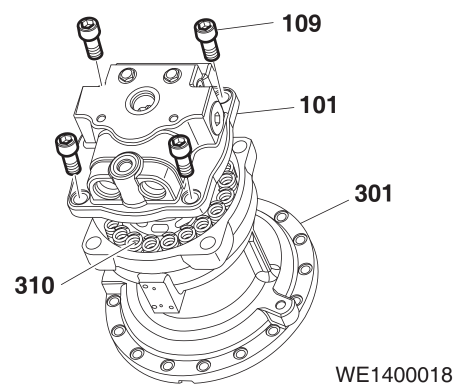


Figure 41

9. Remove brake springs (310) from the brake piston (309).

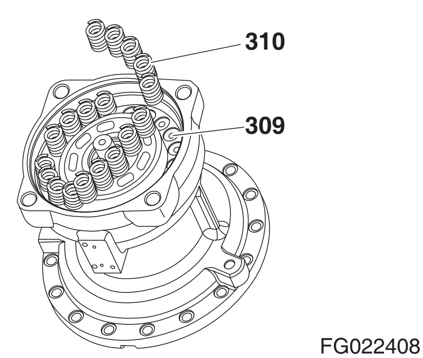


Figure 42

10. Disassemble brake piston (309) from casing (301) by using the special tool for removing the brake piston.

    Lift it up straight by using the bolt hole in the brake piston.

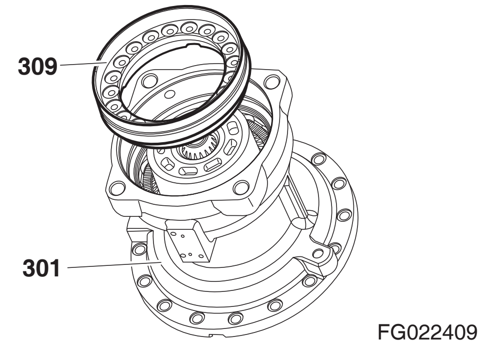


Figure 43

11. After placing the motor horizontally, take out cylinder block (205) from casing (301).

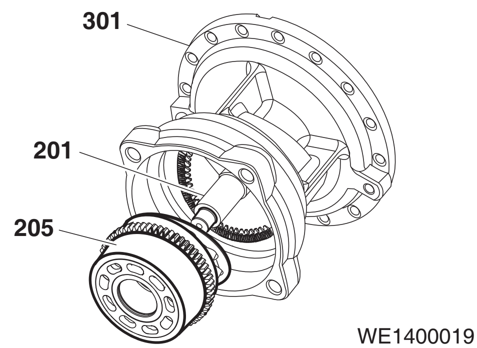


Figure 44

12. Remove piston assembly (203), retainer (207), thrust ball (206). 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, thrust ball and shoe.

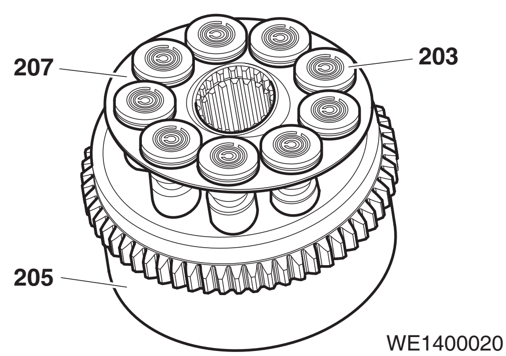


Figure 45

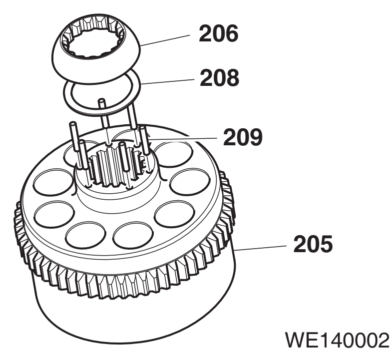


Figure 46

13. Pull out friction plate (306) (2 ea) and separation plate (305) (3 ea) from casing (301).

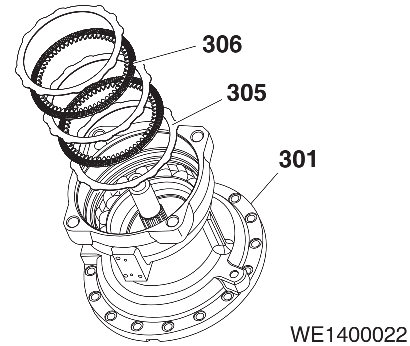


Figure 47

14. Remove shoe plate (202) from casing (301).
When removing the shoe plate (202), be careful not to damage the sliding parts of the shoe plate (202).

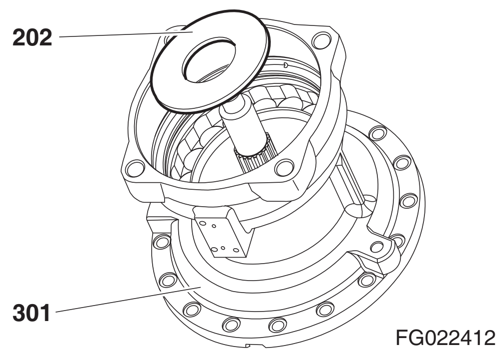


Figure 48

15. Remove driveshaft (201) with bearing (303) from casing (301).

Be careful not to damage the roller bearing and oil seal contact surface. If you beat a driveshaft (201) end with plastic hammer, it is easy to be disassembled.

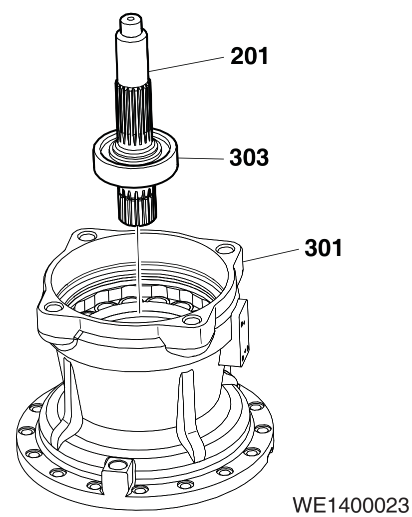


Figure 49

16. Do next step only if required.

    1) Remove roller bearing (303) from driveshaft (201). Do not reuse the disassembling bearing.

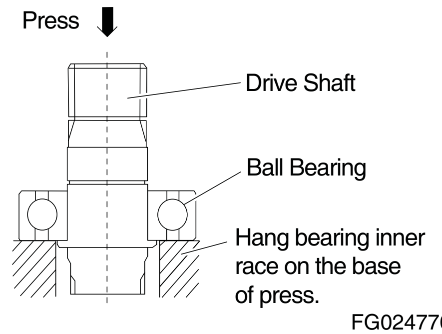


Figure 50

    2) Take out oil seal (302) from the casing (301) with a jig. Do not reuse the disassembling oil seal (302).

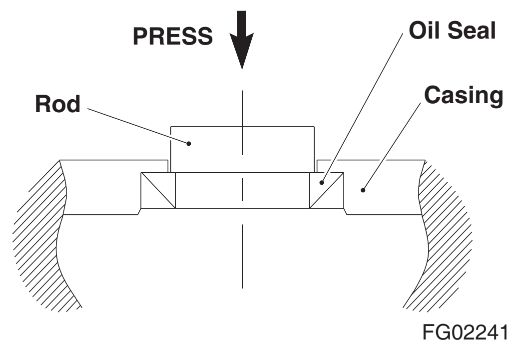


Figure 51

    3) Take out valve plate (213) and O-ring (112) from the valve casing (101).

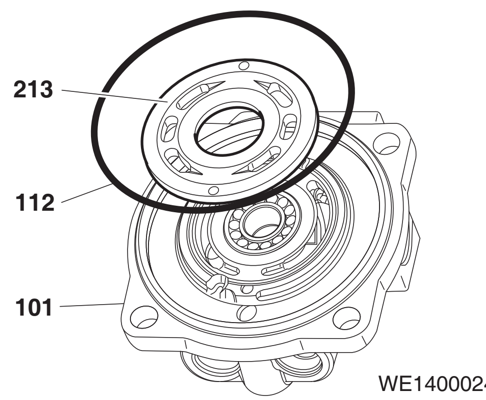


Figure 52

    4) Take out ball bearing (108) from the valve casing (101).
    Do not reuse the disassembling ball bearing (108).

Disassembling is finished, check each component throughly.

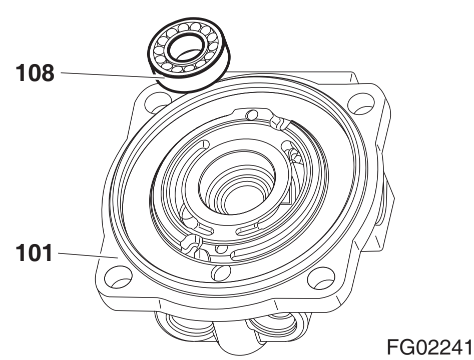


Figure 53

Swing Reduction Gear

Please use the following procedures for the inspection and repair of the reduction gear.

Numerals given in parentheses following the parts names indicate the part number shown by the parts list.

1. Wind the wire rope around reduction gear outside , Lift it up with a crane and clean the reduction gear with cleaning oil. After cleaning, dry with compressed air.
2. Remove the PT plug (510) and drain out gear oil.
    - Gear oil volume: about 4 L (1 U.S. gal)

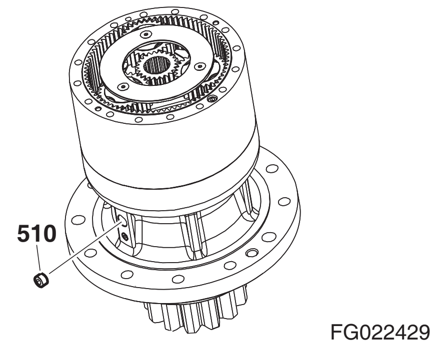


Figure 54

3. Remove No. 1 sun gear (602) from No. 1 carrier subassembly.

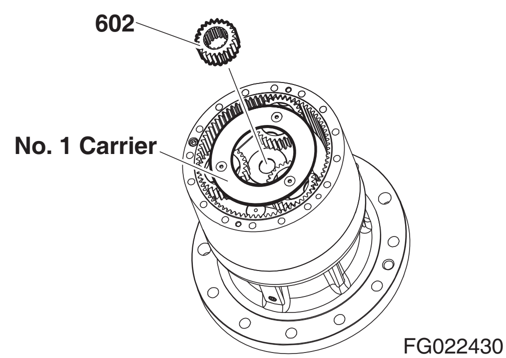


Figure 55

4. Remove No. 1 carrier subassembly.

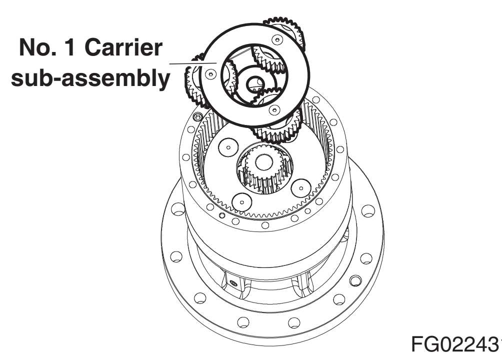
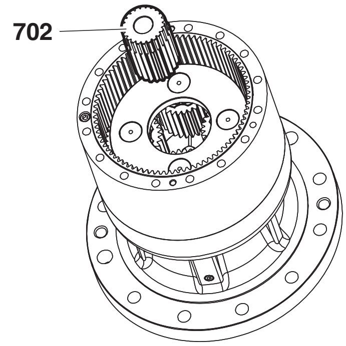


Figure 56

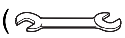
5. Remove No. 2 sun gear (702) from No. 2 carrier subassembly.

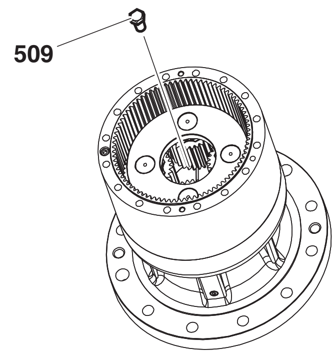


FG022441

Figure 57

6. Remove bolt (509) in No. 2 carrier.

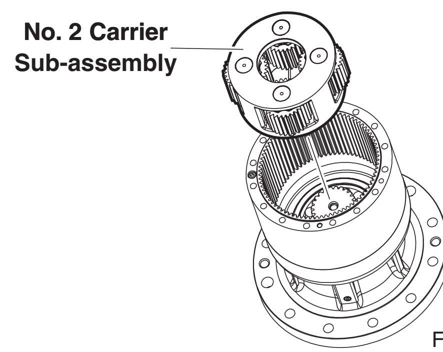
    - Tool: 24 mm ()



FG022451

Figure 58

7. Remove No.2 carrier subassembly from ring gear.

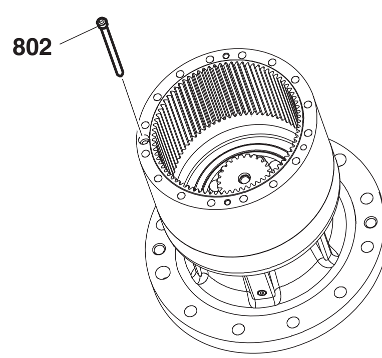


FG022452

Figure 59

8. Remove bolt (802) in ring gear (1 ea).

    - Tool: 6 mm ()



WE1400025

Figure 60

9. Remove ring gear (801) from casing (501).

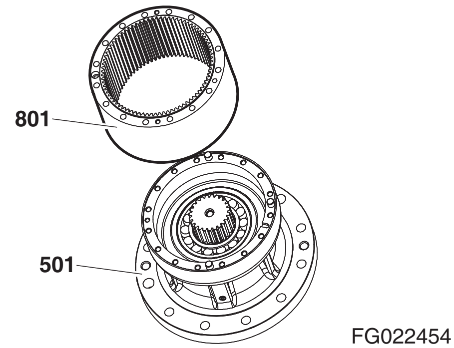


Figure 61

10. Remove pins (512) from casing (501).

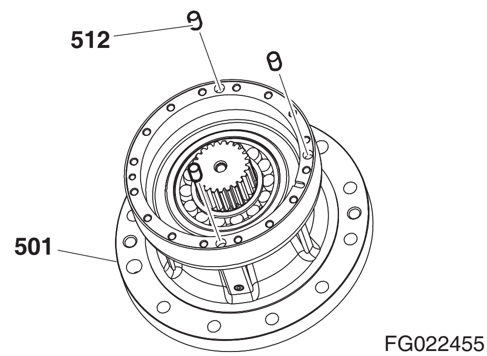


Figure 62

11. Remove bolt (507) from casing (501).

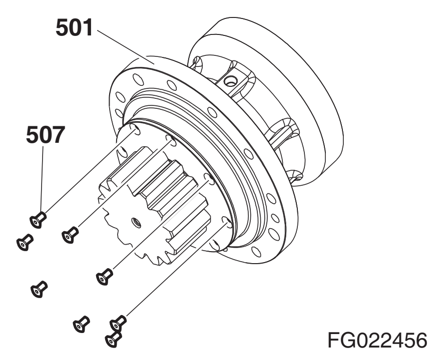


Figure 63

12. Use a rollover machine to turn case over and place a jig on driveshaft. Use a press to remove pinion shaft from case (501).

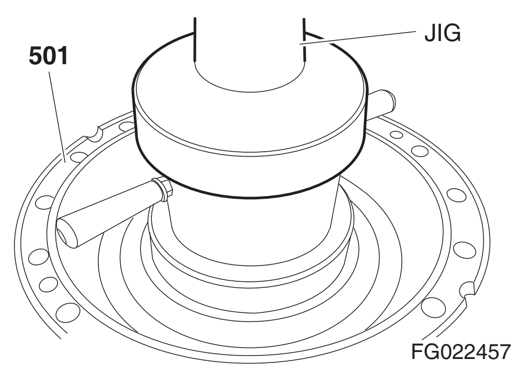


Figure 64

13. Remove bearing (504) from case (501).

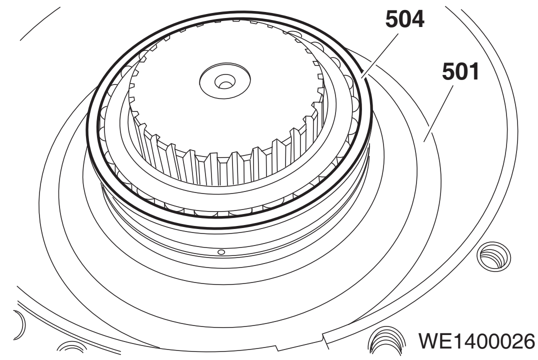


Figure 65

14. Remove pinion shaft (502) from casing (501).

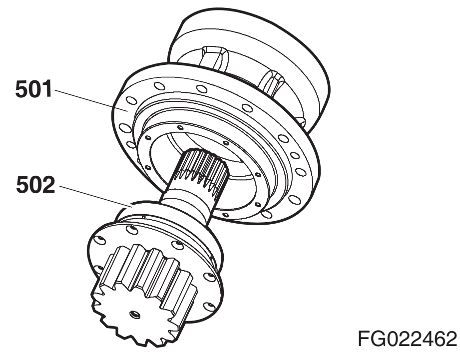


Figure 66

15. Remove oil seal (505).

IMPORTANT

Do not reuse oil seal!

Disassembling is finished, check each component throughly.

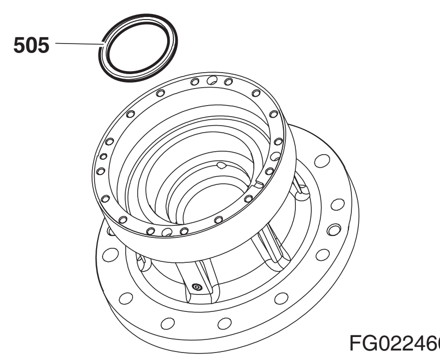


Figure 67

REASSEMBLY

Swing Motor

Use care with the following instructions.

A. After disassembly, make sure to repair damaged parts and prepare the parts to be replaced.

B. Wash all the parts with clean washing fluid and dry with compressed air.

C. Apply clean hydraulic oil on the sliding surfaces and bearings.

D. Replace O-rings and oil seals, which is a principle.

E. Tighten screws, bolts and plugs at specified torque using a torque wrench.

1. Place casing (301) on the work table with the valve casing side downward.

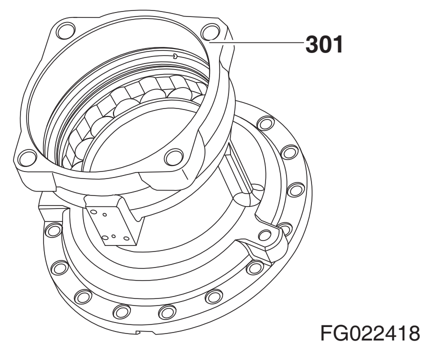


Figure 68

2. (This procedure applies when oil seal was disassembled from the casing.) Insert oil seal (302) at the casing (301) with a tool. (Be careful to note the direction of oil seal and insert until fully seated in the casing.)

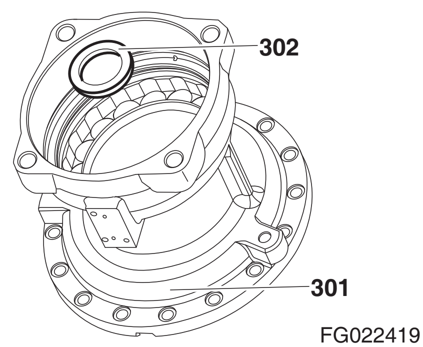


Figure 69

3. This procedure is necessary when the ball bearing was separated from the driveshaft.

   Install the ball bearing (303) in the driveshaft (201) by shrinkage fitting.

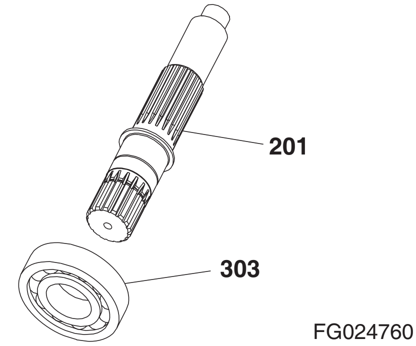


Figure 70

4. Insert the driving shaft (201) with the ball bearing (303) in the casing (301) with its output shaft facing upward and use a hammer to tap the surface of the ball bearing into the casing. At this point, apply grease to the lip of the oil seal lightly and then insert it carefully so it may not be damaged.

   NOTE: *Wrap a tape around the spline of the driving shaft to prevent the damage of the spline because of the lip.*

   Tap the surface of the external circumference evenly until it reaches the end completely.

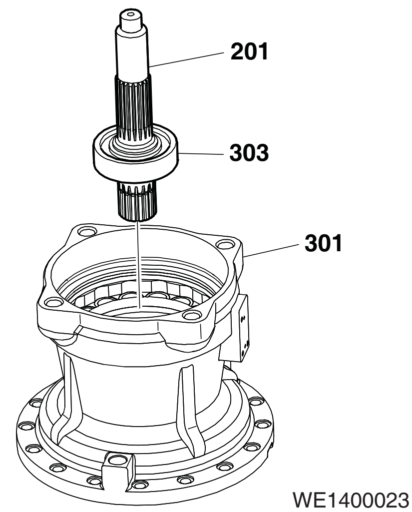


Figure 71

5. Assemble shoe plate (202) to casing (301).

   When assembling the shoe plate (202), be careful not to damage the sliding parts of the shoe plate (202).

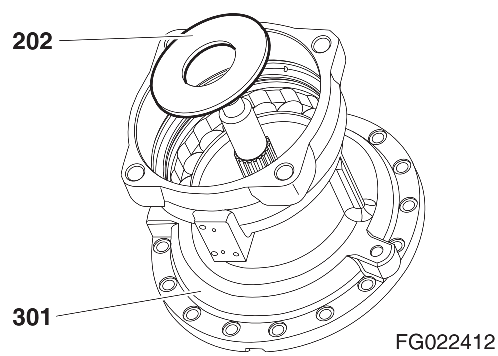


Figure 72

6. 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.)

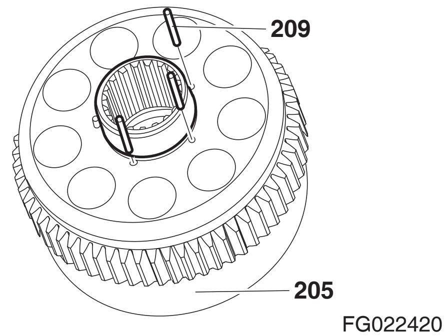


Figure 73

7. Place collar (208), thrust ball (206) to the cylinder block (205).

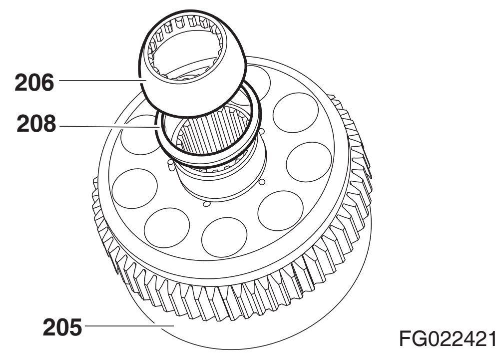


Figure 74

8. Assemble the retainer (207) with the piston sub assembly (203) unit to the cylinder block (205).

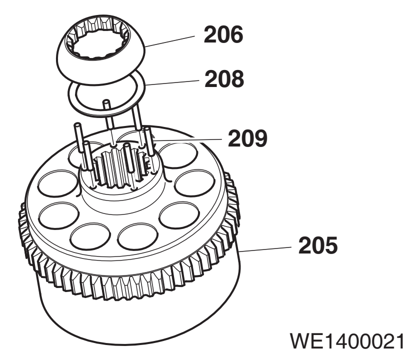


Figure 75

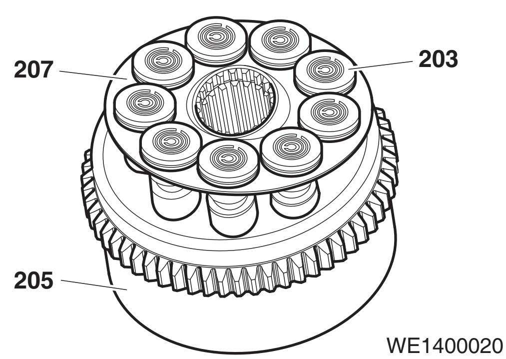


Figure 76

9. Insert cylinder block (205) to driveshaft (201) by aligning with the spline.

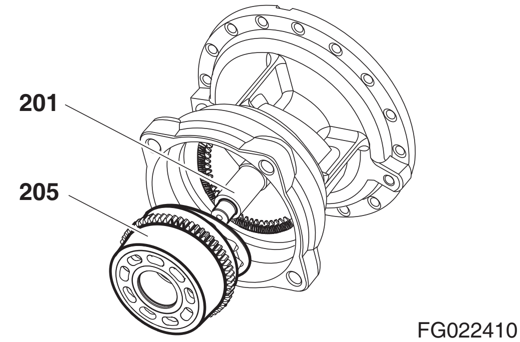


Figure 77

10. Place casing (301) downward and assemble separation plate (305) (3 ea) and friction plate (306) (2 ea) in sequence.

    (Assemble the parts of the friction plate cut-off with four gears at the same phase up and down.)

    (Assemble the parts of the separation plate cut-off with four jaws at the same phase.)

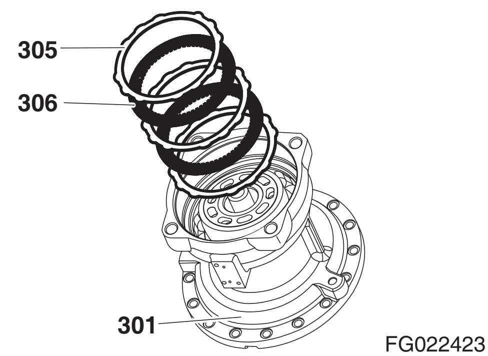


Figure 78

11. Mount O-ring (307, 308) to casing (301).

    (Apply grease thinly on the O-rings to prevent being cut during assembling the brake piston.)

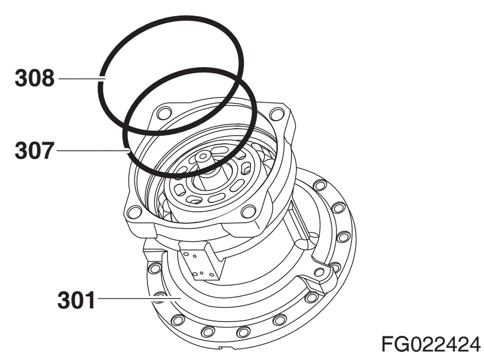


Figure 79

12. Assemble brake piston (309) to casing (301). If 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.

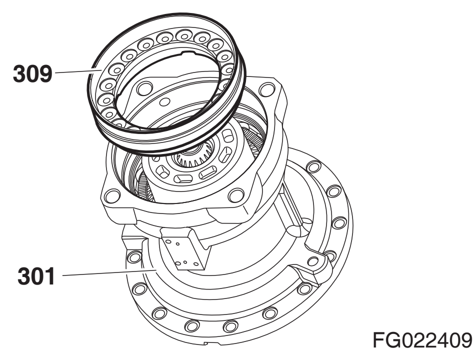


Figure 80

13. Assemble brake springs (310) into brake piston (309).

    Confirm the springs are fitted to the brake piston completely.

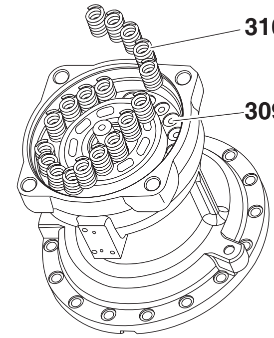


Figure 81

14. (This procedure applies 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.

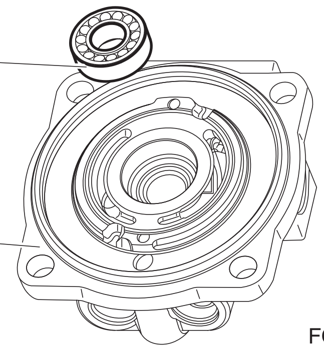


Figure 82

15. Assemble valve plate (213) to valve casing (101) and install O-ring (112).

    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.

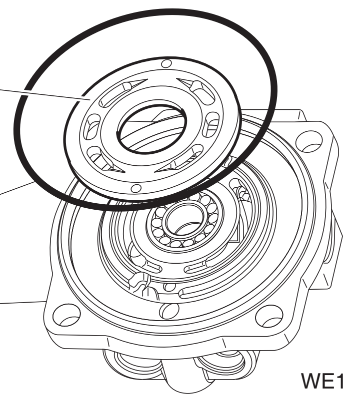


Figure 83

16. Mount valve casing (101) to casing (301) and tighten hex socket bolts (109) 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.

    - Tool: 17 mm ( )
    - Torque: 431.5 N.m (44 kg.m, 318.3 ft lb)

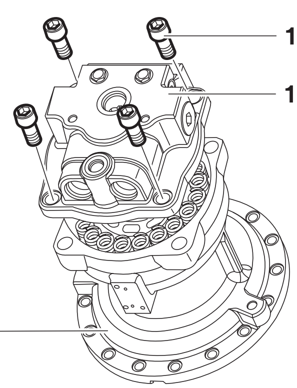


Figure 84

17. 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.

    - Tool: 14 mm ( )
    - Torque: 220.6 N.m (22.5 kg.m, 162.7 ft lb)

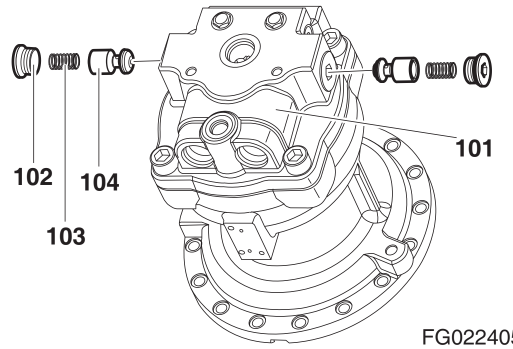


Figure 85

18. Install swing reactionless valve (105) to valve casing (101).

    Confirm the spring in the swing reactionless valve (105).

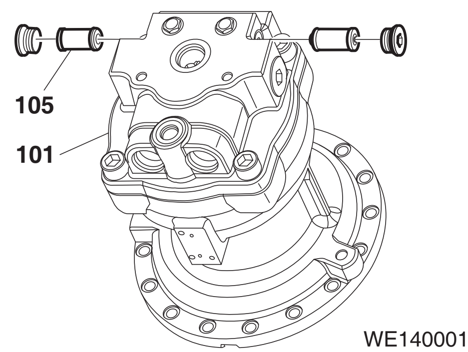


Figure 86

19. Assemble relief valve (107) with O-ring to valve casing (101).

    - Tool: 41 mm ( )
    - Torque: 176.5 N.m (18 kg.m, 130.2 ft lb)

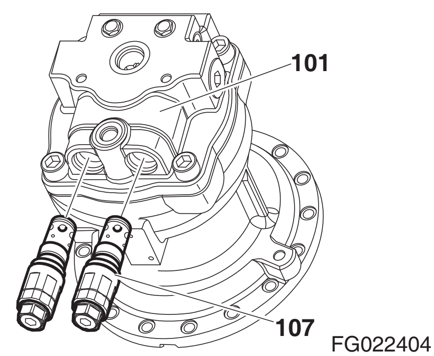


Figure 87

20. Assemble brake valve (400) to casing (301) and tightening the hex bolts to specified torque.

    - Tool: 10 mm ( )
    - Torque: 11.8 N.m (1.2 kg.m, 8.7 ft lb)

The assembly is completed.

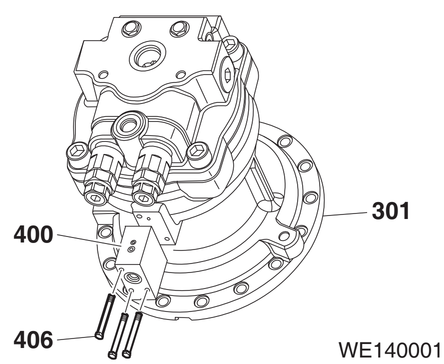


Figure 88

Swing Reduction Gear

Assembly should be done in the reverse order of disassembly described above, taking into consideration the following points:

A. Parts damaged during disassembly should be repaired without fail and spare parts should be prepared in advance.

B. Every part should be cleaned enough with cleaning oil and dried with compressed air before starting assembly.

C. Sliding parts and bearings should be applied clean hydraulic oil before their assembly.

D. Seal parts of the O-ring and the oil seal should be replaced according to the standards.

E. Use a torque wrench to tighten or engage bolts and plugs in accordance with "Tightening Torque" on page 5-8-24.

1. Install the bearing cover (506) and the taper roller bearing (503) on the pinion shaft (502).

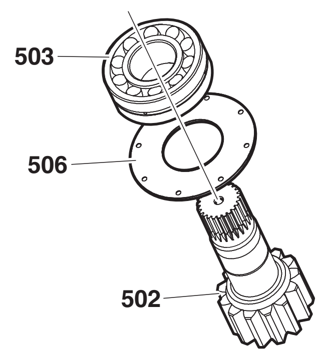


Figure 89

2. Install the pinion shaft (502) and other associated parts.

IMPORTANT

Prior to assembling the pinion shaft,etc.

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

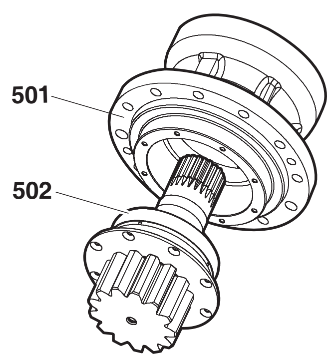


Figure 90

3. Tighten screws (507) to assemble cover (506).
   - Torque: 29 N.m (3 kg.m, 21 ft lb)

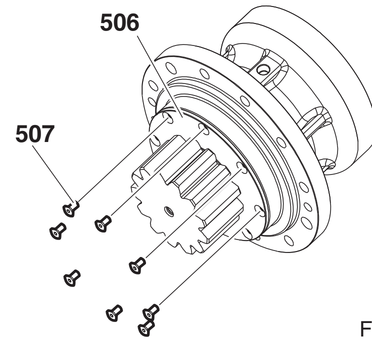


Figure 91

4. Mount a casing (501) on a suitable work table or jig.

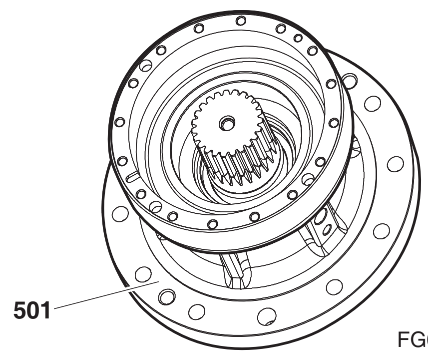


Figure 92

5. Apply grease thinly on the outer circumference of the oil seal (505) and insert it into casing (501) by using pressing jig.

IMPORTANT

Do not reuse oil seal!

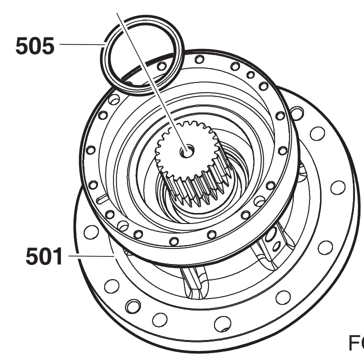


Figure 93

6. Install the taper roller bearing (504) with a using of tool.

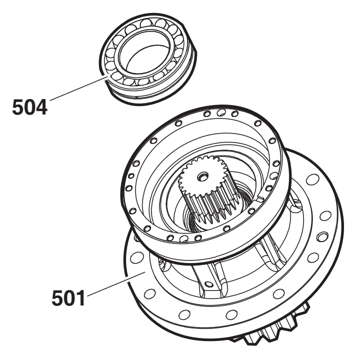


Figure 94

7. Assemble pins (512) with casing (501).

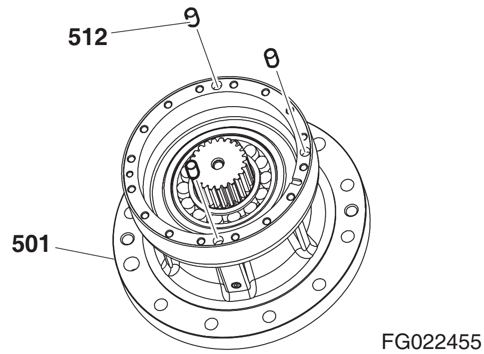


Figure 95

8. Apply sealant evenly to ring gear assembly of casing.

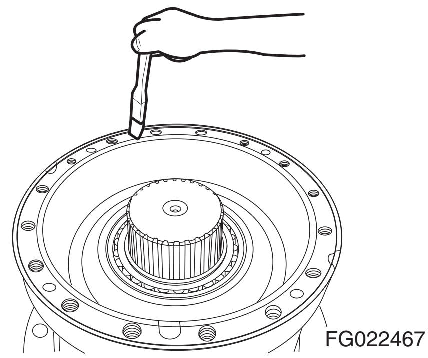


Figure 96

9. Lift ring gear (801) with hoist, wipe its mating surface clean with cloth, Match and align holes and attach to casing (501).

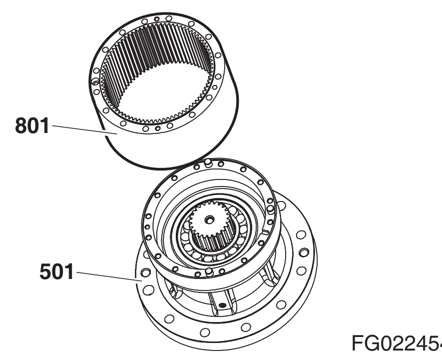
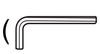


Figure 97

10. Tightening special bolts (802) with no Loctite applied.

- Tool: 6 mm ()

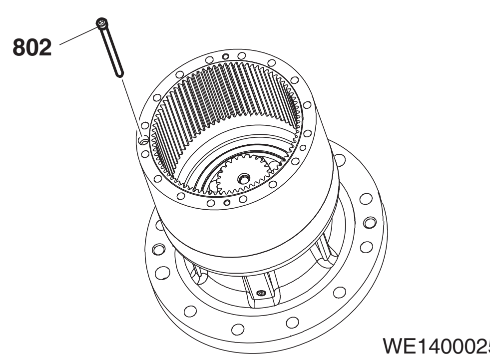


Figure 98

11. Assemble bushing (705) and the washer (706) onto planet gear No.2 (703) and arrange it on the pinhole of the carrier No.2.

    Turn over gear assembly (703, 705, 706) and insert it and thrust washer (508) into No. 2 carrier.

    Align bushing hole with carrier holes.

    NOTE: *Thrust washer (706) must be on both side of gear.*

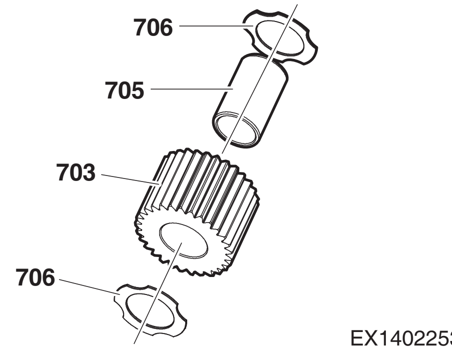


Figure 99

12. Align spring pinhole in pin No.2 (704) with spring pinhole of No. 2 carrier.

    Insert no.2 pin (704) into carrier and No. 2 bushing.

    NOTE: *Pin No.2 may need to be gently tapped with a soft faced hammer.*

    After all four No.2 are installed,align spring pin (707) with carrier hole and drive it into position using a hammer.

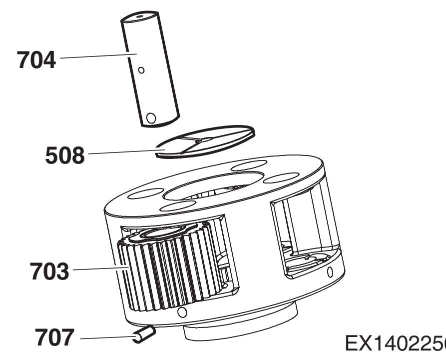


Figure 100

13. Using a suitable lifting device, lower No. 2 carrier subassembly into ring gear, making sure that planetary gears are engaged. Continue to lower carrier and engaging it onto splines of pinion shaft.

    Make sure that carrier is resting on bearing.

    NOTE: *Make sure that carrier and driveshaft can rotate.*

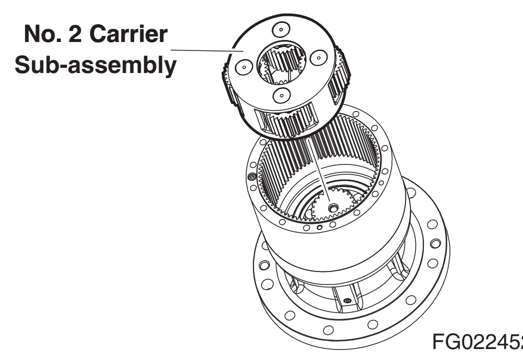


Figure 101

14. After tightening the bolt (509), to attach carrier assembly 2 and use a torque wrench to tighten it up to the standard torque.

    - Tool: 24 mm ( )
    - Torque: 279.5 N.m (28.5 kg.m, 206 ft lb)

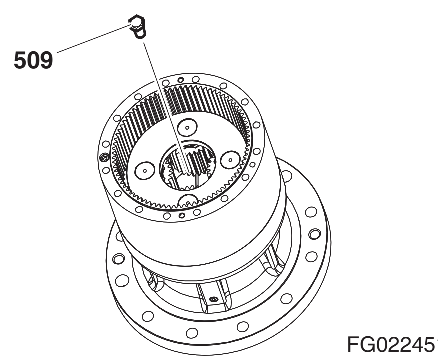


Figure 102

15. Install No. 2 sun gear (702) in No. 2 carrier.

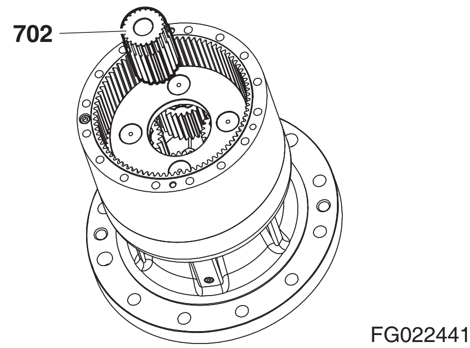


Figure 103

16. Assemble the following parts on the carrier No.1.

Reference Number	Description
603	Planet Gear
604	Innerring
605	Needle Bearing
606	Thrust Washer No.1
708	Thrust Washer

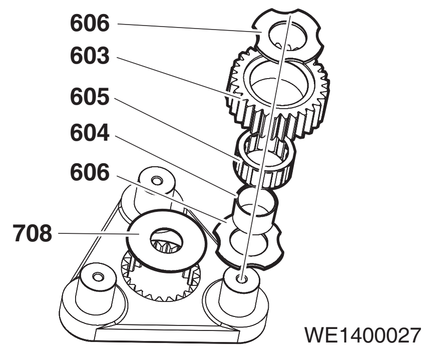


Figure 104

17. Assemble the following parts.

Reference Number	Description
607	Thrust Plate
608	Screw

- Torque (608): 29 N.m (3 kg.m, 21 ft lb)

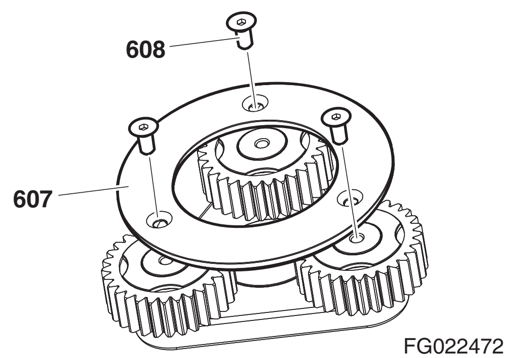


Figure 105

18. Install the carrier No.1 subassembly. Lift the carrier No.1 subassembly and turn it clockwise or counterclockwise gently for it to engage with the spline of the No.2 sun gear (702) and the ring gear (801).

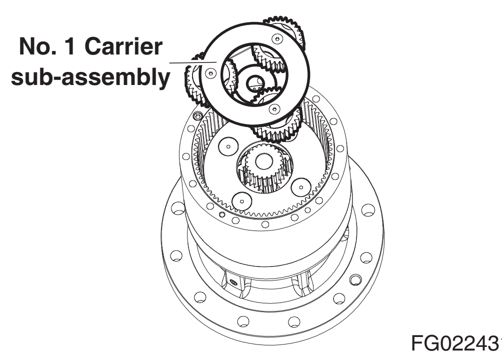


Figure 106

19. Install No. 1 sun gear (602) in No. 1 carrier.

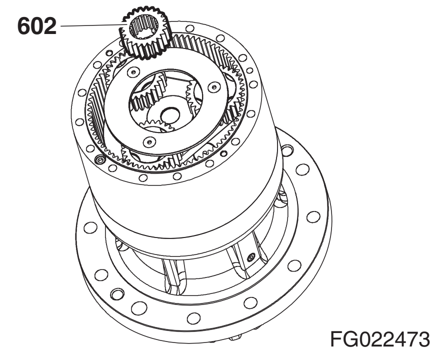


Figure 107

20. Use a hoist to lift the prepared motor, wipe out the assembly, and install the retaining ring (214) on the shaft (201).

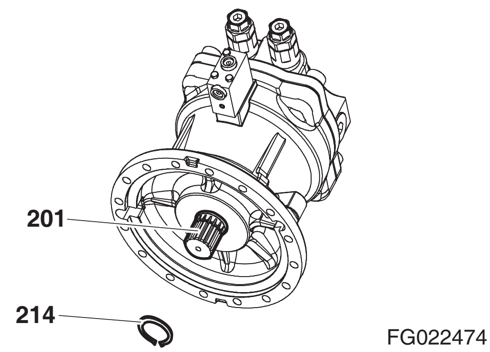


Figure 108

21. Apply sealant evenly to ring gear assembly of motor.

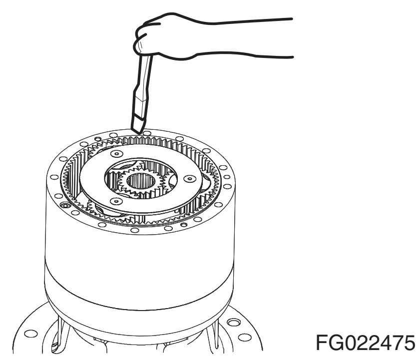


Figure 109

22. Put the motor on the reduction gear carefully as shown in the figure.

    The level gauge port and hole in the ring gear should be alligned.

    Assemble the motor by turning it clockwise or counterclockwise gently so that splines of the shaft shall be engaged with the No.1 sun gear.

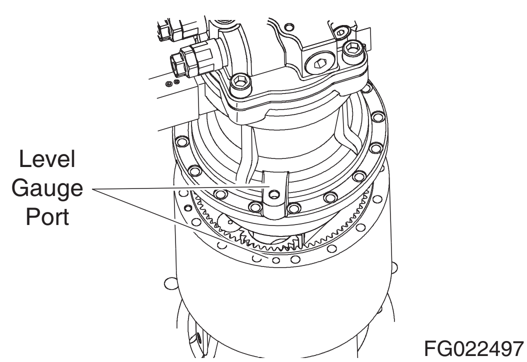


Figure 110

23. Apply Loctite to socket bolts (314) (16 ea).

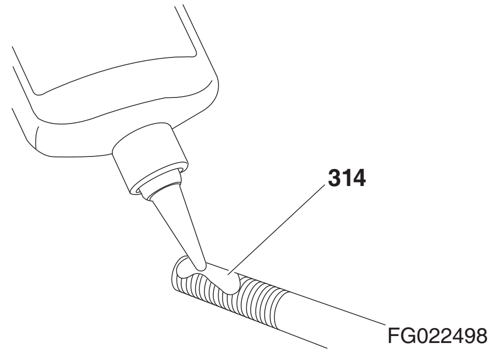


Figure 111

24. Insert bolt into holes, and tighten with an impact wrench.

- Tool: 10 mm ( )
- Torque : 98 N.m (10 kg.m, 72 ft lb)

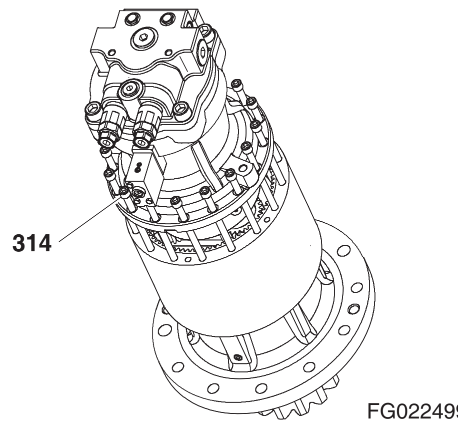


Figure 112

25. Install the level gauge pipe sealed with teflon tape with a pipe wrench.

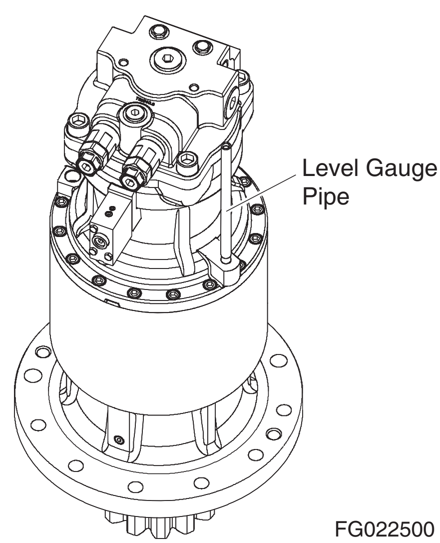


Figure 113

26. Fill with the correct gear oil and check the oil level with stick level gauge.

    - Gear oil volume: about 4 L (1 U.S. gal)

Assembly is done.

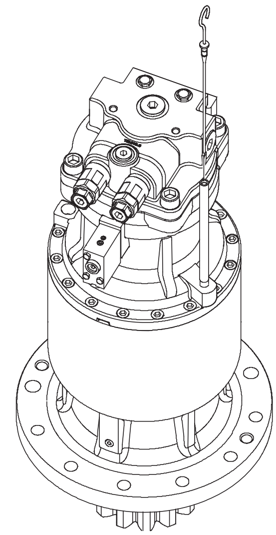


Figure 114

TROUBLESHOOTING

General Instructions

This section provides the corrective actions against any abnormality identified during hydraulic motor operation.

General instructions are as follows:

1. Think before taking action

   Before taking any action, examine the characteristics of the problem, and if there had been similar trouble before.

   In addition, examine once again that cause of the problem is the hydraulic motor.

2. Take care of foreign material

   Foreign materials cause abnormal friction and wear. Take care to avoid foreign materials during disassembly and reassembly.

3. Parts handling

   All the parts are precisely ground, thus, take utmost care not to damage.

4. Take care not to damage O-rings and gasket surfaces.

   It is highly recommended to replace with new O-rings after disassembly.

Examination of Hydraulic Motor

It is very difficult to find out the cause of trouble in hydraulic oil circuit.

Check the items listed below, and examine the cause of the hydraulic motor.

1. Check oil quality in the casing

   Remove drain plug and check the oil in the casing.

   If the oil contains many metal particles, the cause of trouble may be a part in the hydraulic motor.

2. Abnormal noise

   Check if the motor makes abnormal noise.

3. Pressure measurement of each parts

   Before disassembly and inspection, measure the pressure of each parts and examine the problem.

4. Measure the drain quantity of the motor

   1) Lock the swing and supply high-pressure oil to the motor, and normal drain quantity must be approximately 25 LPM or less.

   2) Normal drain quantity in normal swiveling must be 2 LPM of less.

Troubleshooting

1. Hydraulic motor fails to rotate

Symptom	Possible Cause	Corrective Action
Pressure does not rise	1. The setting of the relief valve in the circuit is incorrect. 2. Relief valve malfunction. 1) Plunger sticks 2) Plunger orifice clogged. 3. Plunger seat failure	1. Set up with correct value 2. 1) Plunger sticks 2) Plunger orifice clogged. 3. Check the seat and replace it if damaged.
Pressure rises up to normal level	1. Overloaded. 2. Sticking of moving parts 3. Brake release pressure is not applied. 4. Brake piston is sticking. 5. Friction plate is sticking.	1. Remove load. 2. Check/repair piston, shoe, cylinder block, and valve plate. 3. 1) Check/repair the circuit. 2) Check the brake switching valve. 4. Disassemble and check 5. Disassemble and check Replace the sticking part.

2. The direction of rotation is reverse.

Symptom	Possible Cause	Corrective Action
Direction of rotation is reverse	1. Motor rotates in reverse direction. 2. The inlet and outlet of pipeline are reverse.	1. Referring to Figure 12, assemble correctly. 2. Correct the pipeline.

3. Rotating speed fails to reach setting value.

Symptom	Possible Cause	Corrective Action
Rotating speed fails to reach setting value	1. Insufficient incoming flow.	1. Check pump discharge rate, circuit to the motor.
	2. Temperature is too high and oil leaks too much.	2. Reduce the oil temperature.
	3. Wear of damaged of sliding parts	3. Replace the damaged part.

4. Insufficient brake torque

Symptom	Possible Cause	Corrective Action
Insufficient brake torque	1. Friction plate is worn.	1. Disassemble and check. Replace the part if excessively worn.
	2. Brake piston is sticking	2. Disassemble and check
	3. Brake release pressure cannot be removed.	3. 1) Check/repair the circuit. 2) Check the brake switching valve.
	4. The spline of the friction plate is damaged.	4. Disassemble and check Replace the damaged part

5. Hydraulic motor slips excessively

Check the drain quantity of the motor.

Normal drain rate is 500 cc/min.

Symptom	Possible Cause	Corrective Action
Excessive slip when external torque to drive the hydraulic motor is applied.	1. Relief valve malfunction. Same as subclause 1).	1. Same as subclause 1).
	2. Bad plunger seat	2. Replace the damaged part.

6. Oil leak

1) Leak at oil seal

Symptom	Possible Cause	Corrective Action
Leak at oil seal	1. The lip is damaged by dust.	1. Replace the oil seal.
	2. Worn or damaged shaft.	2. Change the relative position of the lip and shaft, or replace the lip.
	3. Oil seal lip is overturned because of excessively high-pressure in the casing.	3. Repair clogged pipeline.
	4. Rusted shaft.	4. Disassemble and correct it.

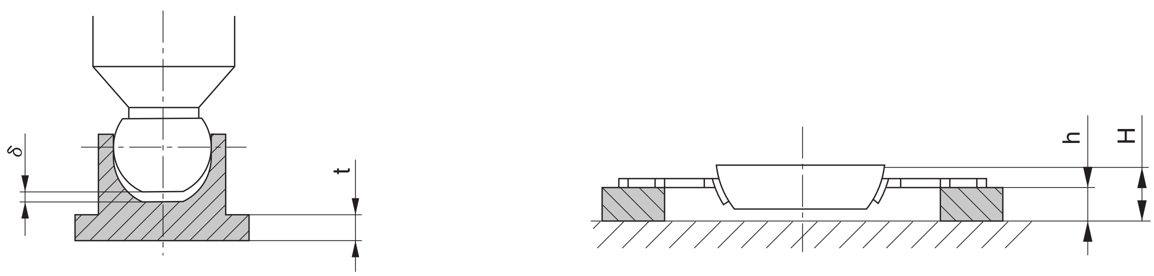
2) Oil leak at joint surface

Symptom	Possible Cause	Corrective Action
Oil leak at joint surface	1. O-ring is missing.	1. Insert correctly and reassemble
	2. O-ring is damaged.	2. Replace.
	3. Seal surface is damaged.	3. Disassemble and correct it
	4. Loose or damaged bolt.	4. Tighten at specified torque or replace the bolt

Replacement Standard of Worn Parts

When a part is worn exceeding the criteria below, adjust or replace the part. However, the criteria for parts with distinct damage are not defined.

Item	Standard Dimension (mm)	Replacement Criteria (mm)	Corrective Action
Clearance between the piston and cylinder block	0.025	0.055	Replace the piston or cylinder block
Clearance between the piston and shoe compressed part (δ)	0.05	0.2	Replace the piston or shoe assembly
Shoe thickness (t)	4.5	4.3	Replace the piston or shoe assembly
Assembled height of the retainer plate and spherical bushing (H-h)	10.8	10.3	Replace the retainer and spherical bushing set
Friction plate thickness	3.5	3.1	Replace



Piston and shoe clearance between the piston and shoe (δ)
Shoe thickness (t)

Assembled height of the retainer and spherical bush (H-h)

FG019002

Figure 115

Standard of Sliding Surface Correction

Correct or replace the part whose surface roughness of the sliding face exceeds the following criteria.

Part Name	Standard Roughness	Roughness Requiring Correction
Shoe	0.8 - Z (Ra = 0.2) (Lapping)	3 - Z (Ra = 0.8)
Shoe Plate	0.4 - Z (Ra = 0.1) (Lapping)	3 - Z (Ra = 0.8)
Cylinder	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: [1] *All the sliding surfaces must be lapped to make the roughness below the standard roughness.*

NOTE: [2] *If the sliding surfaces of the retainer or spherical bushing are excessively rough, replace the parts by set unit*

Joystick Valve (Work Lever)

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Joystick Valve (Work Lever)

GENERAL

Specifications

Max. Primary Pressure		49 bar (50 kg/cm^2, 711.1 psi)
Max. Back Pressure		2.9 bar (3 kg/cm^2, 42.7 psi)
Rated Flow		20 L/min (5.3 U.S. gal)
Continuous Rated Current of Switch		DC30 V x 6 A
Internal Leakage	Oil Temperature Range	-20 ~ 90°C (-4 ~ 194°F)
	Neutrality	Max. 300 cc/min
	At Work (14.7 bar (15 kg/cm^2, 213.3 psi)	Max. 500 cc/min

Performance

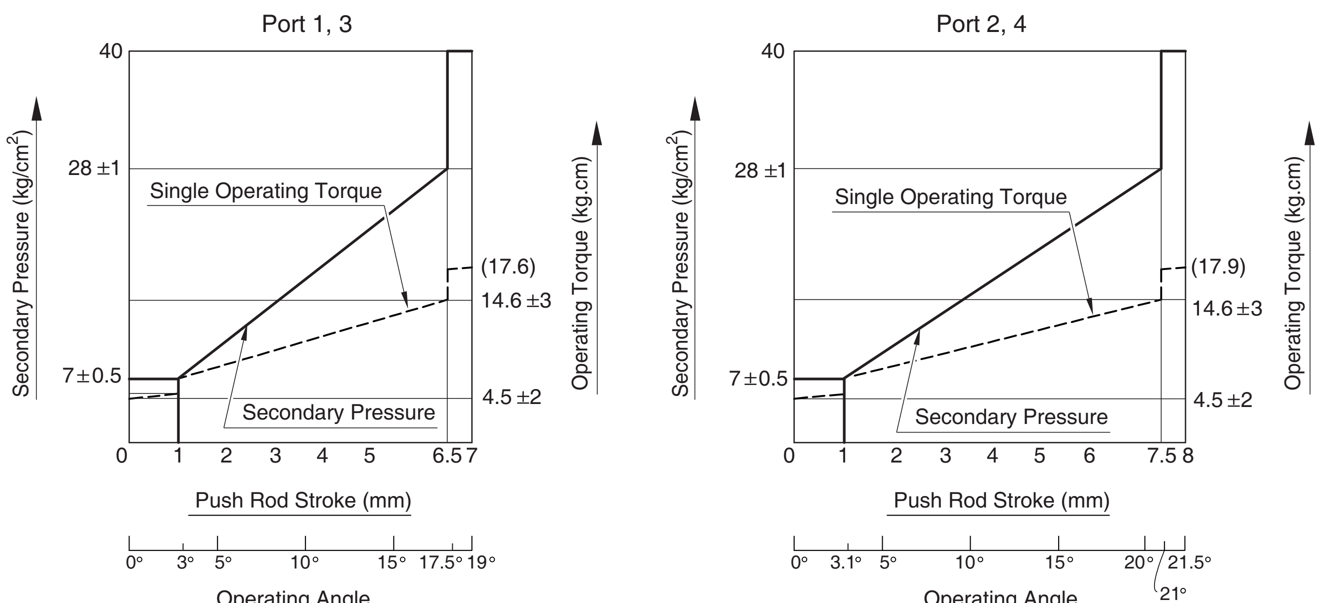


Figure 1

Overview

The pilot valve is a valve that controls the spool stroke, direction, etc of a main control valve.

This function is done by providing the spring at one end of the main control valve spool and applying the output pressure (secondary pressure) of the pilot valve to the other end.

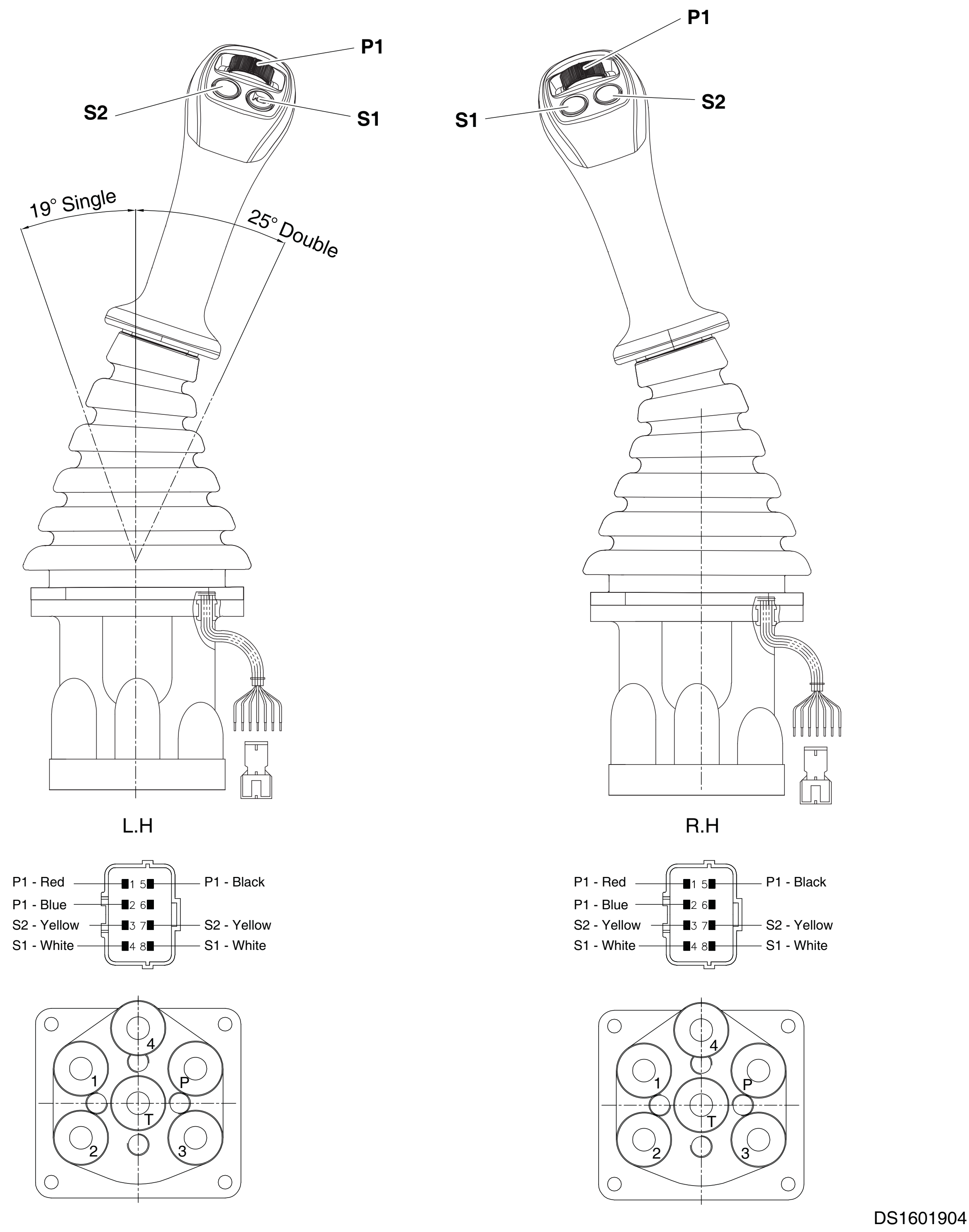


Figure 2

Port and Hydraulic Circuit

Switches

1. Push button switch

Switch	LH	RH
S1	Horn Button	Booster Button
S2	One Touch Deceleration Button	Spare Button

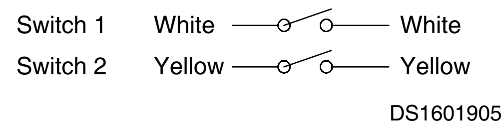


Figure 3

2. Proportional switch

Switch	LH	RH
P1	Rotating Switch	Shear Switch

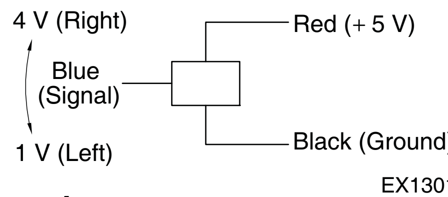


Figure 4

Ports

Port	LH	RH	Size
1	Left Swing	Heel Rack IN	PF 3/8
2	Arm Dump	Boom Down	
3	Right Swing	Heel Rack OUT	
4	Arm Crowd	Boom Up	
P	Pilot Oil Inlet	Pilot Oil Inlet	
T	Pilot Oil Return	Pilot Oil Return	

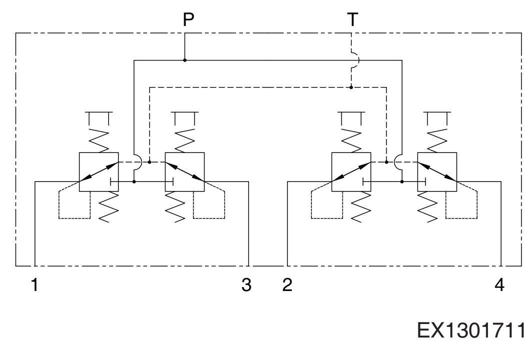


Figure 5

Parts List

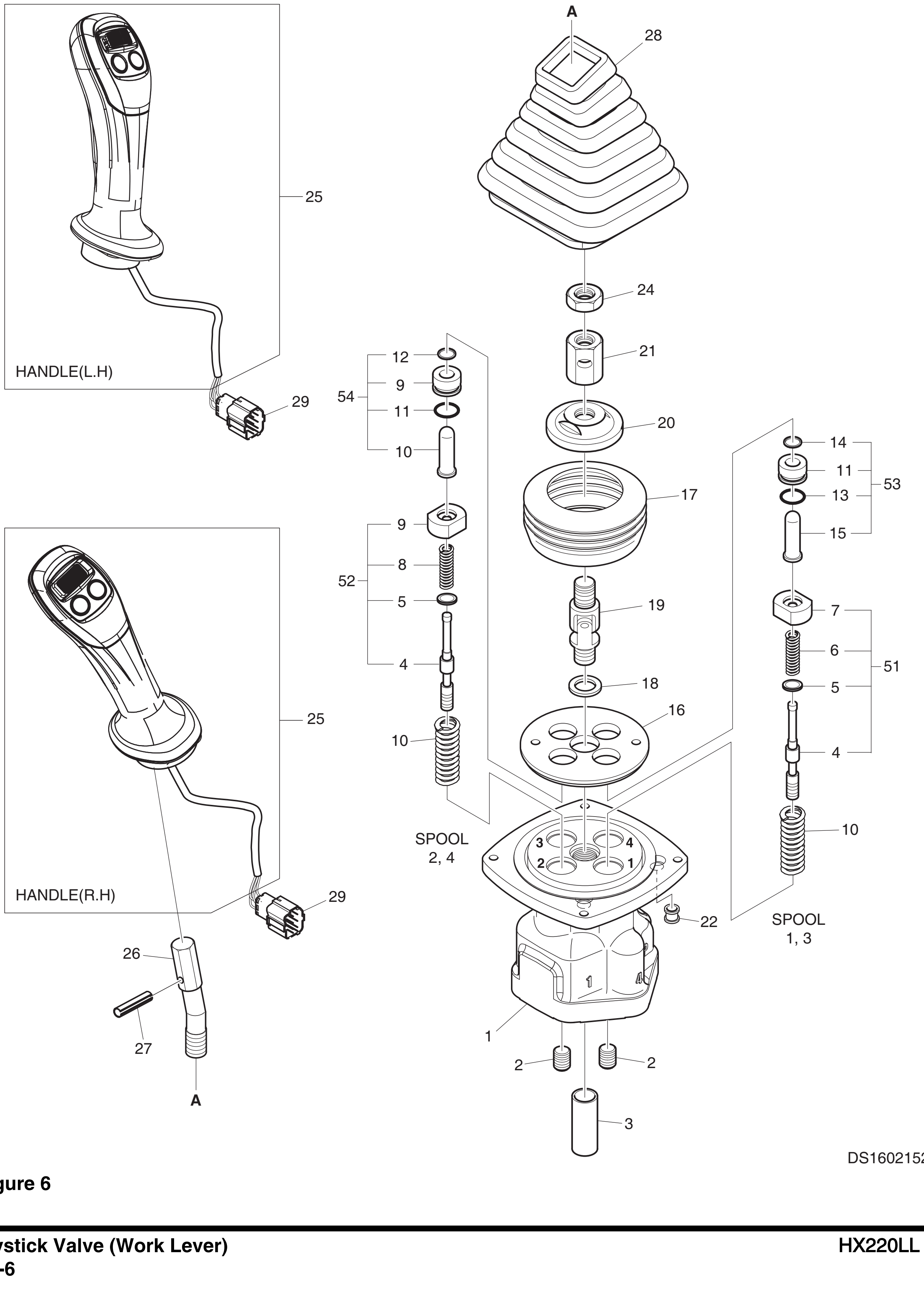


Figure 6

Reference Number	Description
1	Case
2	Plug
3	Bushing
4	Spool
5	Shim
6	Spring
7	Seat, Spring
8	Spring
9	Spring Seat
10	Spring
11	Plug
12	Rod; Push
13	O-ring
14	Seal, Rod
15	Rod; Push
16	Plate
17	Boot

Reference Number	Description
18	Spacer
19	Joint Assembly
20	Plate, Swash
21	Nut
22	Bushing
24	Nut
25	Joy Stick (LH)
25	Joy Stick (RH)
26	Bar, Handle
27	Pin, Spring
28	Bellows
29	Connecter Assembly
51	Spool Kit
52	Spool Kit
53	Plug Kit
54	Plug Kit

Theory of Operation

Structure

The joystick valve contains four push rods, spring seat, spools and return springs, which are in the valve casing. Moves the spool of the main control valve by reducing the pressure of the pilot pump from a first pressure to a second pressure.

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 joystick lever is in the neutral state, the spool is pressed upward by the return spring and the spring seat.

   The P-port is blocked by the lower part of the spool, and the 4 operation ports are connected to the T-port by the upperpart of the spool.

Reference Number	Description
1	Swash Plate
2	Push Rod
3	Balance Spring
4	Return Spring
5	Spool

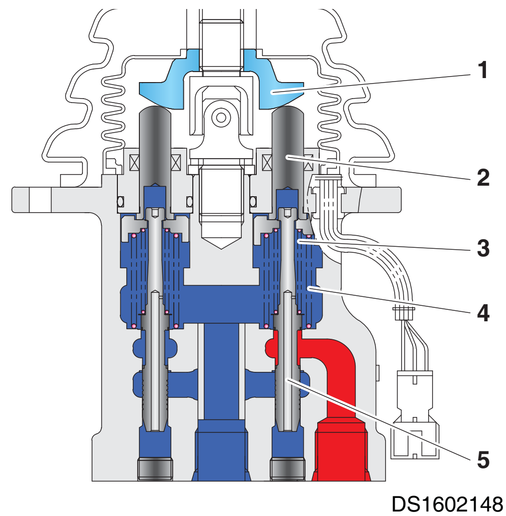


Figure 7

2. Half-operated state

   When the joystick lever is moved, the push rod moves downward, and the force thereof is transferred to the spool through the spring seat and the control spring. When the spool moves, the first pressure is transferred to the operation ports through the spool.

   When the lever spring stops in the halfway position, the force of the compressed spring and the hydraulic pressure caused by the second pressure applied upward because of the difference in area of the upper and lower ends of the spool create a state of equilibrium, and this pressure is transferred to the spool of the control valve. That is, the first pressure is transferred to the operation ports through the spool as a hydraulic pressure (second pressure) corresponding to the force of the compressed control spring.

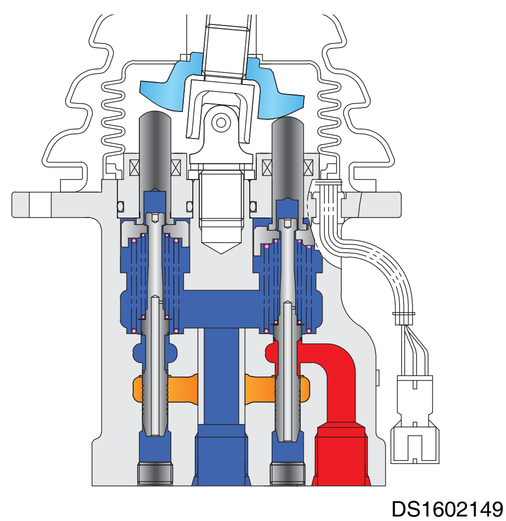


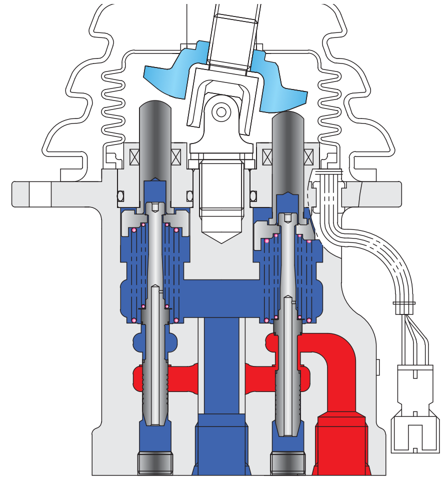
Figure 8

3. Fully operated state

When the joystick lever is moved to its full extent, the lower end of the push rod fully presses the spool seat to fully compress the control spring.

The first pressure is transferred to the operation ports through the spool, and the second pressure coming through the spool overpowers the force of the control spring, pushing the spool upward, and thus the spool is restricted from movement by the push rod.

That is, when the joystick lever is fully pressed, the control spring cannot perform its function and the spool is restricted, making the first pressure and the second pressure equal.



DS1602150

Figure 9

Tools and Torques

Reference Number	Description	Torque			Tool
		Nm	kg.m	ft lb	
2	Plug	36.3	3.7	27	PT1/8 ( )
20	Swash Plate	162.8	16.6	120	27 mm ( )
21	Hex Nut	162.8	16.6	120	22 mm ( )
24	Nut	162.8	16.6	120	22 mm ( )

SECTION VIEW

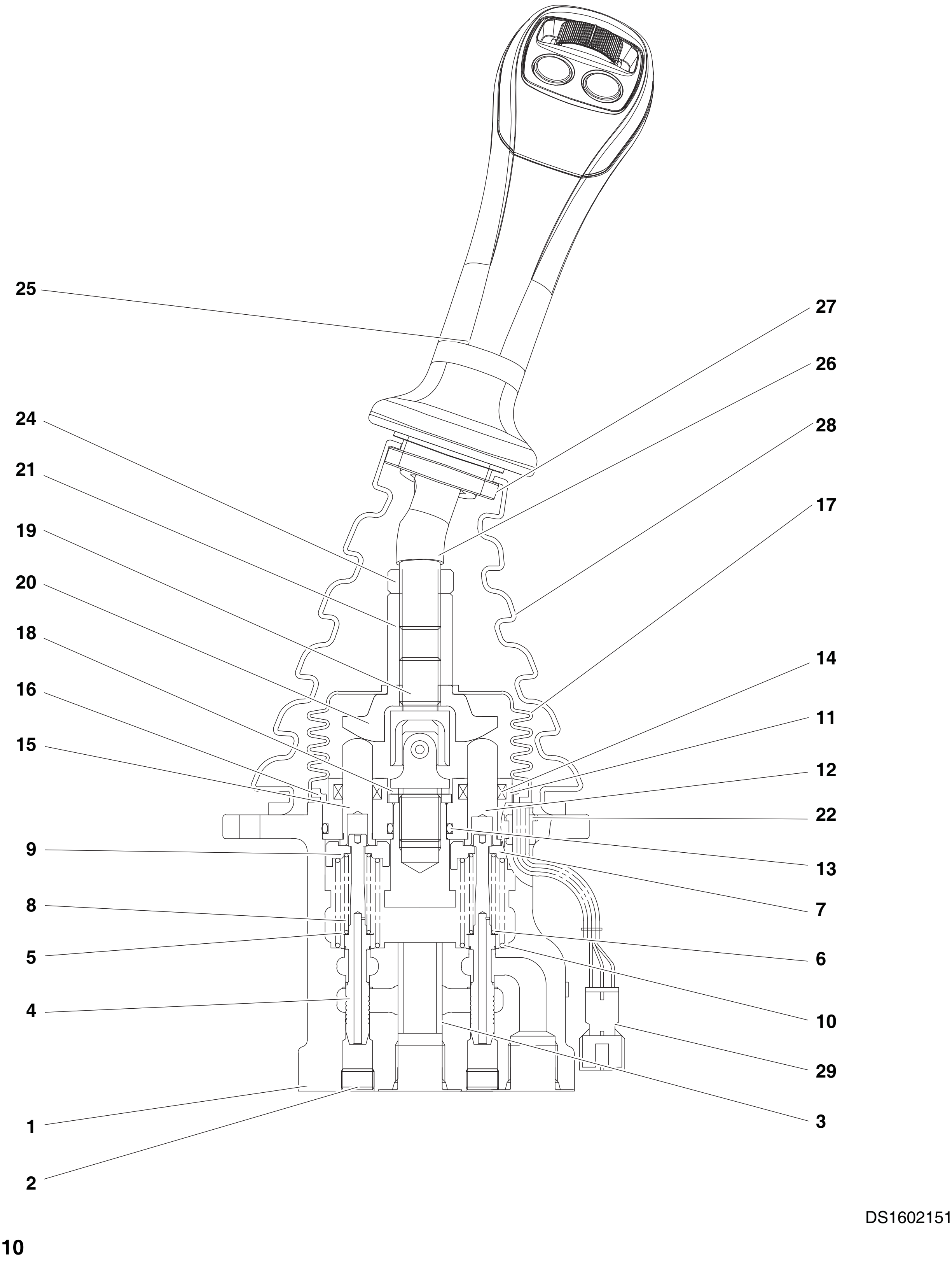


Figure 10

Reference Number	Description
1	Case
2	Plug
3	Bushing
4	Spool
5	Shim
6	Spring
7	Spring Seat
8	Spring
9	Spring Seat
10	Spring
11	Plug
12	Push Rod
13	O-ring
14	Rod Seal
15	Push Rod

Reference Number	Description
16	Plate
17	Inner Boots
18	Spacer
19	Joint Assembly
20	Swash Plate
21	Hex Nut
22	Bushing
24	Nut
25	Handle Assembly (LH)
	Handle Assembly (RH)
26	Handle Bar
27	Spring Pin
28	Boots
29	Connector Assembly

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Park on firm and level ground.
2. Lower front attachment to ground. (Figure 11).
3. Stop engine.

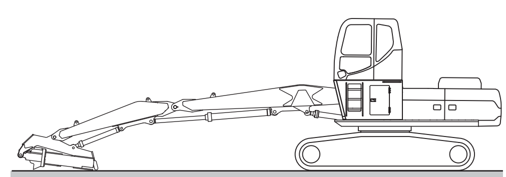


Figure 11 EX1300554

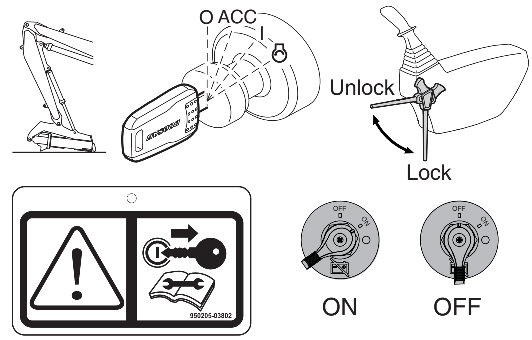
4. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 12)
5. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

6. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
7. Move safety lever to "LOCK" position. (Figure 12)
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Attach a maintenance warning tag on controls.
10. Turn battery disconnect switch to "OFF" position. (Figure 13)



EX1504829

Figure 12

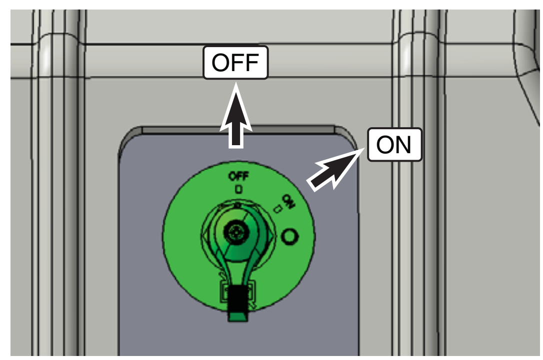
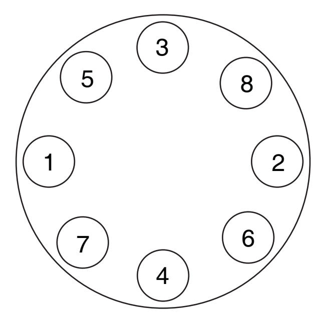


Figure 13 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 14

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

11. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.
    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

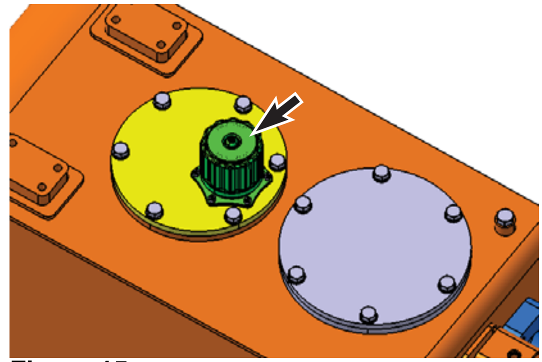


Figure 15 EX1404054

12. Remove bolts (3 ea) and washers (3 ea) and remove arm rest from bracket. (Right side)

    Left side is same.

    - Tool: 13 mm ()
    - Torque: 19.6 N.m (2 kg.m, 14.5 ft lb)

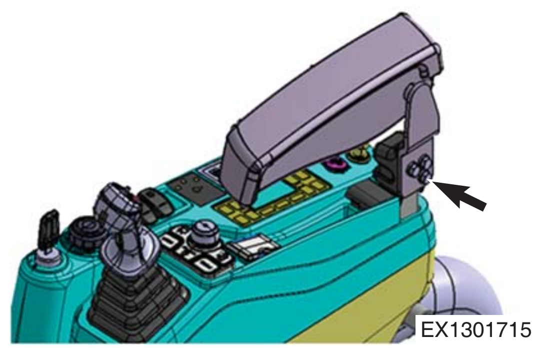


Figure 16

13. Remove screw with arm rest cover.

    Left side is same.

    - Tool: Phillips screwdriver

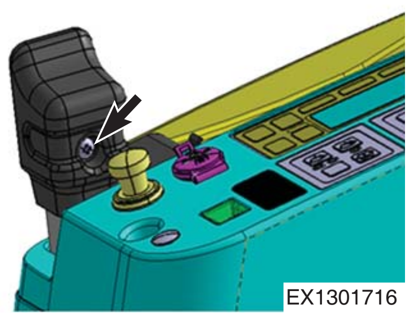


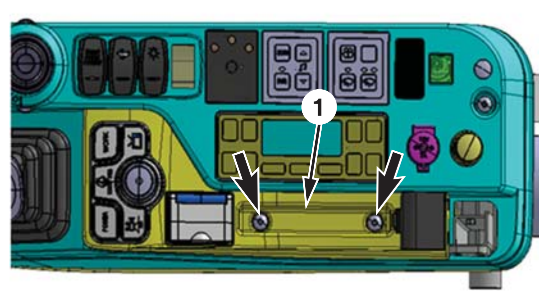
Figure 17

14. Remove rubber and screws, remove cover (1, Figure 18) from stand upper cover, and disconnect the connector of harness which connect with switches.

    NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
    If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

    Left side is same.

    - Tool: Phillips screwdriver



EX1301717

Figure 18 Stand RH

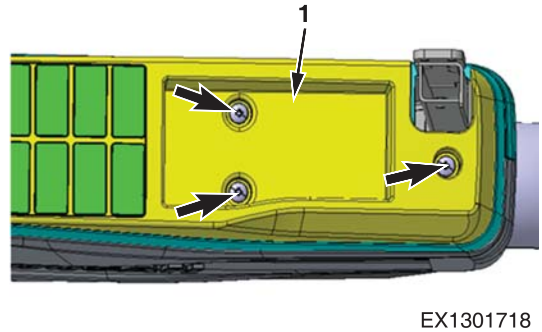


Figure 19 Stand LH

15. Remove screws (Figure 20) (3 ea) and bolt (2) (1 ea), remove upper cover (1, Figure 20) from bracket, and disconnect the connector of harness which connect with switches.

    NOTE: *Be careful not to let water get into electrical components (sensor, connectors).*
    If water gets into electrical system, this will cause an electrical short circuit and result in improper machine operation.

    Left side is same.

    - Tool: 3 mm (), Phillips screwdriver

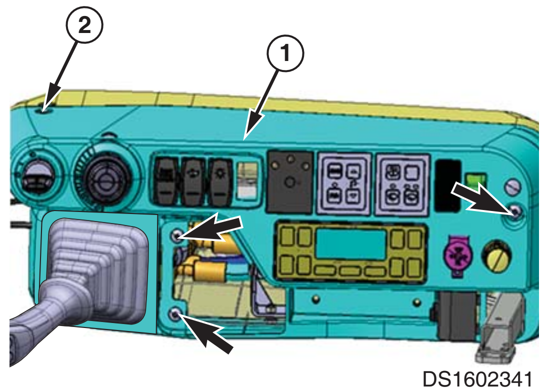


Figure 20 Stand RH

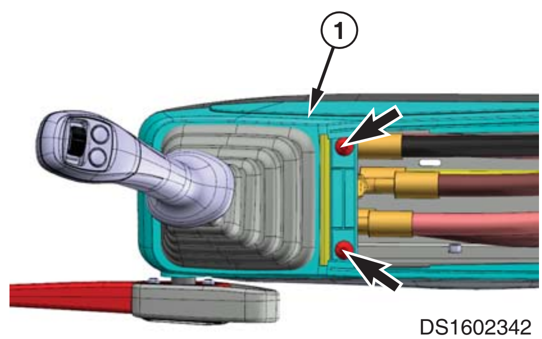
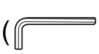


Figure 21 Stand LH

16. Remove screws (4, Figure 22) (2 ea), socket bolts and washers (3) (4 ea) of joystick valve (1).
17. Remove bracket (2, Figure 22) from control stand bracket.
18. Separate joystick valve from control stand.

    Left side is same.

    - Tool: 5 mm (), Phillips screwdriver

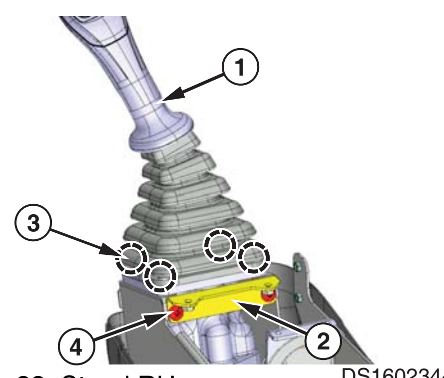


Figure 22 Stand RH

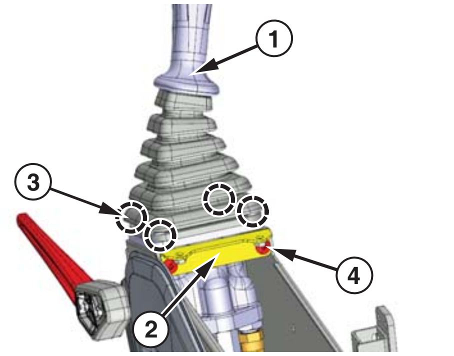


Figure 23 Stand LH

19. Remove hoses and adapters from joystick valve.

NOTE: *Attach identification tags to the removed hoses for reassembling.*

After disconnecting hoses from joystick valve, plug them to prevent dirt or dust from entering.

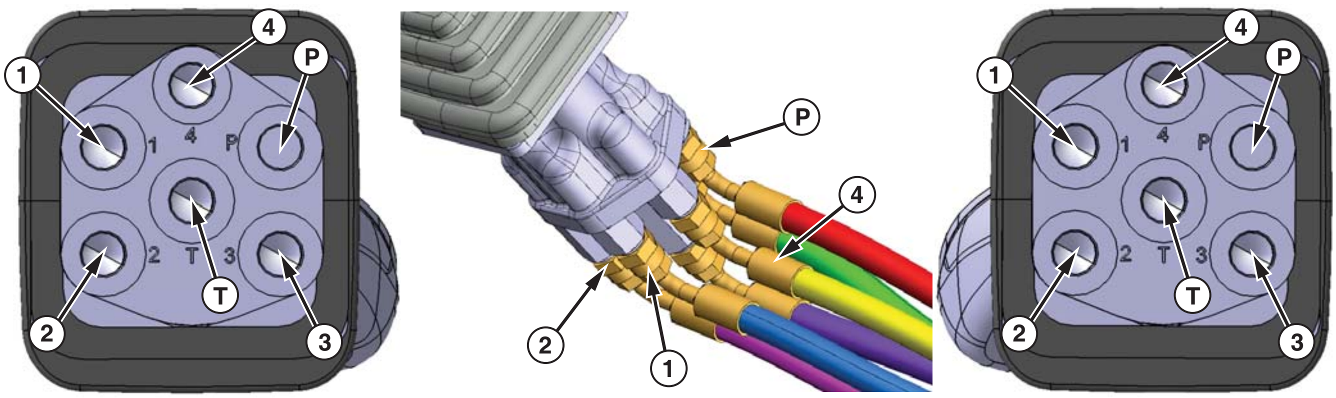


Figure 24

- Hoses and plugs ports

Port		Name	Plug/Flange Size (Hose)	(mm)	Torque		
					N.m	kg.m	ft lb
Left Hand	1	to Joint Sub Assembly "A6"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	2	to Joint Sub Assembly "A2"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	3	to Joint Sub Assembly "A8"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	4	to Joint Sub Assembly "A4"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	P	from PT Block "P"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	T	to PT Block "T" (Drain)	UNF 11/16"-16-2B	22	38.2	3.9	28.2
Right Hand	1	to Joint Sub Assembly "A7"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	2	to Joint Sub Assembly "A3"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	3	to Joint Sub Assembly "A5"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	4	to Joint Sub Assembly "A1"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	P	from PT Block "P"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
	T	to PT Block "T" (Drain)	UNF 11/16"-16-2B	22	38.2	3.9	28.2

- Fitting

Port		Name	Size		(mm)	Torque		
			A	B		N.m	kg.m	ft lb
Left/Right Hand	1, 2, 3, 4, P, T	Adapter	PF 3/8"	UNF 11/16"-16	22	40.2	4.1	29.6
	1, 2, 3, 4, P, T	O-ring	S8000145 (4D, P14)	S8030061 (1B, F-06)				

* A: Opposite side of hose, B: Hose side

20. Remove joystick valve from control stand.

Figure 25

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

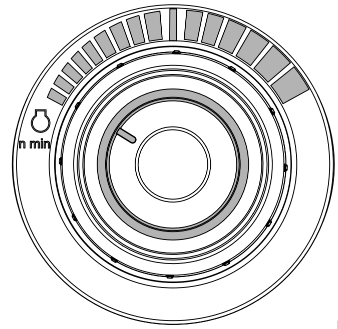
Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

1. Perform installation in the reverse order to remove.
2. Keep the assembly angle when installing the hoses to joystick valve.

COMPLETING WORK

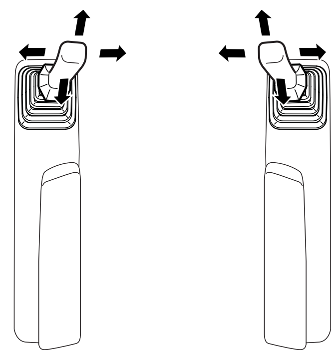
1. Start engine and set throttle at "LOW IDLE".
2. Move safety lever to "UNLOCK" position.



FG019382

Figure 26

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.
4. Perform the machine performance test.

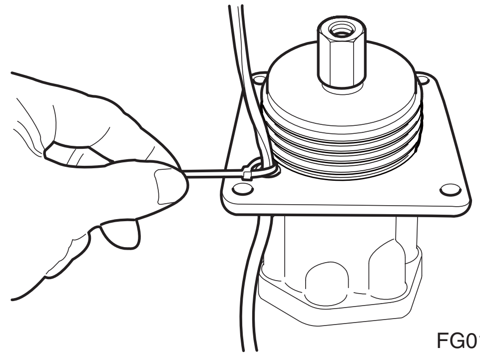


FG018384

Figure 27

DISASSEMBLY

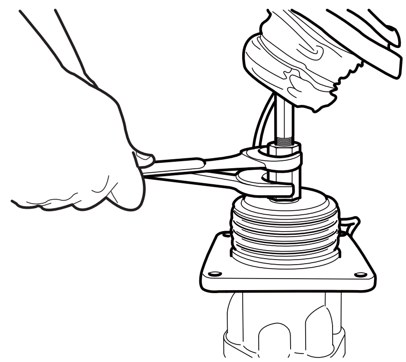
1. Remove lead wire from bushing (29).



FG013494

Figure 28

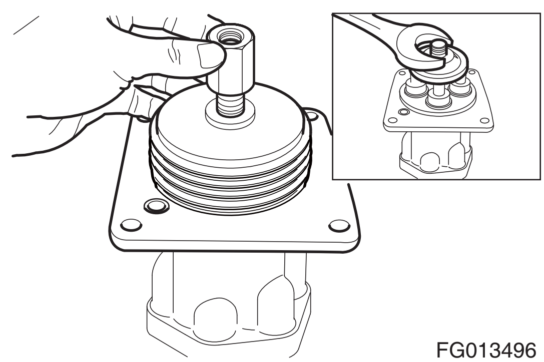
2. Remove lever assembly from case (1).



FG013495

Figure 29

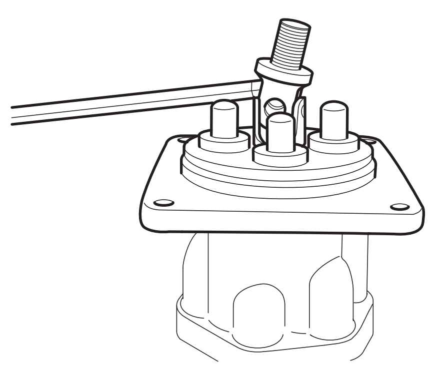
3. Remove hex nut (23) and swash plate (22) from case (1).



FG013496

Figure 30

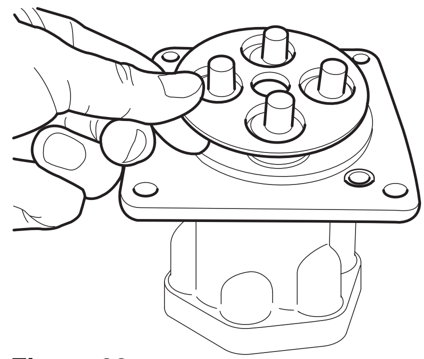
4. Remove joint assembly (21) from case (1).



FG013497

Figure 31

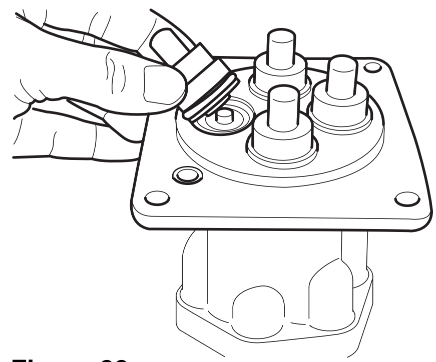
5. Remove plate (19) from case (1).



FG013498

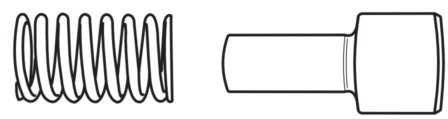
Figure 32

6. Remove plug kit assembly, stopper and spring (11) from case (1).



FG013499

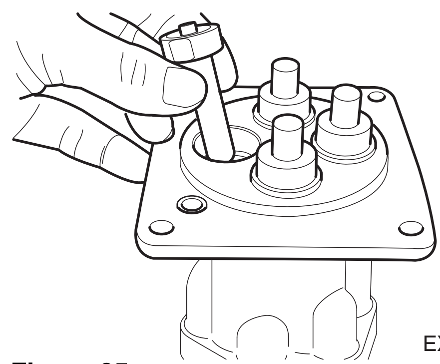
Figure 33



FG013501

Figure 34

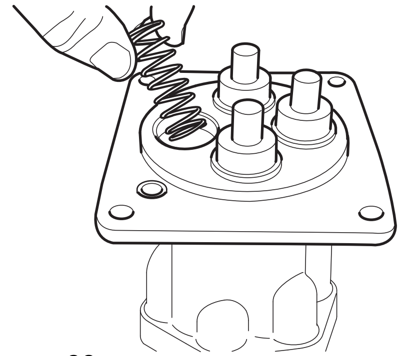
7. Remove 4 spool kit assemblies from case (1).



EX1301732

Figure 35

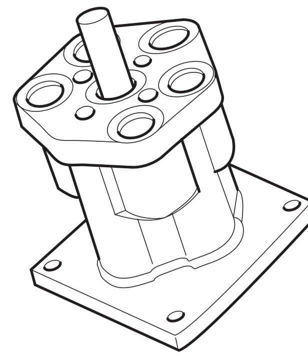
8. Remove spring (9) from (1).



FG013510

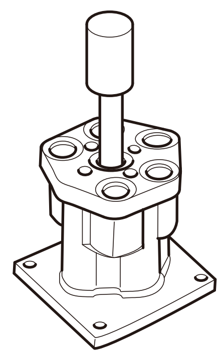
Figure 36

9. Remove bushing (3) from case (1).



FG013506

Figure 37



FG013508

Figure 38

10. Remove 4 plugs (2) from case (1).

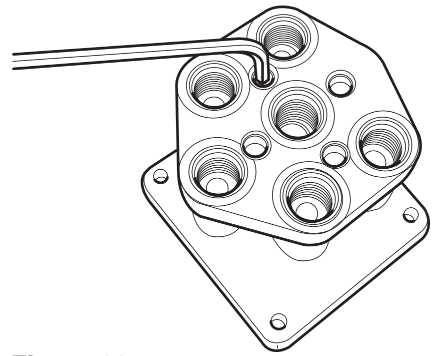


Figure 39

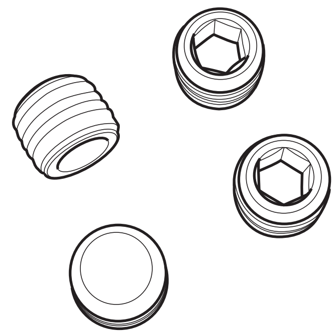
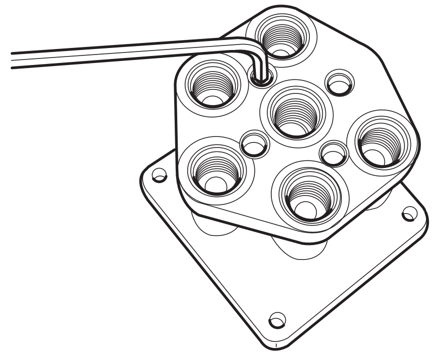


Figure 40

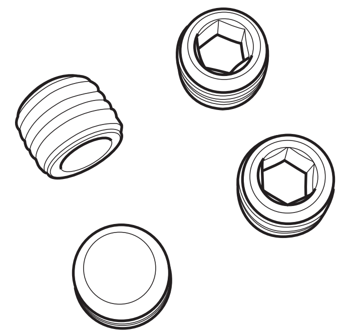
REASSEMBLY

1. Install 4 plugs (2) into case (1).



FG013504

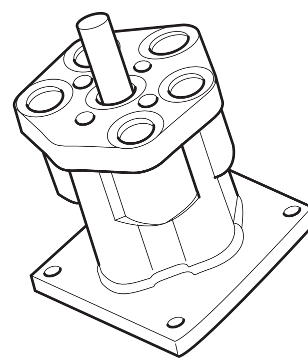
Figure 41



FG013507

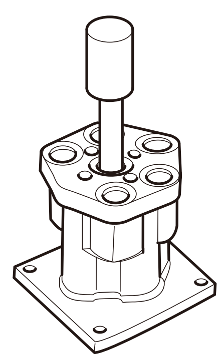
Figure 42

2. Install bushing (3) into case (1) using jig.



FG013506

Figure 43

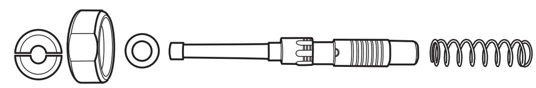


FG013508

Figure 44

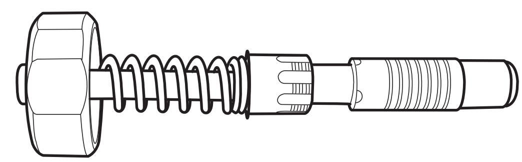
3. Take care when assembling spool kit assemblies (1 and 3, 2 and 4). (They must be assembled in same way).

   The assembly order is; spool (4), shim (5), spring (6), spring seat (7), and stopper (8).



FG013509

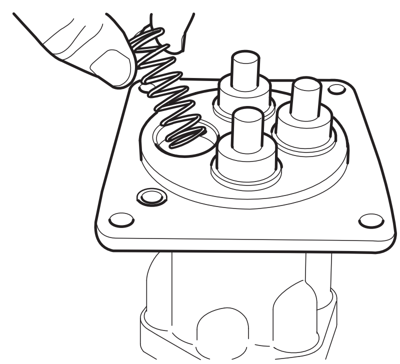
Figure 45



FG013503

Figure 46

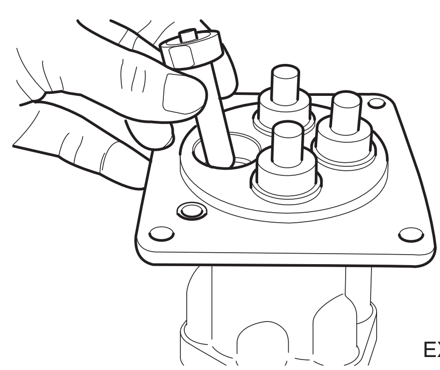
4. Install spring (9) into case (1).



FG013510

Figure 47

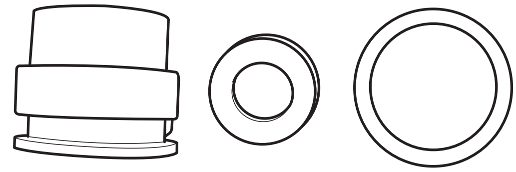
5. Install spool kit assembly into case (1). (The same way is used for four parts.)



EX1301732

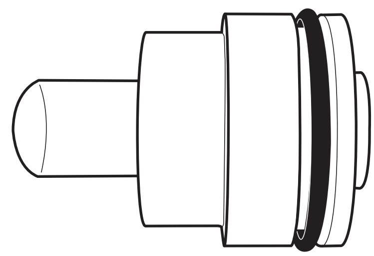
Figure 48

6. Assemble plug kit insert rod seal (18), O-ring (17), and push rod (12) into plug (16) in proper order.



FG013511

Figure 49

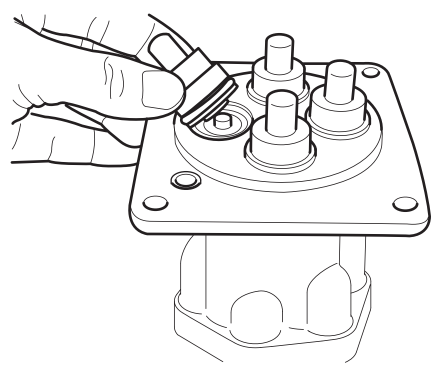


FG013512

Figure 50

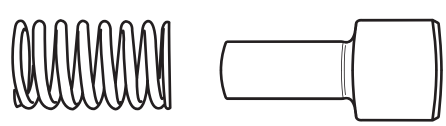
7. Install four springs (11) and stoppers and insert assembled set in case (1) to form a plug kit assembly.

   NOTE: *Pay attention to measurement specifications of stoppers (1 and 3, 2 and 4).*



FG013499

Figure 51



FG013501

Figure 52

8. Install plate (19) into case (1).

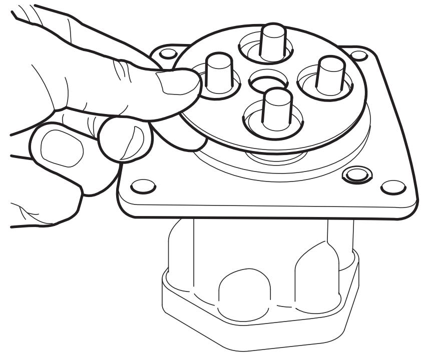

FG013498

Figure 53

9. Install joint assembly (21) into case (1).

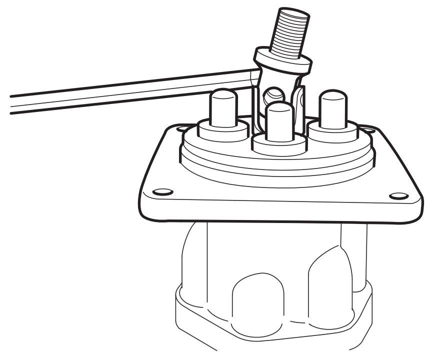

FG013497

Figure 54

10. Install boot and swash plate (22) and hex nut (23) into case (1).

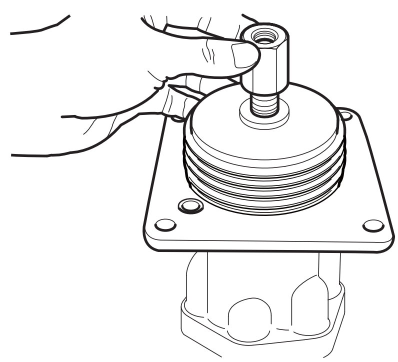

FG013513

Figure 55

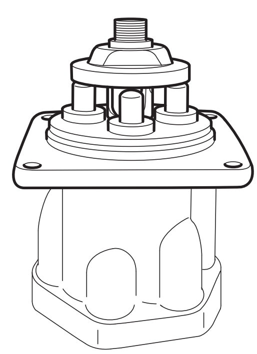

FG013514

Figure 56

11. Insert bar and tighten it with a wrench to check balance of joint assembly.

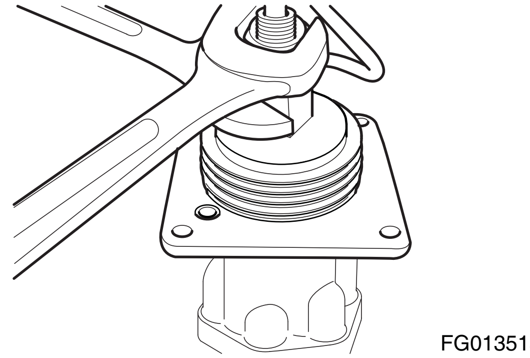


Figure 57

12. Install bushing (29) into case (1).

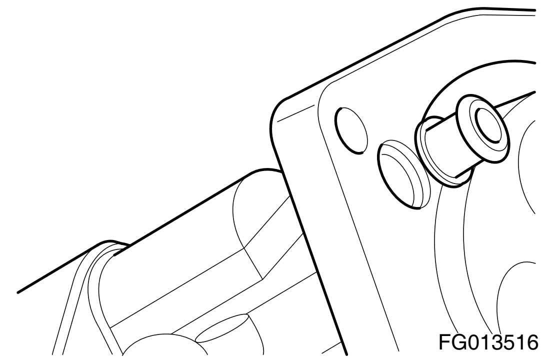


Figure 58

13. Install lever assembly into case (1).

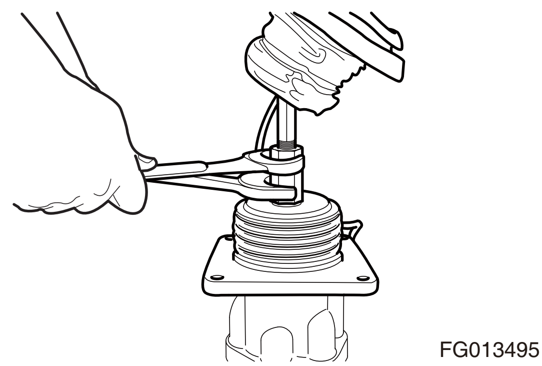


Figure 59

14. Put lead wire in bushing (29), tie it, and arrange boot.

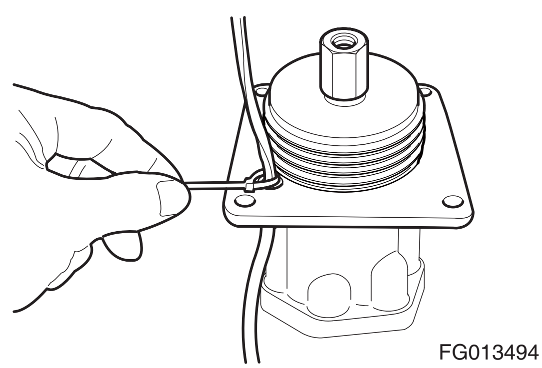


Figure 60

15. Assemble connector assembly (30), and connect it to lead wire terminal, and properly route wiring.

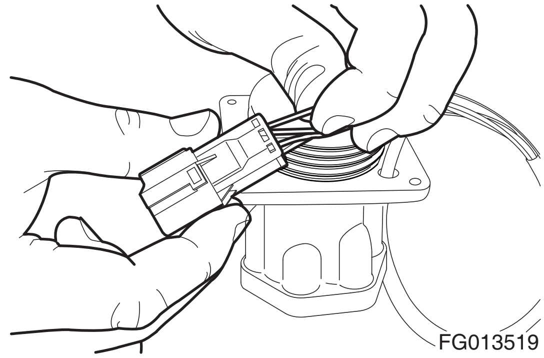


Figure 61

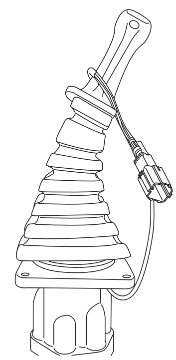


Figure 62

Travel Control Valve (with Damper)

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Travel Control Valve (with Damper)

GENERAL

Specification

Type	Pilot (with Damper)
Pressure/Stroke Characteristic	7.5 ~ 25 kg/cm^2 (7.4 ~ 25 bar) (@1 ~ 4.3 mm Stroke)
Max. Primary Pressure	100 kg/cm^2 (98 bar, 1,422 psi)
Max. Back Pressure	3 kg/cm^2 (2.9 bar, 42.7 psi)
Rated Flow	20 L/min (5.3 U.S. gal)
Weight	7.8 kg (17.2 lb)

Performance

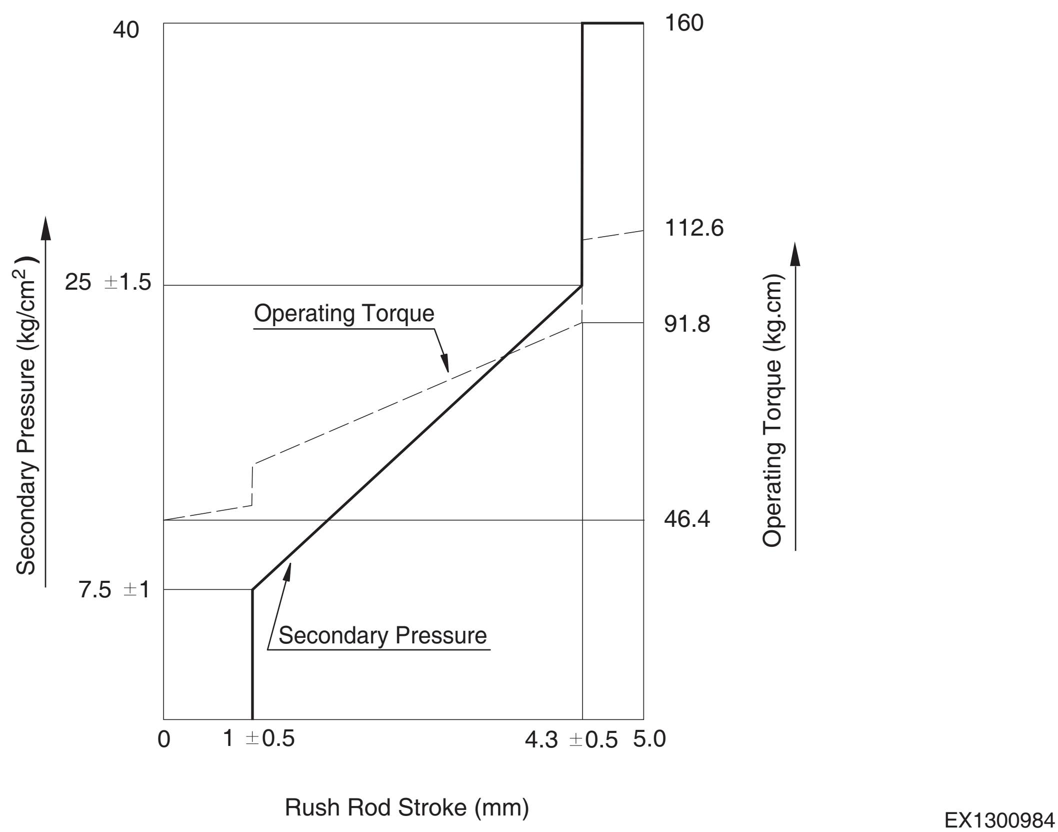
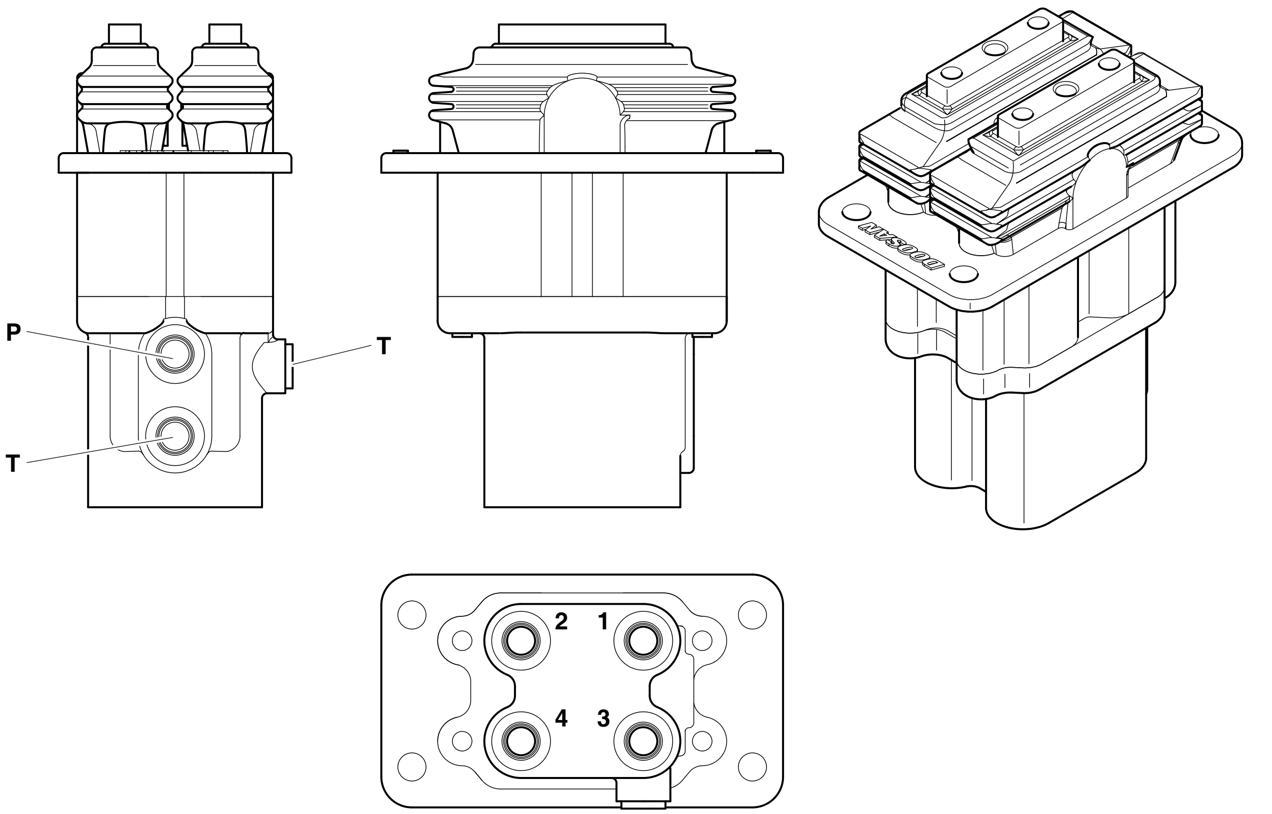


Figure 1

Overview

The pilot valve is a valve that controls the spool stroke, direction, etc of a main control valve.

This function is done by providing the spring at one end of the main control valve spool and applying the output pressure (secondary pressure) of the pilot valve to the other end.

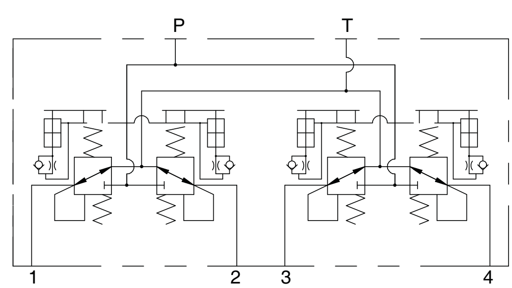


EX1301730

Figure 2

Port and Hydraulic Circuit

Port	Name	Size
1	Backward	PF 1/4" O-ring
2	Forward	
3	Backward	
4	Forward	
P	Pilot Oil Inlet	
T	Pilot Oil Return	



EX1301731

Figure 3

Parts List

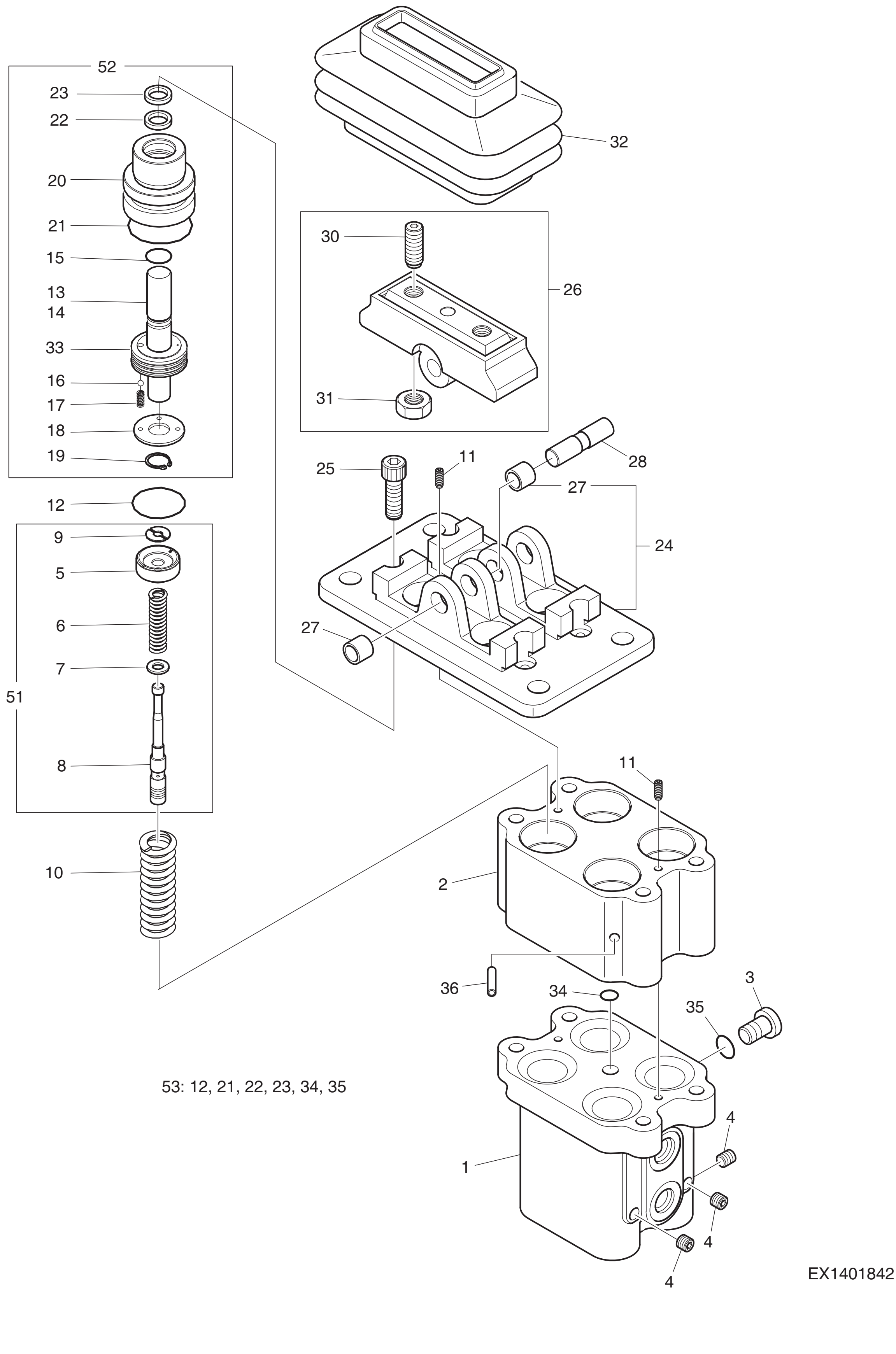


Figure 4

Reference Number	Description
1	Body (1)
2	Body (2)
3	Plug
4	Plug
5	Spring Seat
6	Spring
7	Spring Seat
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

Reference Number	Description
20	Plug
21	O-ring
22	Rod Seal
23	Dust Seal
24	Cover Kit
25	Socket Bolt
26	Cam Kit
27	DU Bushing
28	Camshaft
30	Set Screw
31	Nut
32	Bellows
33	Piston
34	O-ring
35	O-ring
36	Expand
51	Spool Kit
52	Plug Kit
53	Pedal Valve Seal Kit

Theory of Operation

Structure

The casing (spacer) has oil inlet port P (primary pressure), and the oil outlet port T (tank). In addition the secondary pressure is taken out through ports 1, 2, 3 and 4 provided at the bottom face.

Pressure Reducing Valve

1. Neutral position

   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-operated state

   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. Fully operated state

   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.

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 upperpart of low-pressure, now, 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.

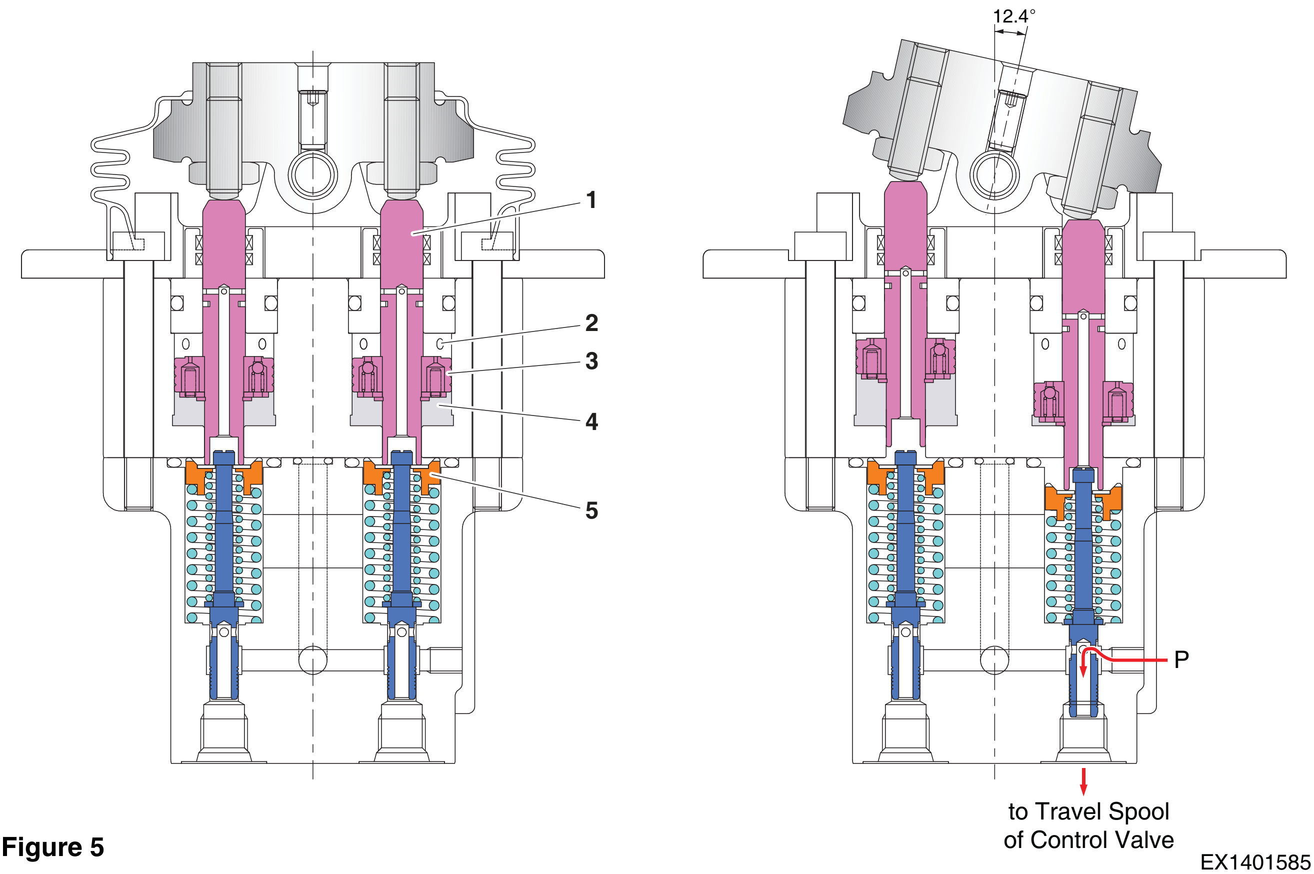


Figure 5

Reference Number	Description
1	Push Rod
2	Orifice
3	Piston

Reference Number	Description
4	Piston Chamber
5	Plug

Tools and Torques

Reference Number	Description	Size	Torque			Tool
			Nm	kg.m	ft lb	
25	Socket Bolt	M6	29.4	3	6	5 mm ( )
31	Nut	M10	43.1	4.4	32	17 mm ( )

SECTION VIEW

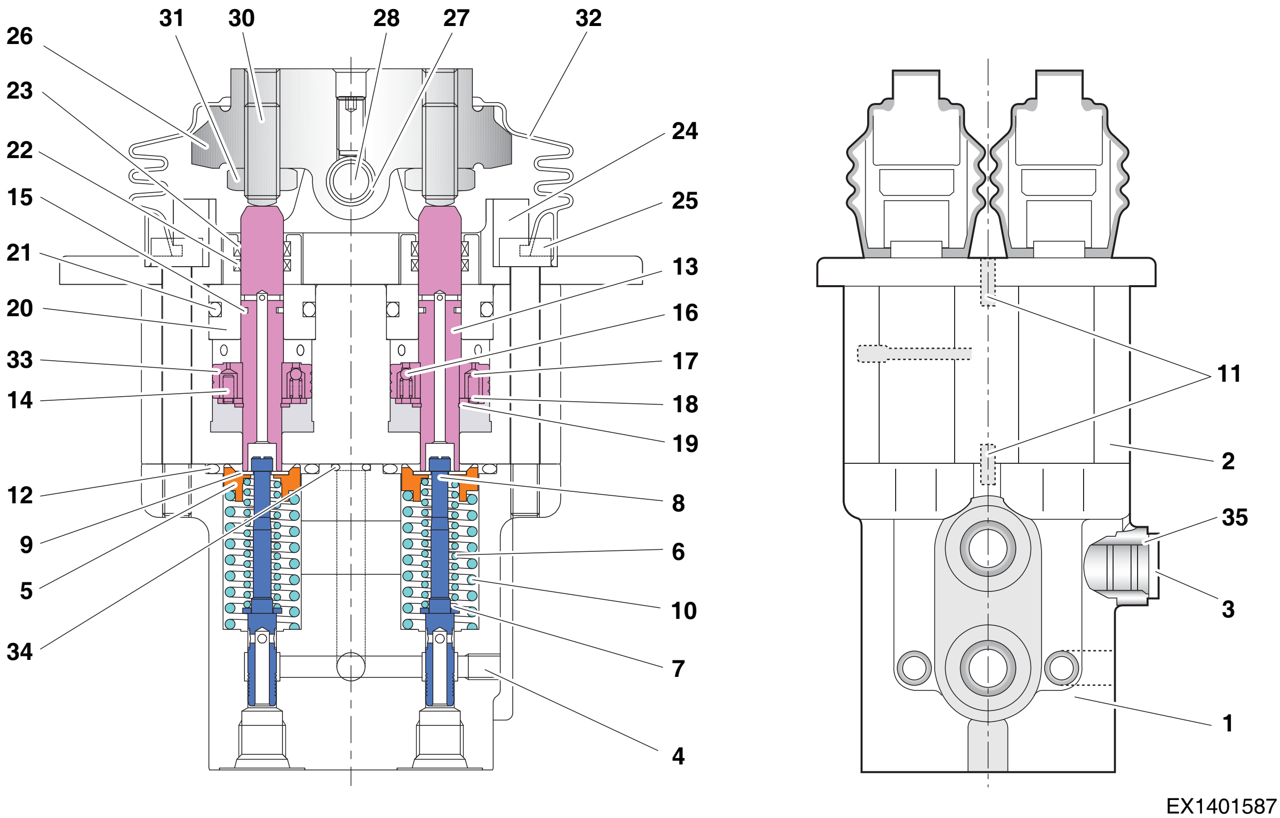


Figure 6

Reference Number	Description
1	Body (1)
2	Body (2)
3	Plug
4	Plug
5	Spring Seat
6	Spring
7	Spring Seat
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

Reference Number	Description
18	Plate
19	Snap Ring
20	Plug
21	O-ring
22	Rod Seal
23	Dust Seal
24	Cover
25	Socket Bolt
26	Cam
27	Bushing
28	Camshaft
30	Set Screw
31	Hex Nut
32	Bellows
33	Piston
34	O-ring
35	O-ring

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Make the machine swing about 30 degrees rightward on the flat ground as shown in Figure 7 before lowering the heel on the ground and then stop engine.

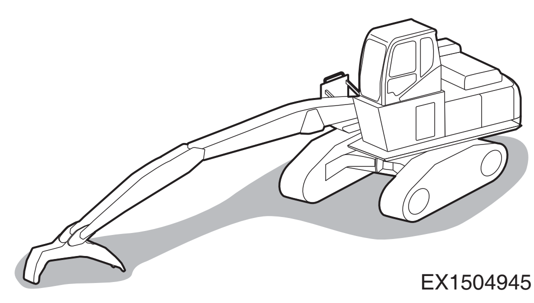


Figure 7

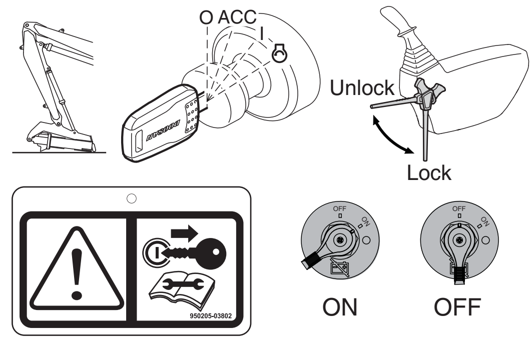
2. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 8)
3. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

4. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
5. Move safety lever to "LOCK" position. (Figure 8)
6. Turn key to "O" (OFF) position and remove from starter switch.
7. Attach a maintenance warning tag on controls.
8. Turn battery disconnect switch to "OFF" position. (Figure 9)



EX1504829

Figure 8

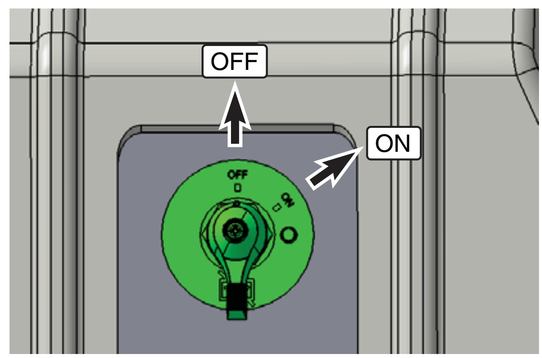
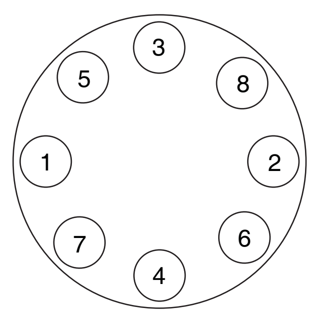


Figure 9 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*



EX1401809

Figure 10

WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

9. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.
   Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

10. Open the cabin riser cover (Figure 12).

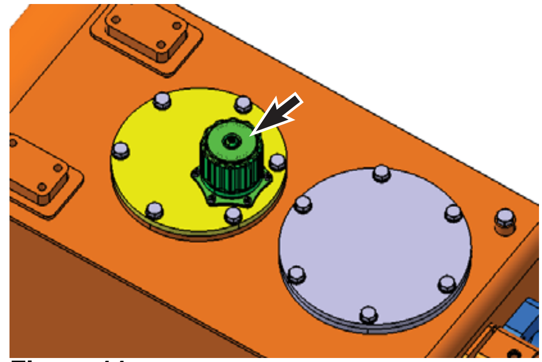
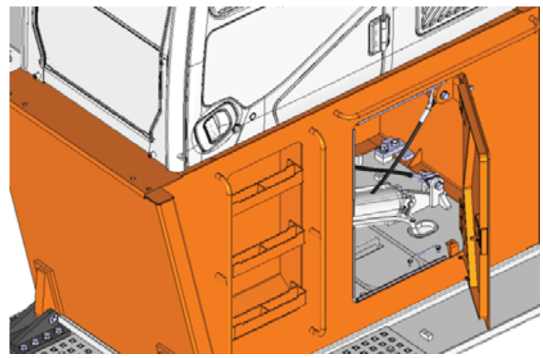


Figure 11 EX1404054



EX1505075

Figure 12

11. Remove hoses and adapters from travel control valve.

NOTE: *Attach identification tags to the removed hoses for reassembling. After disconnecting hoses from travel control valve, plug them to prevent dirt or dust from entering. Disconnect the hoses from the bottom to top of travel control valve.*

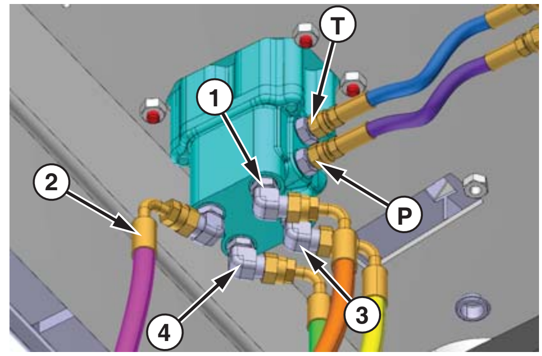


Figure 13 Bottom of Cabin DS1602392

- Hoses and plugs ports

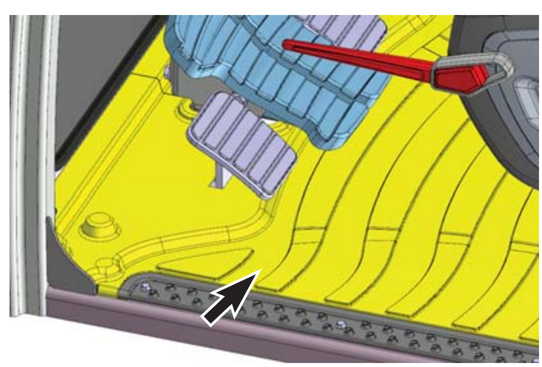
Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
1	to Control Valve "pa1"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
2	to Control Valve "pb1"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
3	to Control Valve "pa6"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
4	to Control Valve "pb6"	UNF 11/16"-16-2B	22	38.2	3.9	28.2
P	from Block PT	UNF 9/16"-18-2B	19	25.5	2.6	18.8
T	to Block PT (Drain)	UNF 9/16"-18-2B	19	25.5	2.6	18.8

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B		N.m	kg.m	ft lb
1, 2, 3, 4	Elbow	PF 1/4"	UNF 11/16"-16	19	36.3	3.7	26.8
P, T	Adapter	PF 1/4"	UNF 9/16"-18	19	36.3	3.7	26.8
1, 2, 3, 4	O-ring	S8000115 (4D P11)	S8030061 (1B F-06)				
P, T		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Valve side, B: Hose side

12. Open the cabin door.
    Remove floor mat from the cabin.



DS1602753

Figure 14

13. Remove bolts (1, Figure 15) (4 ea) and washers with foot rests (2) (2 ea) from floor plate.

    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

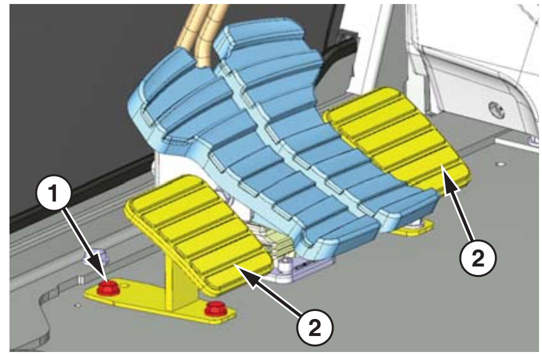


Figure 15 DS1602754

14. Remove bolts (1, Figure 16) (4 ea) and washers with travel pedals (2) (2 ea) from travel pedal bracket.

    - Tool: 17 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

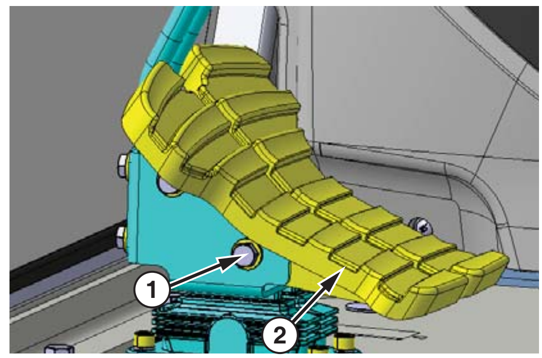


Figure 16 EX1402317

15. Remove bolts (1, Figure 17) (4 ea) and washers with travel pedal brackets (2) (2 ea) from travel control valve.

    - Tool: 8 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

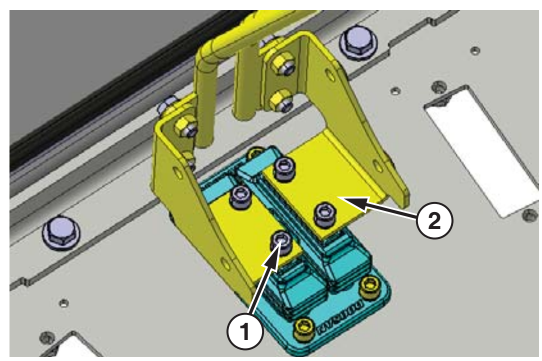


Figure 17 EX1402318

16. Remove bolts (1, Figure 18) (4 ea) and washers with travel control valve (2) from floor plate.

    - Tool: 8 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

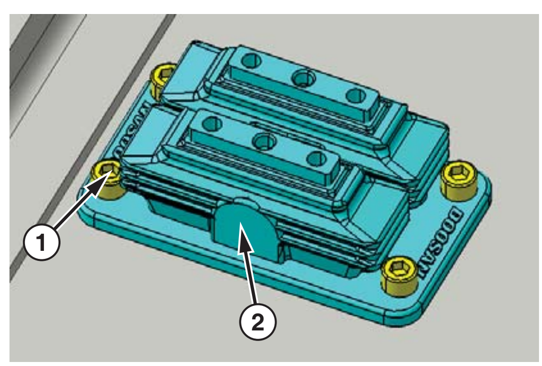


Figure 18 EX1402319

17. Remove travel control valve from floor plate.
    - Valve weight: about 8 kg (17.6 lb)

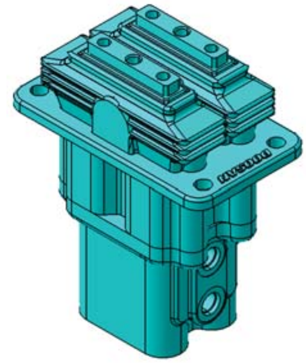


Figure 19 EX1402320

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

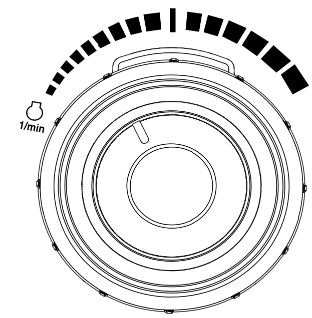
Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

1. Perform installation in the reverse order to removal.
2. When installing the hose, be install the drain hose first.

COMPLETING WORK

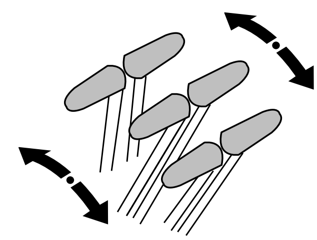
1. Start engine and set throttle at "LOW IDLE".
2. Move safety lever to "UNLOCK" position.



FG018148

Figure 20

3. Slowly push and pull both travel lever about five times without a load to vent air from pilot lines.



HAOB903L

Figure 21

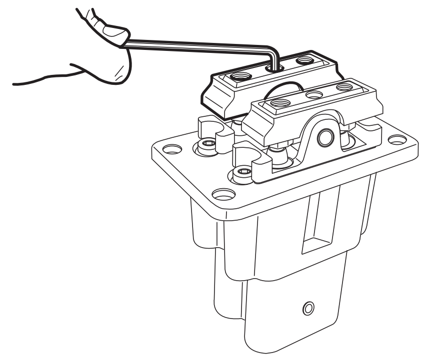
DISASSEMBLY

1. Remove bellows (32).

FG013535

Figure 22

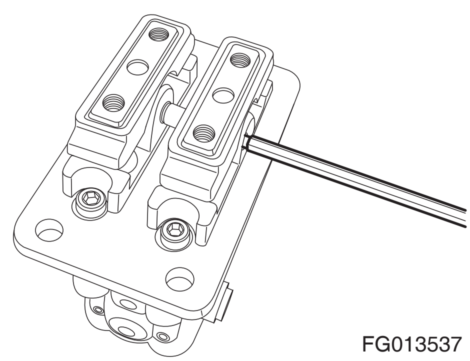
2. Remove set screw (29) from cam (26).



FG013536

Figure 23

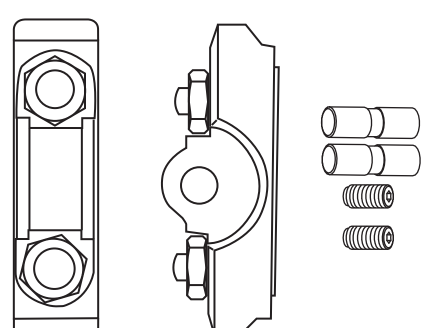
3. Remove camshaft (28) from cam (26).



FG013537

Figure 24

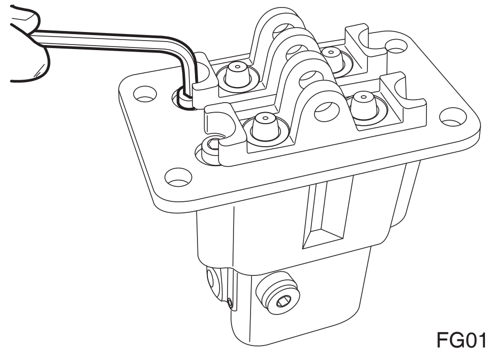
4. Remove hex nut (31) and set screw (30) from cam (27).



FG013538

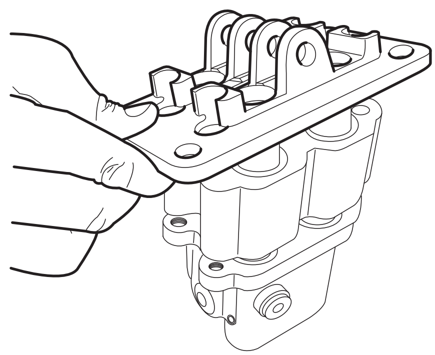
Figure 25

5. Remove hex socket head bolt (25) and cover (24) from each body (1 and 2).



FG013539

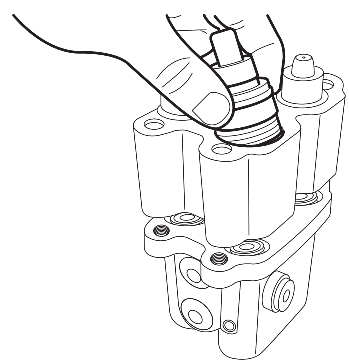
Figure 26



FG013540

Figure 27

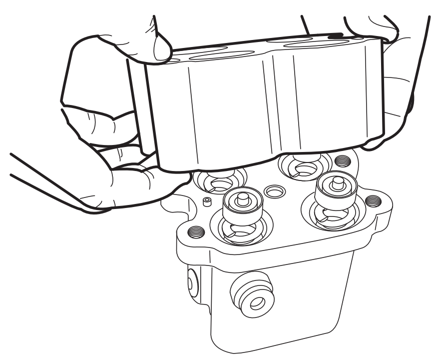
6. Remove push rod assembly from body (2).



FG013541

Figure 28

7. Remove body (2) from body (1).



FG013542

Figure 29

8. Remove damper spool assembly and spring (10) from body (1).

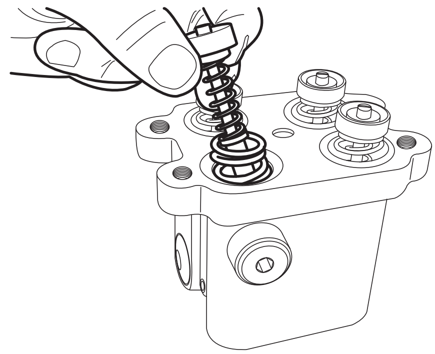

FG013543

Figure 30

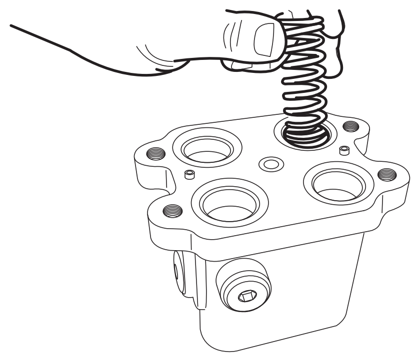

FG013544

Figure 31

9. Remove plug (3 and 4) and O-rings (12 and 34).

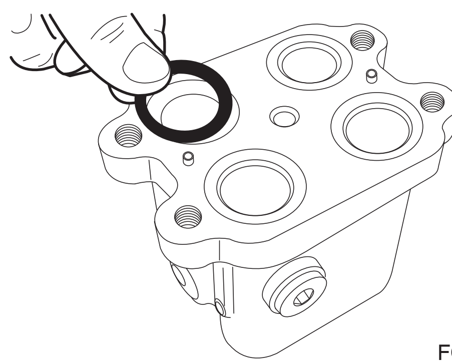
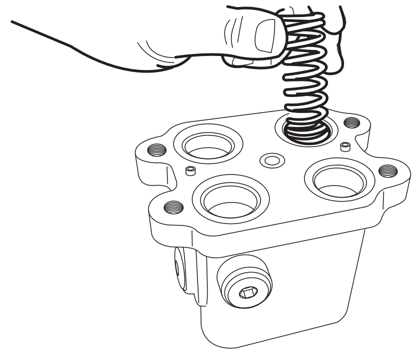

FG013545

Figure 32

REASSEMBLY

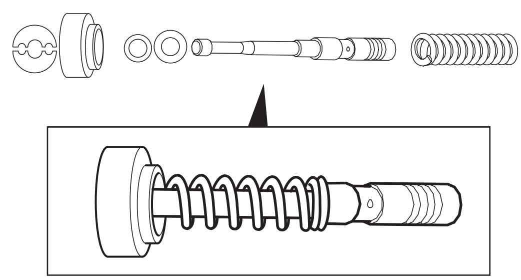
1. Insert spring (10) into body (1).



FG013544

Figure 33

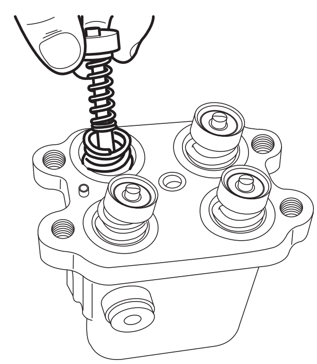
2. Assemble in proper order, damper spool (8), shim (7), spring (6), spring seat (5) and stopper (9).



FG013546

Figure 34

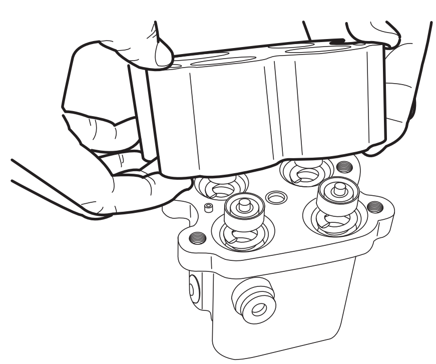
3. Install damper spool assembly into body (1).



FG013547

Figure 35

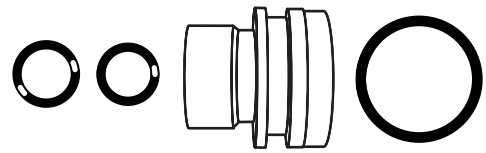
4. Assemble body (2) onto body (1).



FG013542

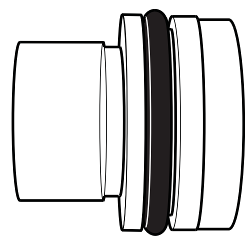
Figure 36

5. Assemble rod seal (22), dust seal (23) and O-ring (21) into plug (20).



FG013548

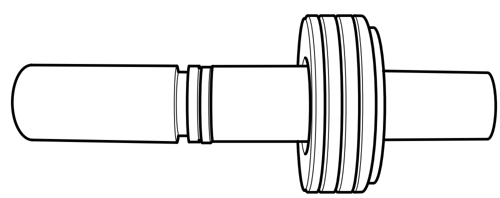
Figure 37



FG013549

Figure 38

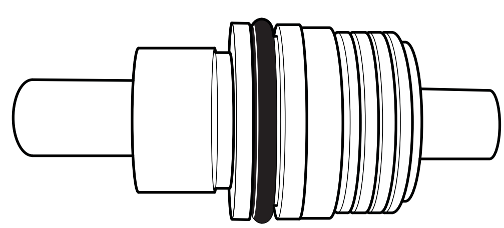
6. Assemble seal (15), piston (33), steel ball (16), plate (18), spring (17) and retaining ring (19) into push rod (13).



FG013550

Figure 39

7. Assemble push rod and plug.



FG013551

Figure 40

8. Install push rod assembly into body (2).

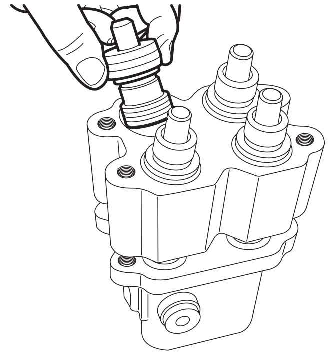

FG013552

Figure 41

9. Install bushing (27) in cover (24) using jig.

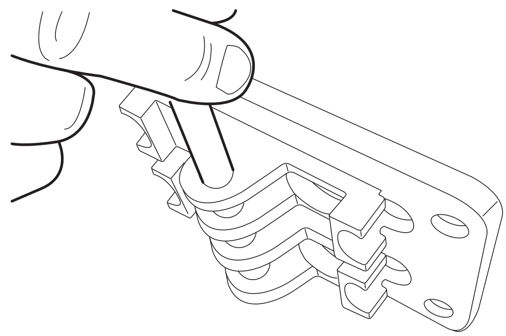

FG013553

Figure 42

10. Assemble cover (24) onto each body (1 and 2) and install hex socket head bolt (25) using torque wrench.

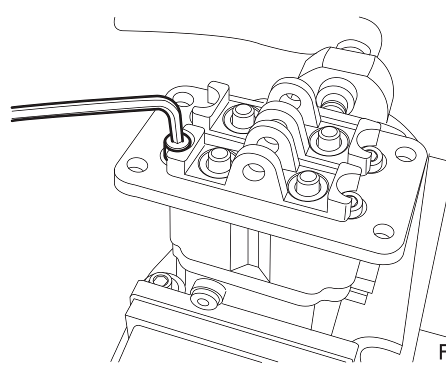

FG013554

Figure 43

11. Install set screws (30) and hex nut (31) into cam (26) and tighten it.

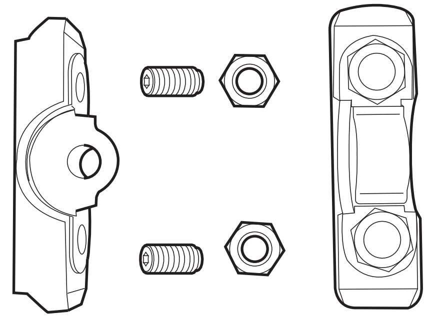

FG013555

Figure 44

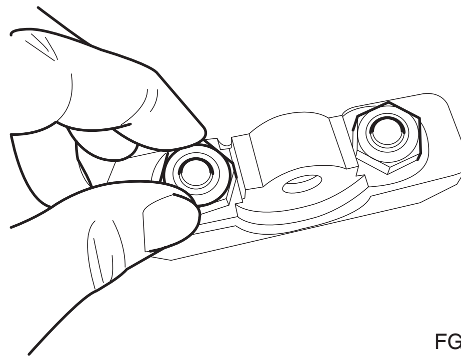

FG013556

Figure 45

12. Position cam (26) on cover (24) and insert camshaft (29) using hammer.

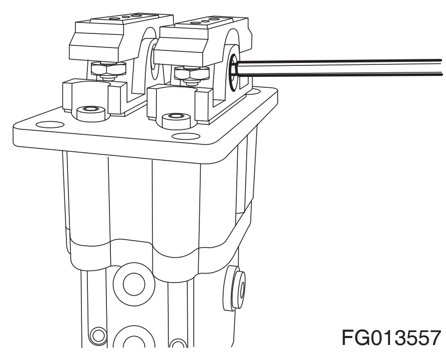

FG013557

Figure 46

13. Install set screw (29) in cam (26) and tighten it using torque wrench.

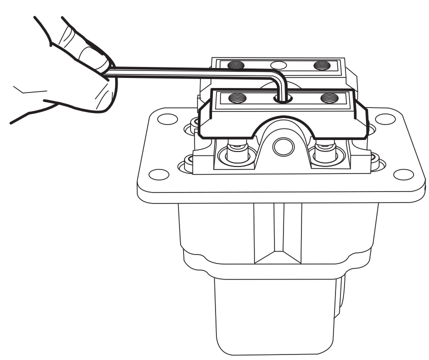

FG013558

Figure 47

14. Check cam balance.

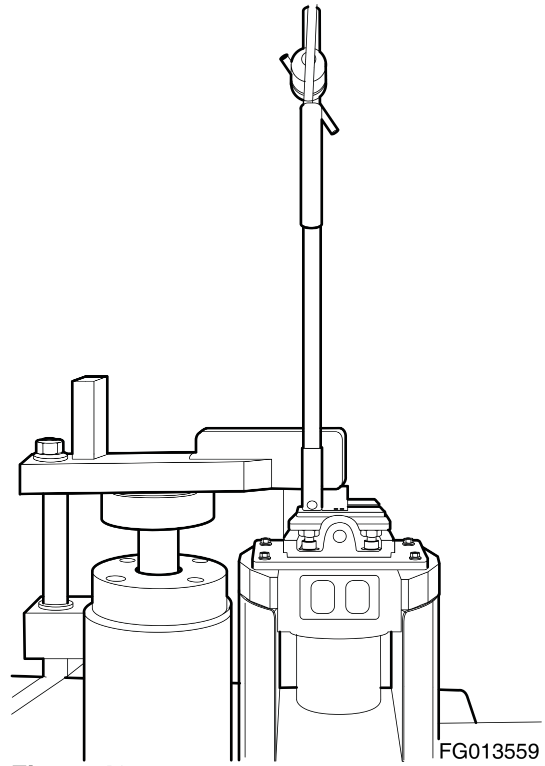


Figure 48

15. Install bellows.

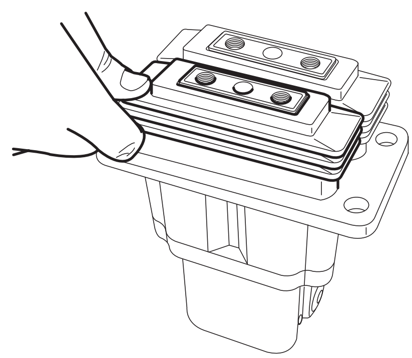


Figure 49

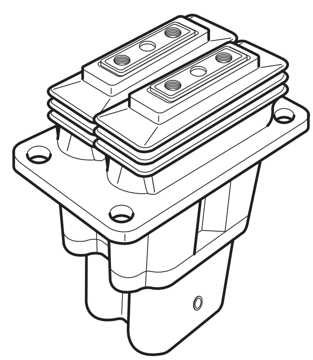


Figure 50

TROUBLESHOOTING

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. Often 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.

Solenoid Valve

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

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Table of Contents

Solenoid Valve

GENERAL

Specification

Pressure (Max.)	69 bar (70 kg/cm^2, 996 psi)
Flow (Max.)	23 L/min (6.1 U.S. gal)
Leakage	40 ml/min
Solenoid Coil	
Rated Voltage	DC 24 V
Operation Voltage Range	20 ~ 30 V
Surge Absorber	Built in
Connector Type	Deutsch DT-02 Series
	Housing Series: DT04-2P-Type molded
	Deutsch Terminals: Pin 1060-16-0122
Test	49 bar at 20 L/min

Overview

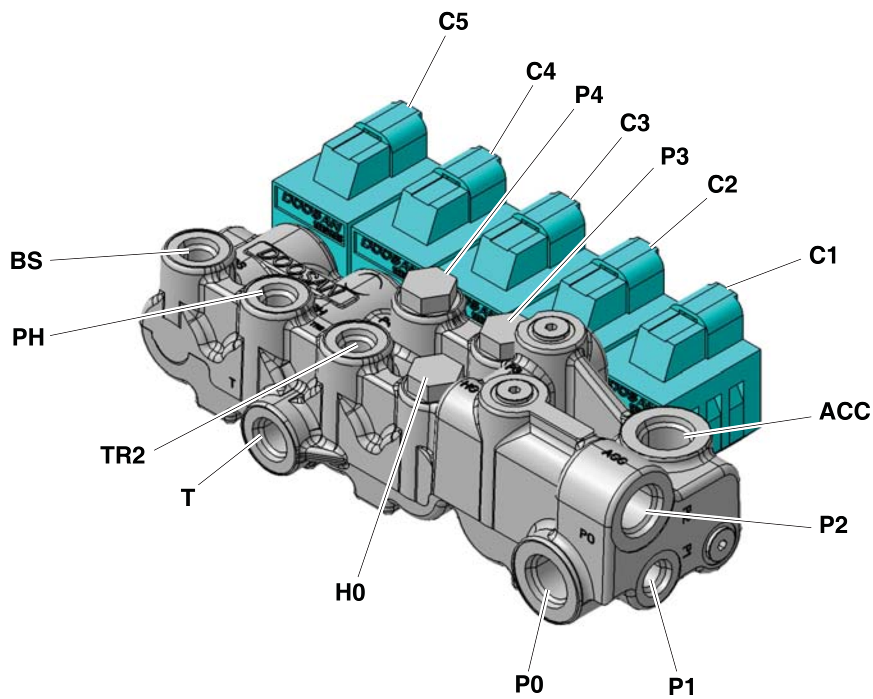
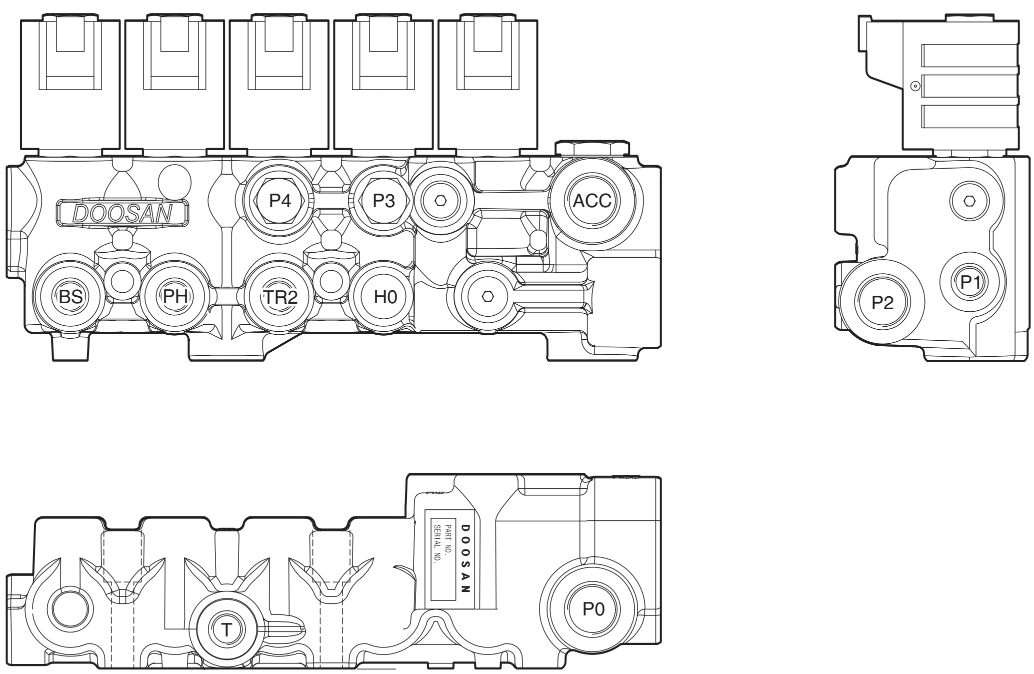


Figure 1

EX1301733

Port and Hydraulic Circuit



DS1602580

Figure 2

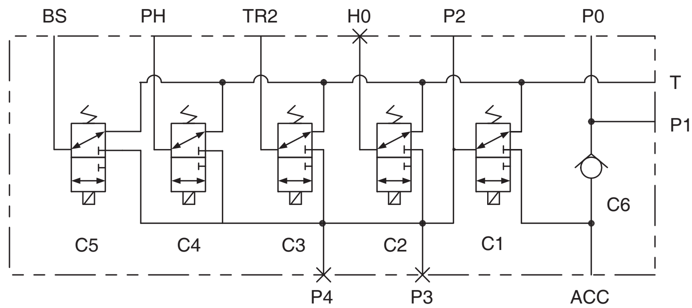


Figure 3

Port	Name	Size
P0	Pilot Filter	PF 1/2", O-ring
P1	Pilot Inlet Pressure	PF 1/4", O-ring
P2	Safety Cut-off	PF 1/2", O-ring
P3	Plugged	PF 1/4", O-ring
P4	Plugged	PF 1/4", O-ring
T	Pilot Outlet Pressure	PF 3/8", O-ring
ACC	Accumulator	PF 1/2", O-ring
BS	Two Pump Mode Selection	PF 1/4", O-ring
PH	Pressure Up	PF 1/4", O-ring
TR2	Travel High/low Speed	PF 1/4", O-ring
H0	Plug	PF 1/4", O-ring

Parts List

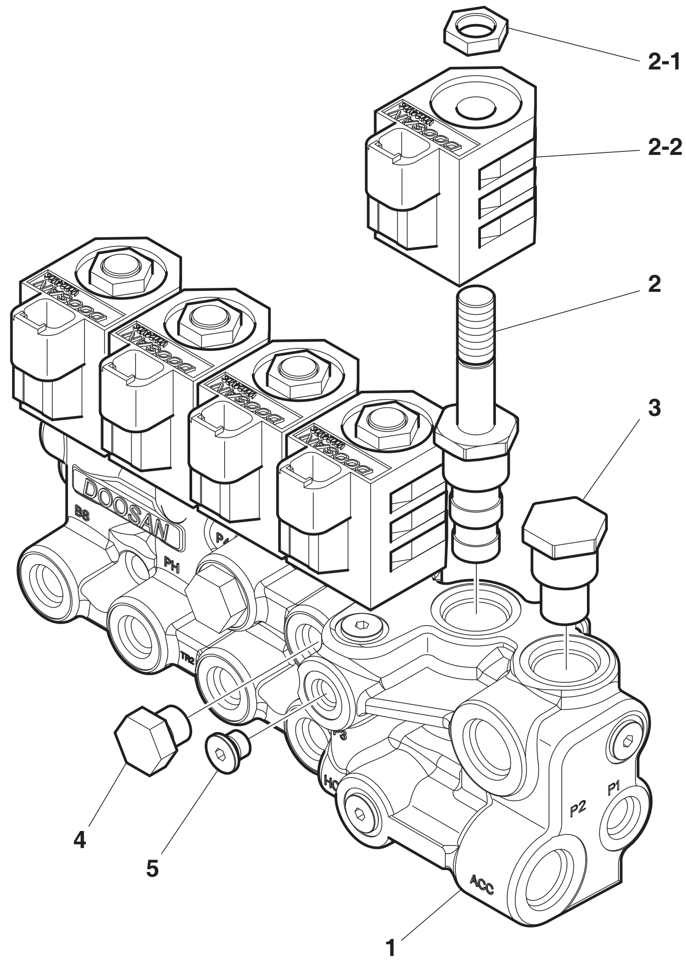


Figure 4

Reference Number	Description	Size	Torque (kg.m)	Tool
2	Solenoid Valve	UNF 7/8" - 14	3.5 ±0.25	Torque Wrench/1", Hex
2-1	Coil Locknut	UNF 1/2" - 20	0.6	Torque Wrench/19 mm, Hex
2-2	Coil			
3	Check Valve	UNF 7/8" - 14	3.5 ±0.25	Torque Wrench/1", Hex
4	Plug	PF 1/4"	2.5 ±0.25	Torque Wrench/19 mm, Hex
5	Plug	PF 1/8"	0.1 ±0.25	Torque Wrench/5 mm, Socket

Theory of Operation

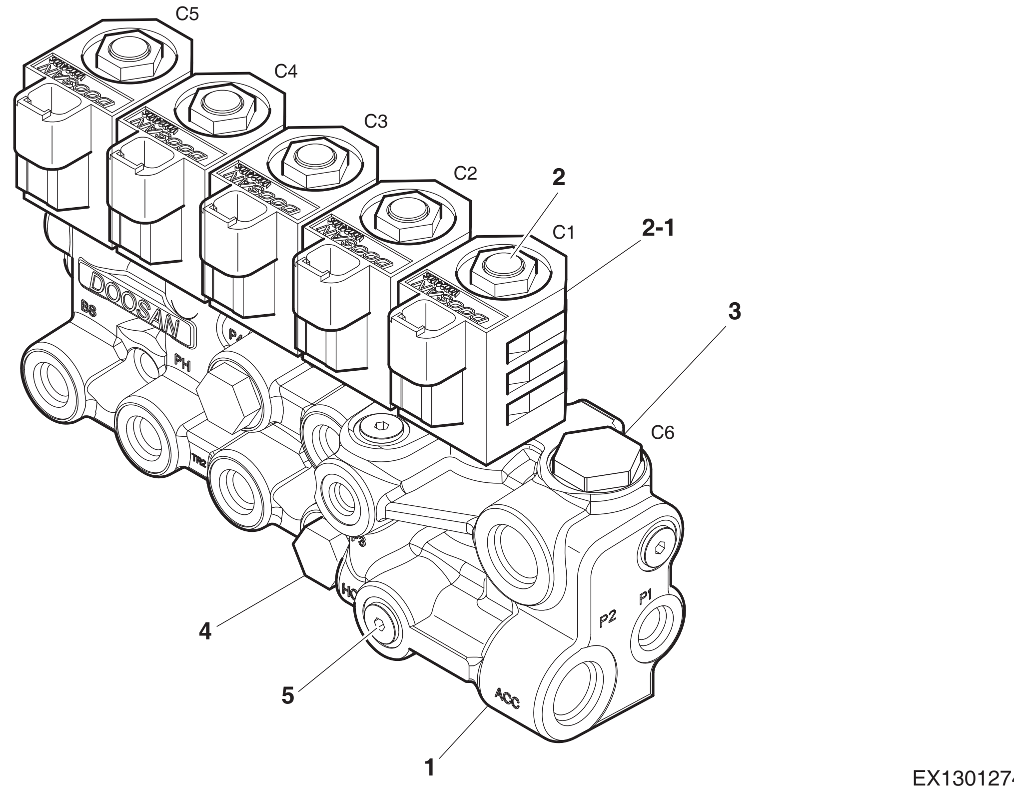


Figure 5

Reference Number	Description	Quantity	Remarks
1	Block Body	1	
2	Solenoid Valve	5	C1 - C5
2-1	Coil (Deutsch Type)	5	C1 - C5
3	Check Valve	1	C6
4	Plug	3	P3, P4, H0
5	Plug	6	

Reference Number	Function	Operations	Remarks
C1	Pilot Cut-off	Provides pressurized oil coming from the pilot pump for the pilot pressure supply solenoid valve to operate each work system.	
C3	High/Low Travel Speed	Sets low and high travel speed. Shifts speed between both depending on the state of the solenoid valve or a signal detected in the EPOS controller.	
C4	Main Pressure (Power Boost) Increase	Temporally increases the pressure setting of the main relief valve, to increase the power.	
C5	Two-Pump Mode Selection	Supplies pilot pressure to two-pump valve that controls the two-pump function so it ready to work in the two-pump mode during shear mode.	

DISASSEMBLY AND REASSEMBLY

1. Choose a work area for disassembly.

   NOTE: *(1) Choose a clean work area.*

   (2) Use a rubber mat or other protective covering on the workbench area to prevent damage or scratching of any precision machined components.

2. For disassembly and reassembly, use torques and tools listed in tables.
3. The directions of disassembly and reassembly are same as the "Disassembly Direction" and "Reassembly Direction" as shown in Figure 4.
4. Disassembly and reassembly of the solenoid valve

   A. Remove coil locknut (2-1) from solenoid valve (2).

   ## IMPORTANT

   Take care not to damage the solenoid valve (2) when removing the coil locknut.

   If the solenoid valve (2) is damaged (bent or deformed), the solenoid valve may not operate.

   B. Remove coil (2-2) by hand.

   C. Remove solenoid valve (2).

   D. Check disassembled components for damage, and reassemble them in the reverse order of the disassembly.

   E. Do not use excessive torque when assembling he solenoid valve and coil.

   ## IMPORTANT

   Excessive torque can damage the solenoid valve.

5. Do not allow any contamination to enter the valve during disassembly and reassembly procedures.
6. Every component must be washed out before reassembly.

TROUBLESHOOTING

Symptoms	Causes	How to Check	Solutions
Malfunction of solenoid valve	Foreign substance, dirt and dust in solenoid valve.	Disassemble the solenoid valve and check if there is any contamination such as a foreign substance and sludge between the case and the spool.	Remove contaminant, wash, and assemble components.
	Tube or retainer of solenoid valve damaged.	Disassemble the solenoid valve and check if there is any deformation (bending or reduction) in the tube or the retainer.	Replace solenoid valve.
	Coil broken, short, or burned.	Disassemble the solenoid valve and check the coil resistance. Spec: 26.7Ω @ 20°C Disconnection: ∞ Short: Low or excessive resistance Disassemble the solenoid valve and check the outside of the coil to see if its casing is burned and melted.	Replace coil.
	Connector terminal ground defect.	Check if the connector (valve side) and housing (where harness is attached) are grounded properly.	Replace coil or housing.
Pilot pressure fails to generate;	Pilot pressure.	Remove plug of the "P5" port, install a pressure gauge, and check the pilot pressure discharged from the pilot pump when operating the pilot cut-off valve (C1).	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 bypassing because of 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.
Poor Actuator Performance	Pilot system.	Check any defect of the pilot system considering findings from "Pilot pressure fails to generate;" category.	Repair defect(s) accordingly.
	Solenoid valve.	Install a pressure gauge at each outlet port of the solenoid valve (H0, TR2, PH, and BS 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.	Repair according to findings.
	Other components.	Check if each component works properly.	Repair according to findings.

EPPR Valve

SAFETY INSTRUCTIONS

⚠ WARNING

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Table of Contents

EPPR Valve

GENERAL

Specification

Max. Supply Pressure	40 bar (40 kg/cm^2, 580 psi)
Back Pressure	3 bar (3 kg/cm^2, 43 psi)
Max. Supply Rate	18.9 L/min (5 U.S. gal)
Weight	0.68 kg (1.5 lb)

Reducing Pressure vs Current Characteristic

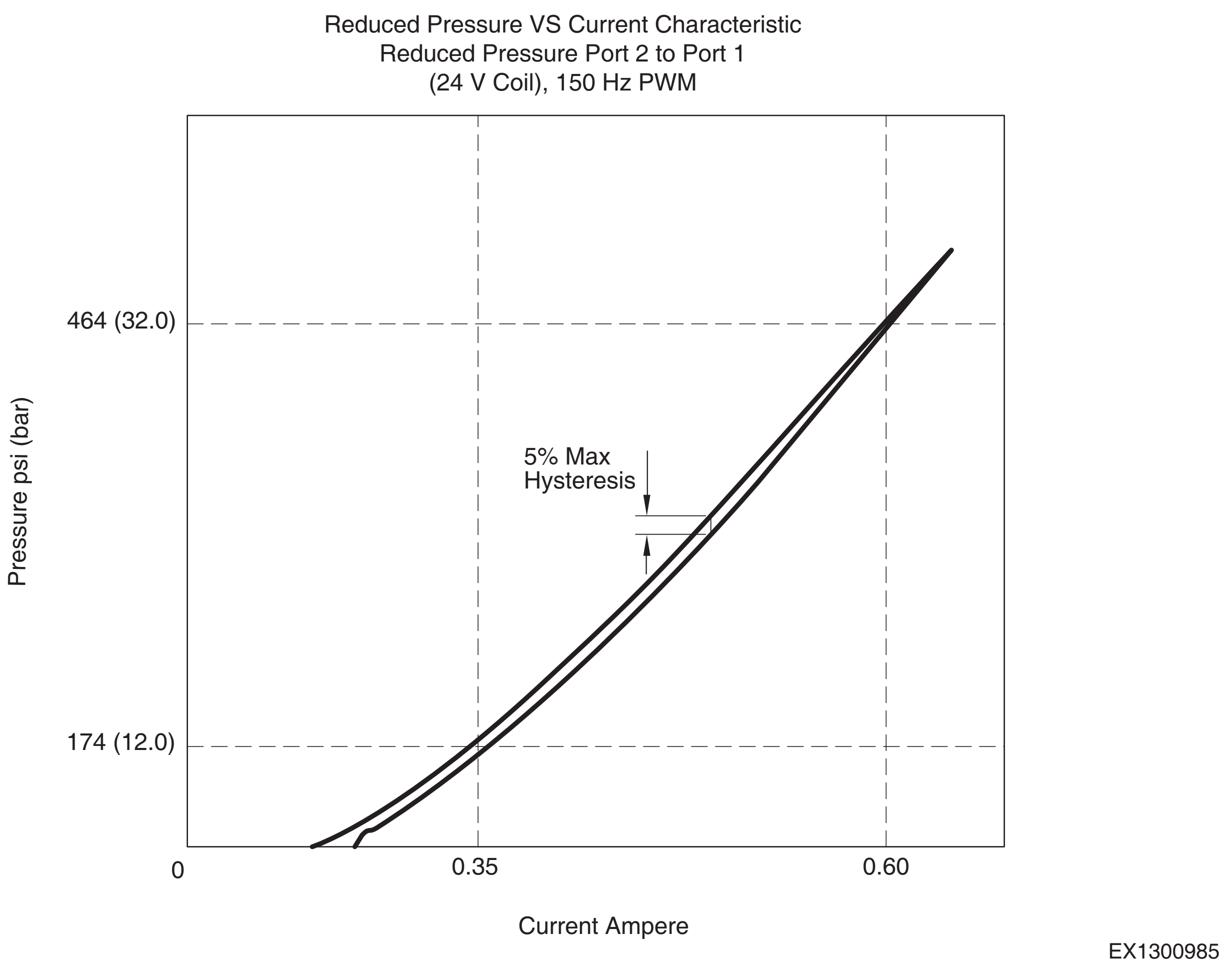

Figure 1

Overview

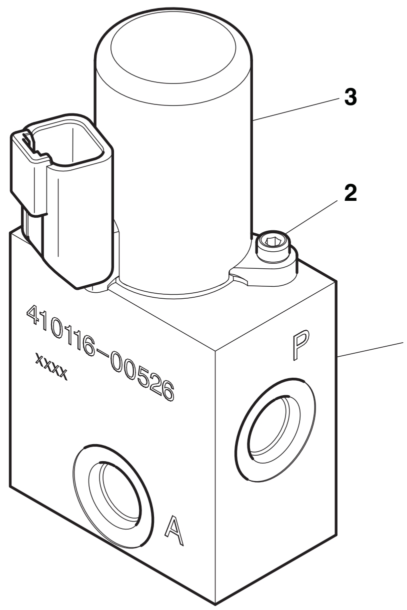

Figure 2

Reference Number	Description	Quantity	Remarks	Torque (Nm)	Tools
1	Block	1			
2	Bolt	2	M4 bolt	1.2 ~ 1.5	Torque Wrench 3 mm, Hex
3	Proportional Reducing/ Relief Valve	1			

Hydraulic Circuit

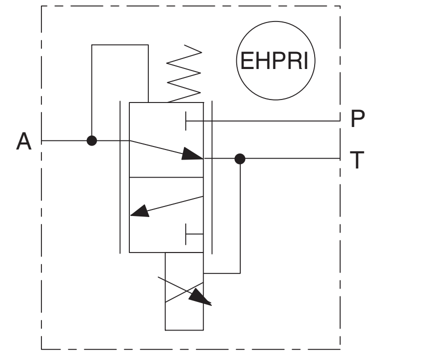

Figure 3

TROUBLESHOOTING

Symptoms	What to check	Possible Solution
Pressure setting at port A constant setting regardless of changes in current at approximately 0 bar.	Remove cartridge and inspect O-rings for possible damage or degradation.	Replace the EPPR valve or solenoid cartridge (part no: 410116-00646).
	Remove cartridge and inspect for contamination.	Clean or replace with new cartridge. DO NOT DISASSEMBLE CARTRIDGE TO ATTEMPT TO REPAIR.
	Check coil resistance (20.9 Ohms @ 20°C)	If shorted or open circuit, replace with new valve
Pressure setting at port A constant setting regardless of changes in current at a very high-pressure.	Remove cartridge and inspect for contamination collected on the screen inlet to the valve.	Clean off the screen or replace with new cartridge. DO NOT DISASSEMBLE CARTRIDGE TO ATTEMPT TO REPAIR.

Accumulator

SAFETY INSTRUCTIONS

WARNING

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Accumulator

GENERAL

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

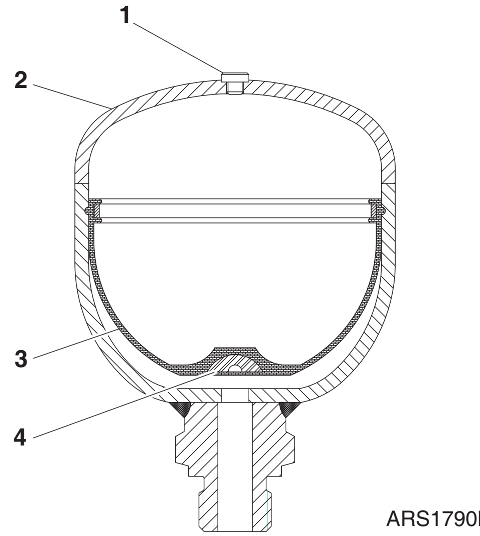

Figure 1

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 must be stamped or marked on the accumulator's rating plate. Annual checks of actual precharge pressure must be made by tapping a hydraulic pressure gauge (and 3-way adapter coupling) into the valve on the bottom of the accumulator.*

   When hydraulic fluid is pushed out the lower valve opening by the pressure of the gas charge on the other side of the diaphragm - and there is no counterpressure from system oil - the valve

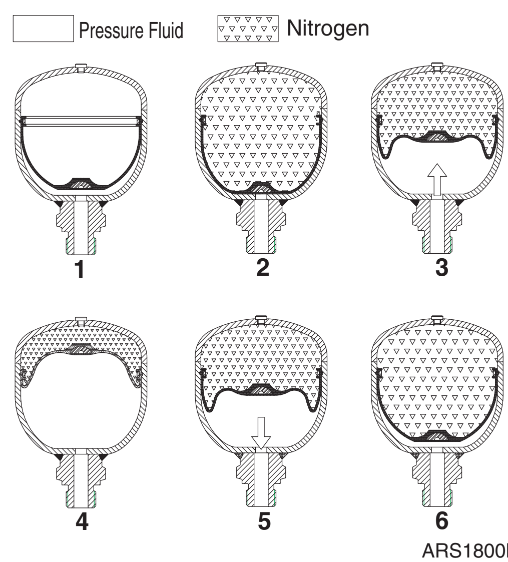

Figure 2

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

Record the highest gauge reading and compare to "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

System	Charge Pressure	Volume
Pilot	9.8 bar (10 kg/cm^2, 142 psi)	320 cc (19.53 in^3)

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 "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

System	Charge Pressure	Volume
Pilot	9.8 bar (10 kg/cm^2, 142 psi)	320 cc (19.53 in^3)

Gear Pump (Rotating)

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

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Gear Pump (Rotating)

GENERAL

Specification

Direction of Rotation (Looking on Driveshaft)	Clockwise
Displacement	26.7 cm^3/rev
Inlet Pressure Range for Pump	0.7 ~ 3 bar (0.7 ~ 3 kg/cm^2, 10.1 ~ 43.5 psi)
Max. Continuous Pressure	280 bar (286 kg/cm^2, 4,061 psi)
Max. Intermittent Pressure	300 bar (306 kg/cm^2, 4,351 psi)
Max. Peak Pressure	310 bar (316 kg/cm^2, 4,496 psi)
Weight	13.7 kg (30.2 lb)

Overview

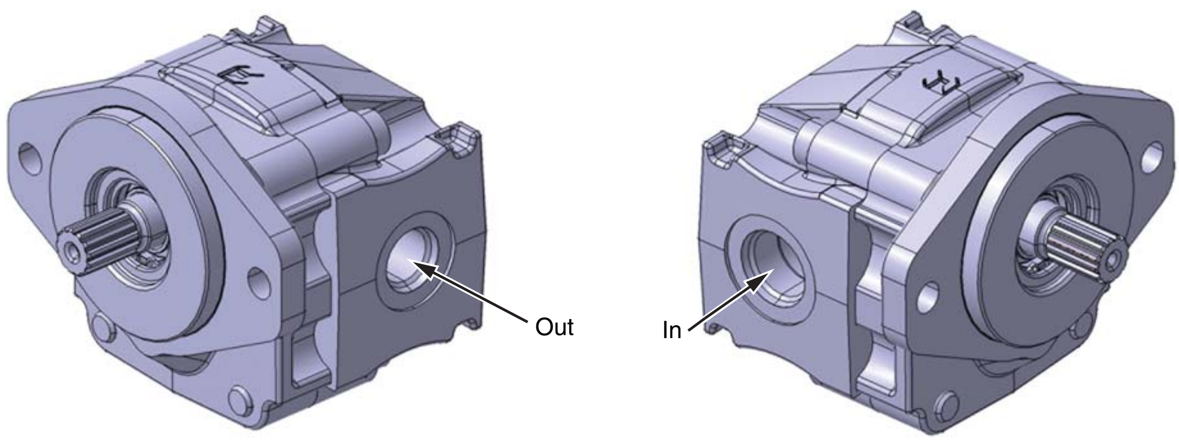
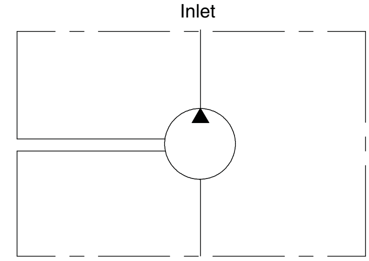


Figure 1

EX1400103

Port and Hydraulic Circuit

Port	Name	Size
In	Hydraulic Oil Inlet	PF 1" O-ring
Out	Hydraulic Oil Outlet	PF 3/4" O-ring



EX1301736

Figure 2

Location

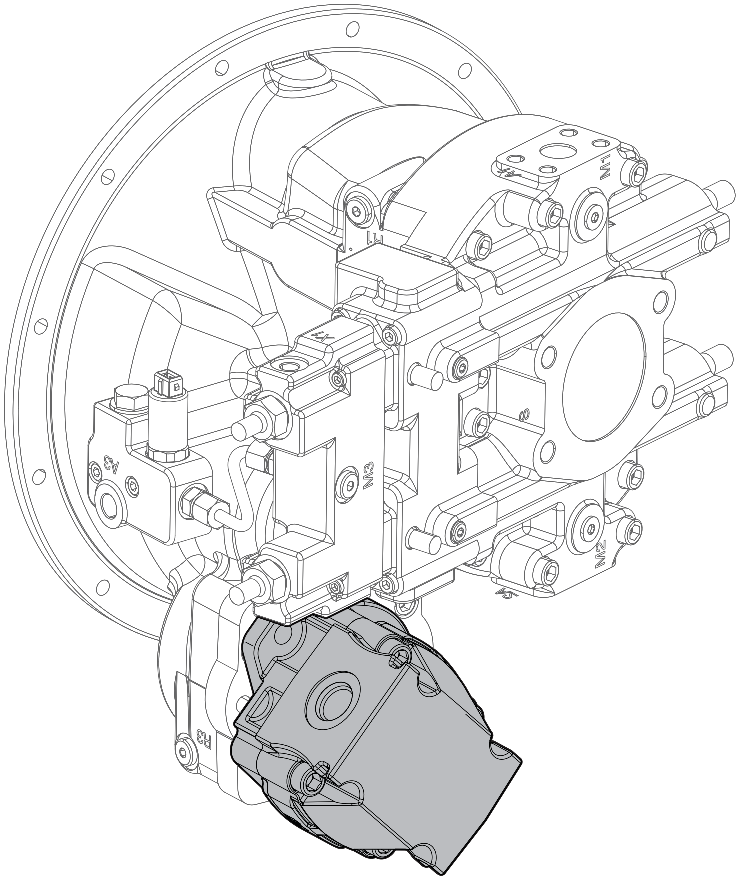


Figure 3

Parts List

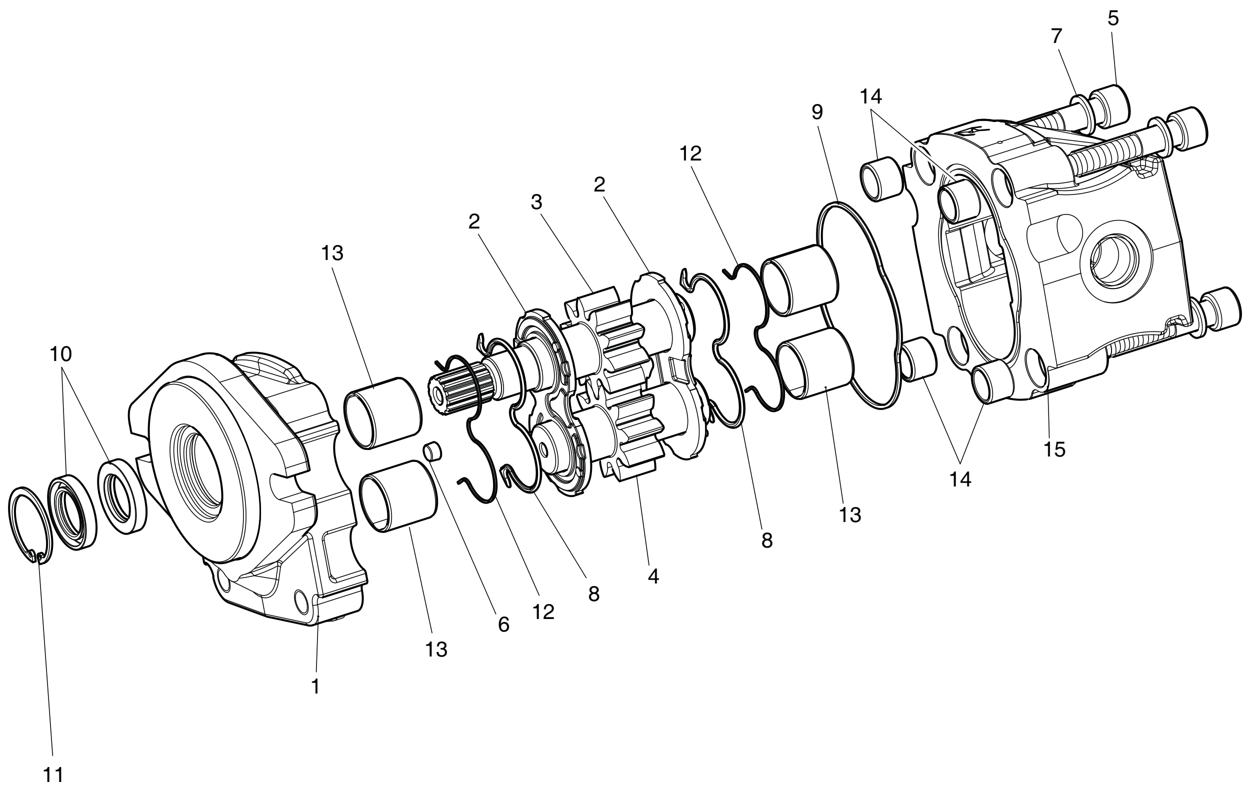


Figure 4

Reference Number	Description
1	Front Cover
2	Thrust Plate
3	Drive Shaft
4	Driven Gear
5	Socket Bolt
6	Plug
7	Washer
8	Seal

Reference Number	Description
9	Seal
10	Shaft Seal
11	Snap Ring
12	Ring
13	Bush
14	Bush
15	Body
*	Gear Pump Seal Kit

One Spool Valve (Rotating)

SAFETY INSTRUCTIONS

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One Spool Valve (Rotating)

GENERAL

Specification

Rated Pressure	83 bar (85 kg/cm², 1,209 psi)
Rated Flow	50 L/min (13 U.S. gal)
Internal Leakage	100 cc/min at 68 bar (69 kg/cm², 986 psi)
Main Relief Pressure Setting	78 bar (80 kg/cm², 1,131 psi)
Overload Relief Pressure Setting	98 bar (100 kg/cm², 1,421 psi)

Overview

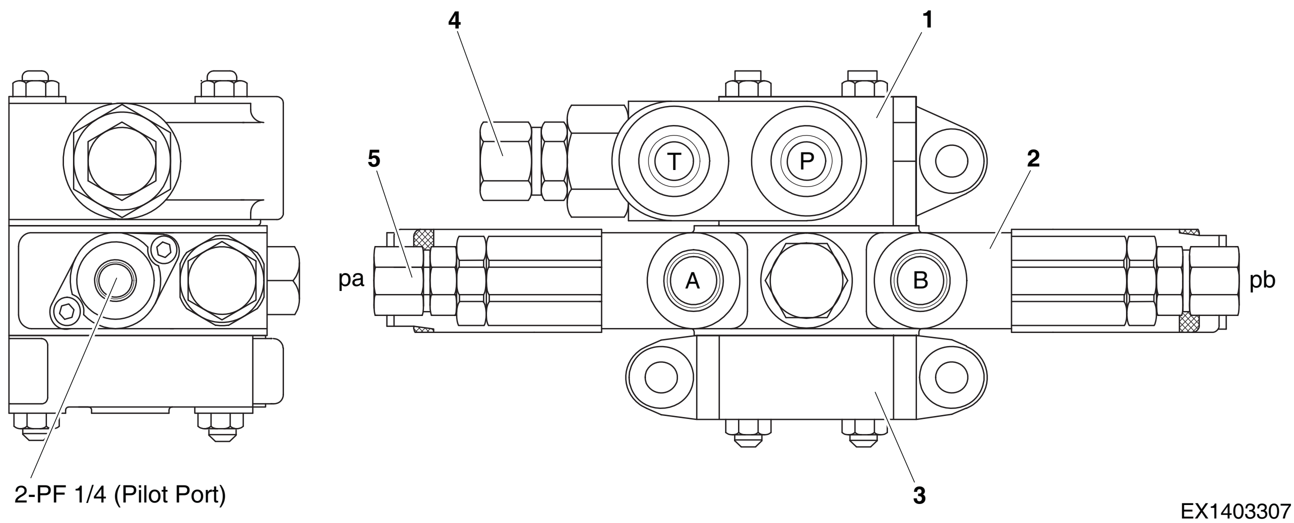


Figure 1

Reference Number	Description
1	Inlet Block
2	Work Block
3	T Block

Reference Number	Description
4	Main Relief Valve
5	Overload Relief Valve

Port and Hydraulic Circuit

Port	Name	Size
P	Pressure Input	PF 1/2"
T	Drain	
A	Attach Pressure In/Out	PF 3/8"
B	Attach Pressure In/Out	
Pa	Pilot Pressure	PF 1/4"
Pb	Pilot Pressure	

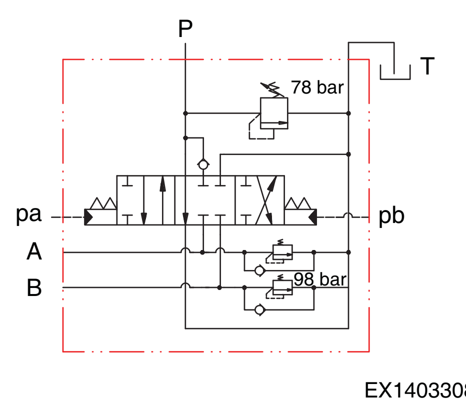
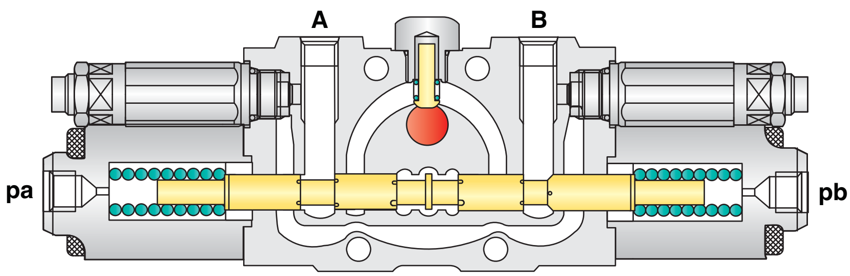


Figure 2

Theory of Operation

In the Neutral Condition

The hydraulic oil, supplied to the P port under the neutral condition, is to be flowed out to the tank passage through the "One Spool Valve".



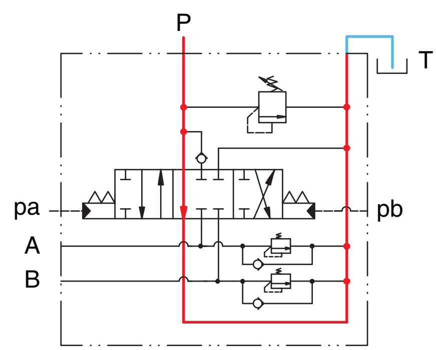
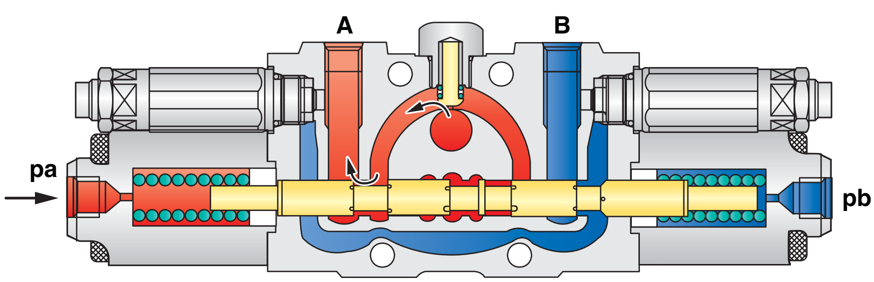


Figure 3

Spool Operation

1. When Pilot Pressure "Pa" is impressed

   When pilot pressure is impressed at the "Pa" port, the pressured oil flowed from the P port is to be discharged to the A port through the load check poppet and the spool, as the hydraulic oil passage for bypass is blocked.



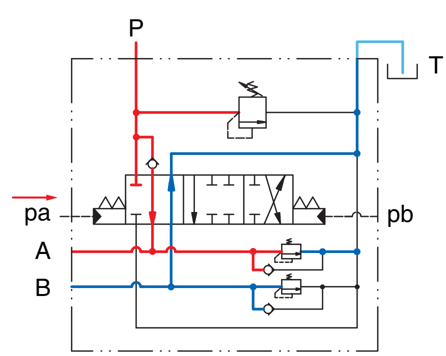


Figure 4

2. When Pilot Pressure "Pb" is impressed

When pilot pressure is impressed at the "Pb" port, the pressured oil flowed from the P port is to be discharged to the B port through the load check poppet and the spool, as the hydraulic oil passage for bypass is blocked.

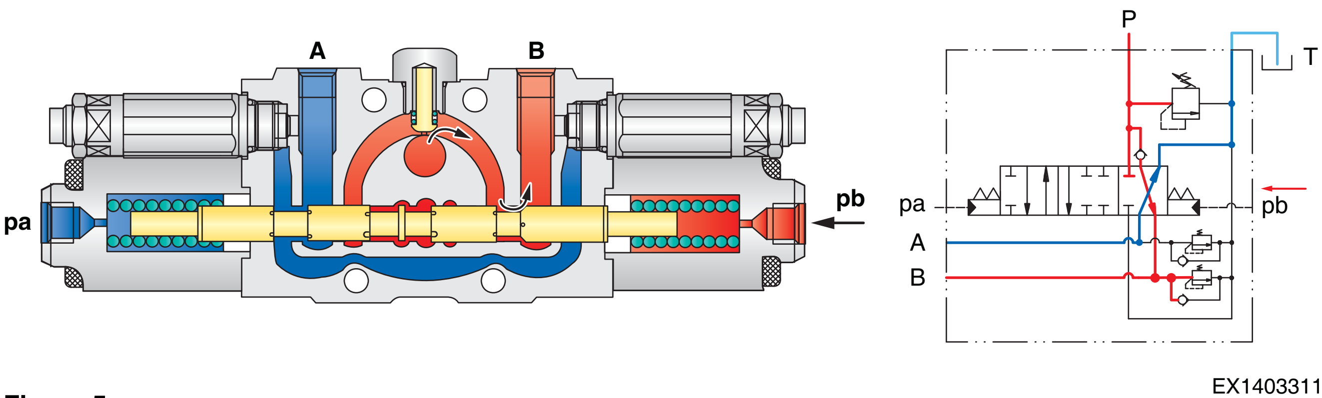


Figure 5

DISASSEMBLY AND ASSEMBLY

General Cautions

It is the principle that disassembly and assembly of this valve should carried out by the manufacturer. In case disassembly and assembly is inevitably required elsewhere, the following cautions must be observed.

1. This valve is precisely processed and the gaps among each part are extremely tiny. This, disassembly and assembly should be performed very carefully so that any foreign material such as dust or sand can not intrude into the valve.
2. For disassembly, a technician should start disassembly after fully understanding the structure of the valve with structural drawings and reference drawings.
3. When the valve needs to be removed from a machine, be sure to put caps on each port and to wash the exterior of the assembly after checking the caps on each port again before assembling.
4. In case the disassembled parts need to be placed unassembled for a while, they must be treated with rust prevent oil and sealed to prevent rusting.
5. Do not hold a pilot cap, a relief valve and a overload relief valve when this valve needs to be moved.
6. Even in case disassembly and assembly is not peformed smoothly, do not hit or treat any part of the product roughly.
7. After disassembly, attach ID tags to each part for accurate assembly.
8. For O-rings and back up-rings, it is the principle to use the new ones. And be sure not to damage one during assembly. (Apply a small portion of grease on the parts for smooth assembly.)
9. Fasten bolts, overload relief valves and main relief valves with the specified standard torque.
10. As various tests (relief characteristics test, leakage test, operational test, etc.) are essential after disassembly and assembly, do not disassemble this valve if those tests are not available.
11. Be careful not to damage the O-ring contacting parts of this valve for preventing oil leakage.
12. Be cautious about safety during operation as this valve assembly is heavy.

Replacement of Spool

⚠ CAUTION

AVOID INJURY

For replacement of a spool, it must be replaced with a sub-assembly of spool.

⚠ CAUTION

AVOID INJURY

During assembly operation of a spool sub-assembly, be careful so that a foreign material can not intrude into the sub-assembly.

1. Removing Pilot Cap

   Unfasten the two bolts for the pilot cap with a L-wrench (5mm) and remove the cap along with the washer.
   (You can remove either of them.)

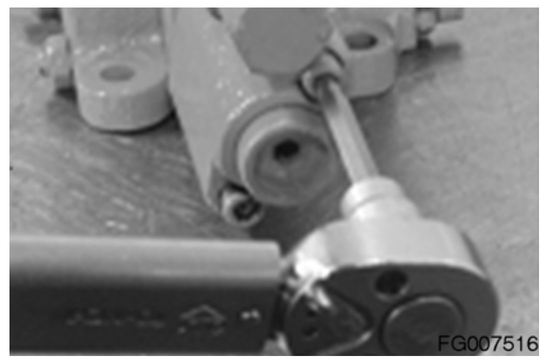


Figure 6

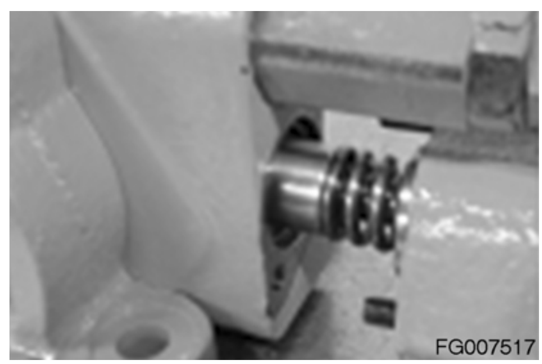


Figure 7

2. Removing Spool

After fixing the main body and removing the return spring and the spring seat first, pull the spool in the horizontal direction (parallel to the spool hole) to remove it from the main body.

Too much impressed force for disassembly may damage the spool. When the spool is stuck, therefore, push it back smoothly and try to pull the spool while rotating it.

While removing the spool, check which end has the mark.

Figure 8

3. Assembling Spool

Insert the spool into the fixed main body. (Overloaded force may damage the main body or the spool. When the spool is stuck, pull it back and press it smoothly while rotating it.)

Check the direction of the mark, identified during the disassembly operation.

Assemble the spring seat and the spring.

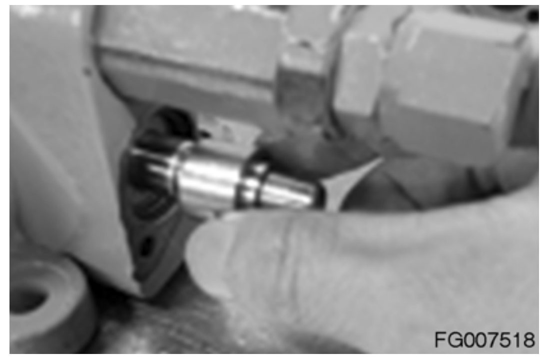


Figure 9

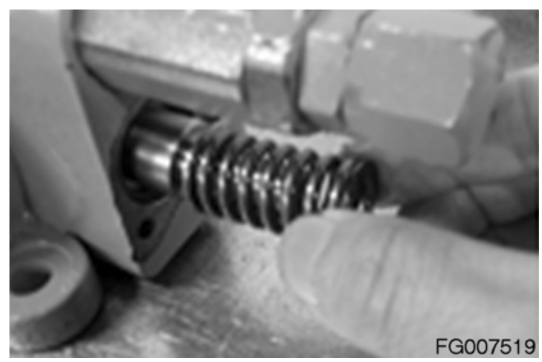


Figure 10

4. Assembling Pilot Cap (on Return Spring Side)

Cover the pilot cap on the return spring of the spool, previously assembled to the main body, and fasten it with two bolts at the specified standard torque using a torque wrench (5mm). Check if there is the O-ring on the contacting surface.

- Torque: 10.8 N.m (1.1 kg.m, 8 ft lb)

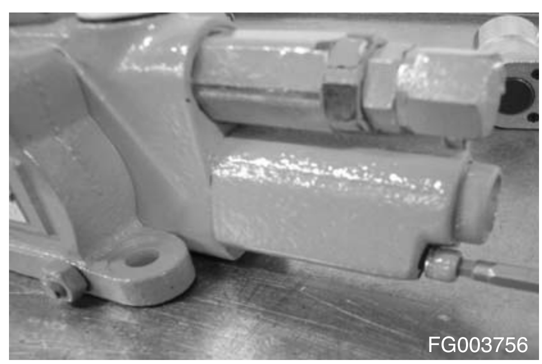


Figure 11

Replacement of Main Relief Valve

⚠ CAUTION

AVOID INJURY

Be careful not to damage the seat of the removed main relief valve.

⚠ CAUTION

AVOID INJURY

As the main relief valve is a very important part, related to performance and safety, and hard to be set for the pressure again, be sure to replace it with an assembly if needed, not disassembling it.

⚠ CAUTION

AVOID INJURY

During assembly of a main relief valve, be careful so that a foreign material cannot intrude into the main frame.

1. Removing Main Relief Valve

   Fix the main body and remove the main relief valve by unfastening the hexagon bolt with a spanner (3 0mm).
   The spanner should hold the bolt as deeply as possible.

Figure 12

Figure 13

2. Assembling Main Relief Valve

Fasten the main relief valve to the main body at the specified standard torque using a torque wrench (30mm). Check if there is the O-ring on the contacting surface.

- Torque: 58.8 N.m (6 kg.m, 43.4 ft lb)

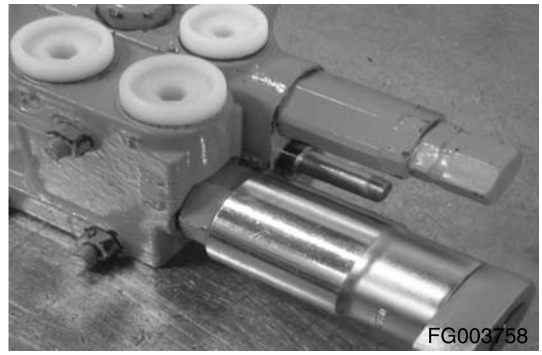


Figure 14

Replacement of Overload Relief Valve

CAUTION

AVOID INJURY

As the removed overload relief valves may have different setting values for each position, identify them for the original position with tags for accurate assembly.

CAUTION

AVOID INJURY

As the overload relief valve is a precision part, be cautious about damage or intrusion of foreign materials.

CAUTION

AVOID INJURY

As the overload relief valve is a very important part, related to performance and safety, and hard to be set for the pressure again, be sure to replace it with an assembly if needed, not disassembling it.

CAUTION

AVOID INJURY

During disassembly of a overload relief valve, be careful not to damage the return cap by the spanner.

1. Removing Overload Relief Valve

   Fix the main body and remove the overload relief valve by unfastening the hexagon bolt with a spanner (22mm). The spanner should hold the bolt as deeply as possible.

Figure 15

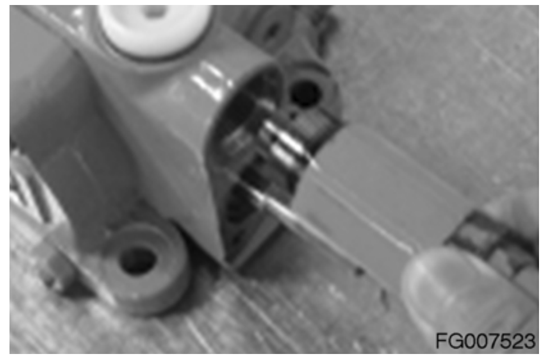


Figure 16

2. Assembling Overload Relief Valve

   Fasten the overload relief valve to the main frame at the specified standard torque using a torque wrench (22mm). Check if there is the O-ring on the contacting surface.

   - Torque: 39.2 N.m (4 kg.m, 28.9 ft lb)

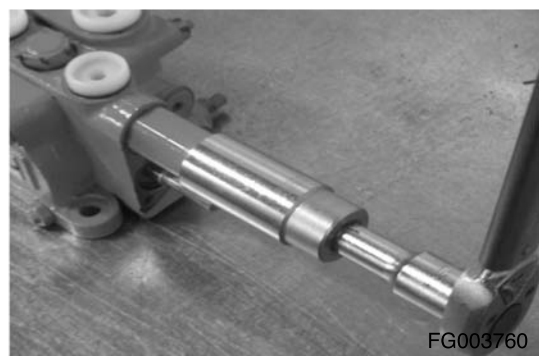


Figure 17

Replacement of Sub-Block

CAUTION

AVOID INJURY

During assembly of the sub-block assembly, be careful so that a foreign material cannot intrude into the main body.

1. Installation of Surface Plate

   Install a surface plate on a workbench for replacement of the sub block assembly.

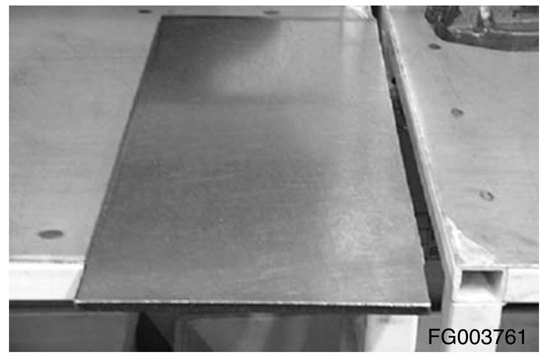


Figure 18

2. Removing Sub-Block Assembly

   Place the main frame on the surface plate, installed on the workbench.

   Remove the assembly by unfastening the four nuts, fixing it, with a spanner or a hexagon wrench (13 mm).

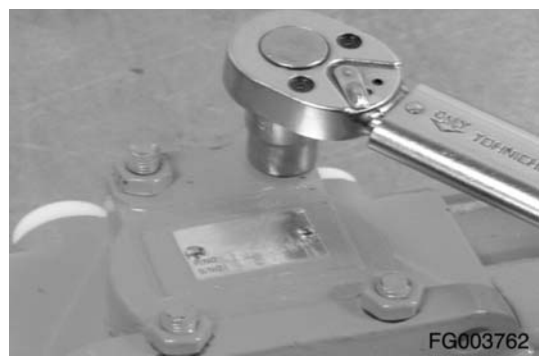


Figure 19

3. Replacing Block Assembly

   Replace the faulty assembly with a new one and assemble the new one in order.

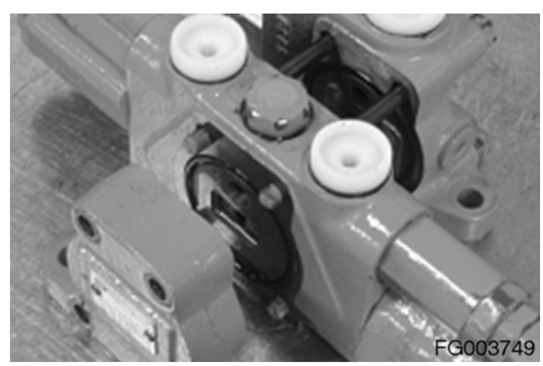


Figure 20

4. Assembling Nuts

Arrange the main frame and fasten the four nuts at the specified standard torque with a torque wrench (13 mm).

Before completely fastening the nuts, check if each sub-lock is properly arranged based on the surface plate.

- Torque: 20.1 N.m (2.05 kg.m, 14.8 ft lb)

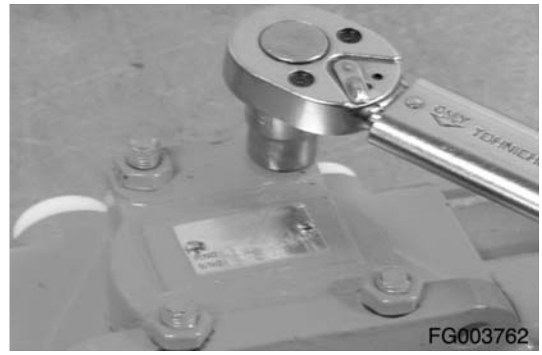


Figure 21

Rotating Grapple

SAFETY INSTRUCTIONS

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Rotating Grapple

GENERAL

General Description

When an attachment such as a grapple is used, a this mechanism is provided according to the task needed to be performed with the attachment.

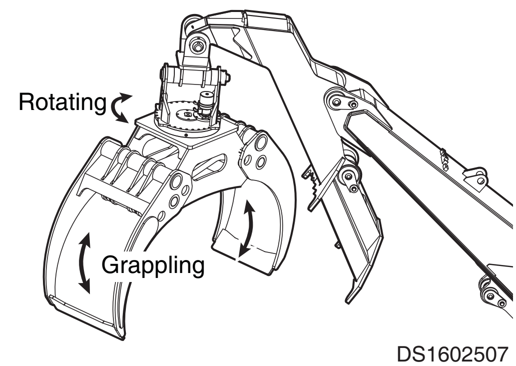

Figure 1

Theory of Operation

When a thumb wheel switch located on the left joystick lever is moved, the switch output signal (1.0 V - 4.0 V) supplies a current to the rotating EPPR valve through the EPOS controller and a control valve for rotating is controlled.

Moving the thumb wheel to the right rotates the attachment clockwise. Moving the thumb wheel to the left rotates the attachment counterclockwise.

Thumb wheel switch voltage output → EPOS controller input → EPOS controller current output → rotating EPPR valve current supply → control valve spool variable supply.

And when a thumb wheel switch located on the right joystick lever is moved, the switch output signal (1.0 V - 4.0 V) supplies a current to the grapple EPPR valve through the EPOS controller and a main control valve option spool for grapple cylinder is controlled.

Moving the thumb wheel to the right rotates the attachment close. Moving the thumb wheel to the left rotates the attachment open.

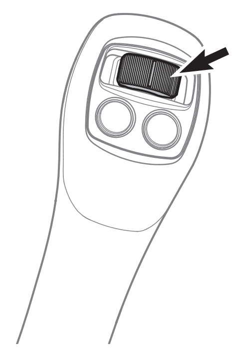

Figure 2

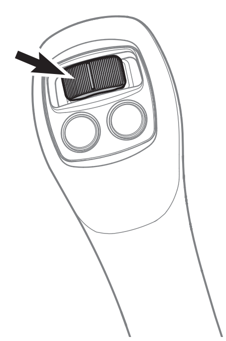

Figure 3

Structure

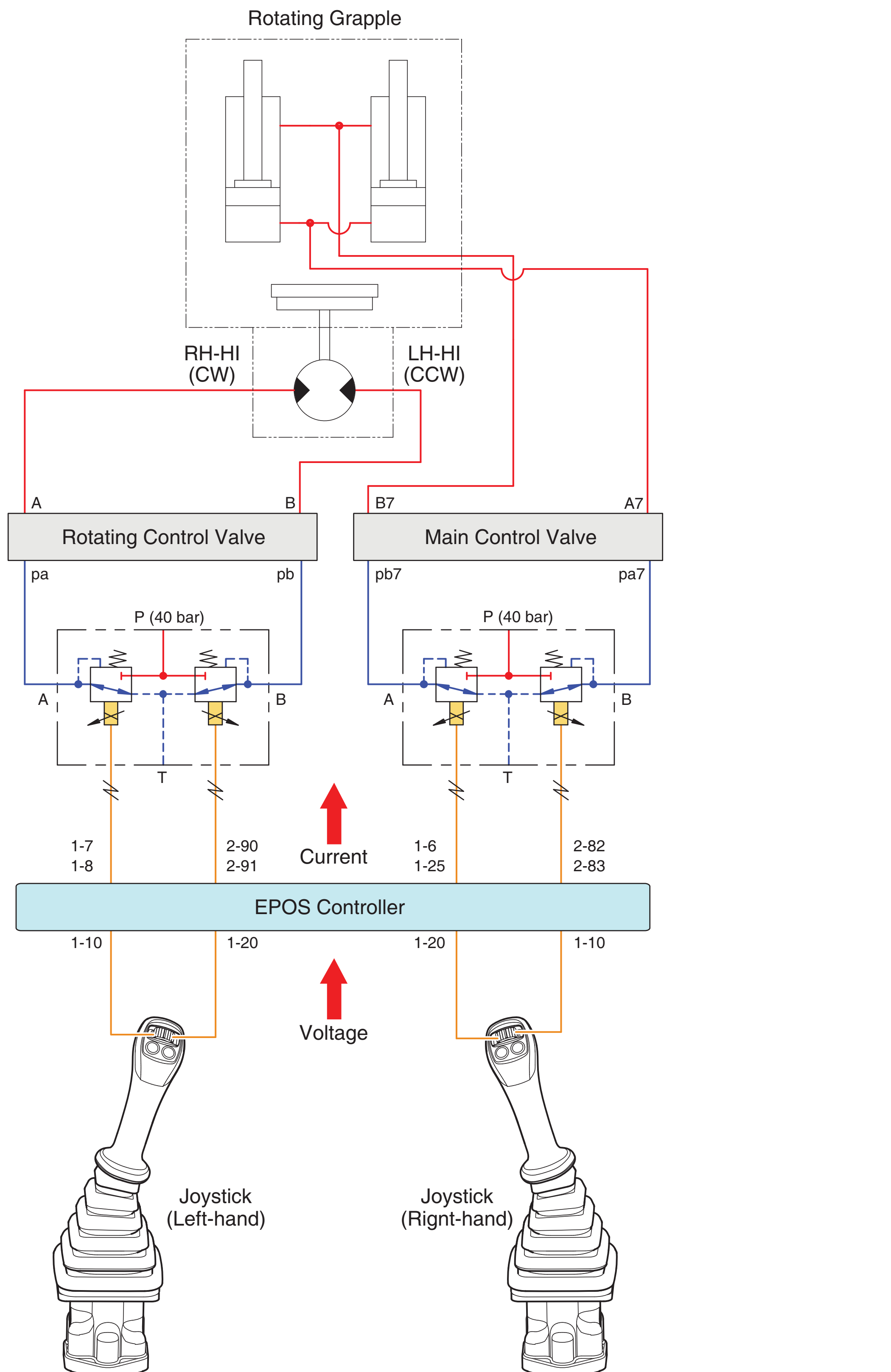

Figure 4

Hydraulic Circuit

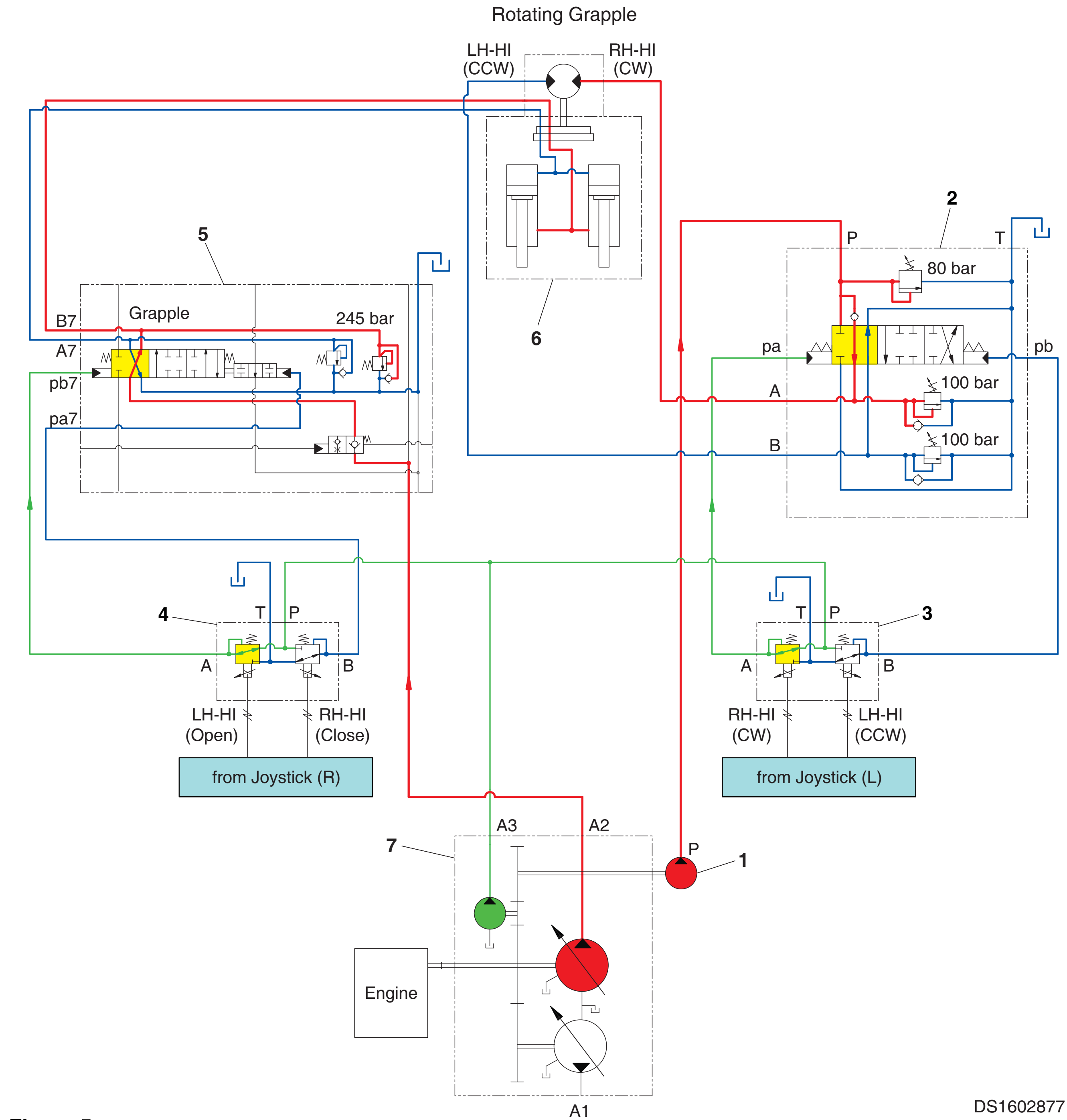

Figure 5

Reference Number	Description
1	Gear Pump (Rotating)
2	Control Valve (One Spool)
3	EPPR Valve (Rotating)
4	EPPR Valve (Grapple)

Reference Number	Description
5	Main Control Valve
6	Rotating System (Customer)
7	Main Pump

Lower Structure and Chassis

Swing Bearing

SAFETY INSTRUCTIONS

WARNING

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Swing Bearing

GENERAL

General Description

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.

Parts List

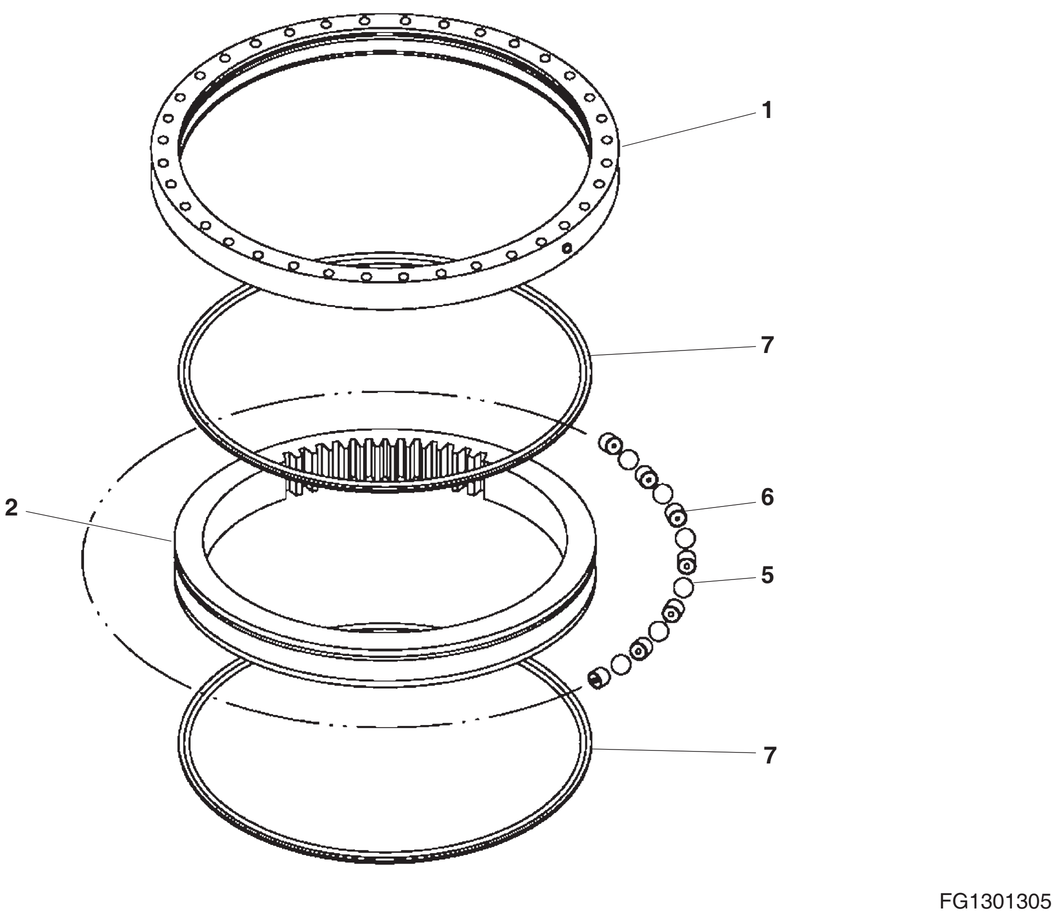


Figure 1

Reference Number	Description
1	Outer Ring
2	Inner Ring
3	Tapered Pin
4	Plug

Reference Number	Description
5	Ball
6	Retainer
7	Seal

MAINTENANCE GUIDELINES

Operating Recommendation

The service life of the swing bearing may be extended if a daily effort is made to equalize usage over both ends of the log loader. If the log loader 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. Repositioning the log loader during the work shift, to work the opposite end of the bearing, will provide a more even and gradual rate of wear and extended service life.

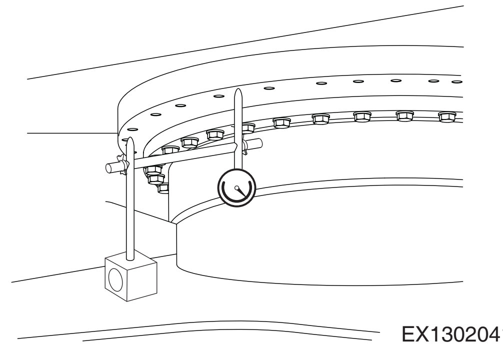


Figure 2

Measuring Swing Bearing Axial Play

Regular checks of bearing displacement must be made at least twice a year. Use a dial indicator. With the arm cylinders fully extended and the heel cylinder fully retracted, position the arm tip pin height is flush with the boom foot pin height.
(Figure 3)

Push the attachment against the ground to lift up the log loader above the ground and take measurements at 4 points, 90° apart, around the circumference of the bearing.

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.

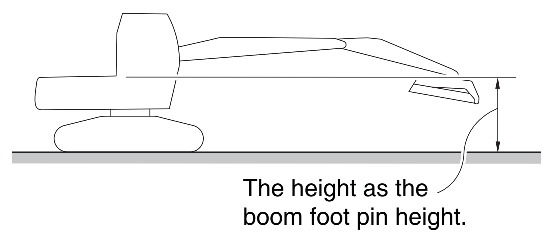


Figure 3 Measurement (h1)

Measuring Bearing Lateral Play

When vertical checks are made, the side to side play in the bearing can be checked by fully extending the arm and heel cylinder and retracting the heel as far forward as it will go. With the log loader parked on a flat, level surface and the heel just off the ground, push against the heel sideways to take up all the lateral clearance in the bearing. Check lateral play in both directions and record the values. When the bearing is beginning to approach the end of its service life, the measured lateral clearance should start to show increase in value.

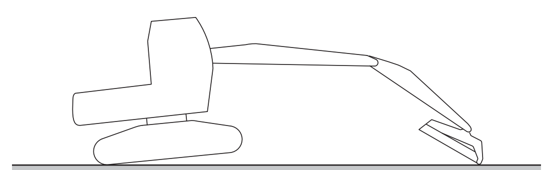


Figure 4 Measurement (h2)

DISASSEMBLY

1. Remove tip of tapered pin (3, Figure 5) using grinder and tap lightly to remove debris.

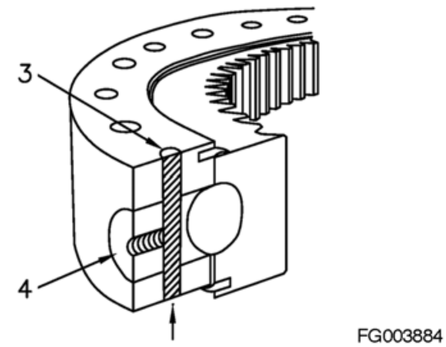


Figure 5

2. Remove plug (4, Figure 6) using a M10 x P 1.5 bolt.

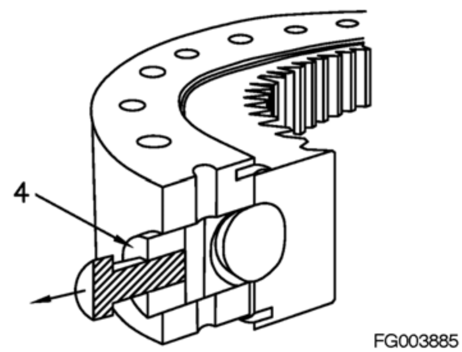


Figure 6

3. Lift outer ring and check that inner ring can move freely. See Figure 7, if not, replace seal (7, Figure 8).
   - Weight: 280 kg (617 lb)

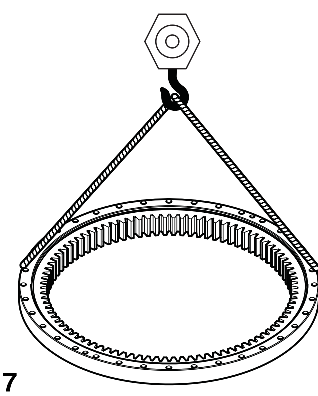


Figure 7 WE1401490

4. Turn inner ring and use magnet bar (C, Figure 8) to remove steel balls (5).

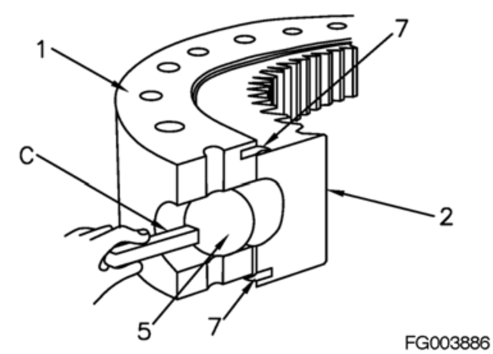


Figure 8

5. Turn inner ring and use wire (D, Figure 9) to remove retainers (6).

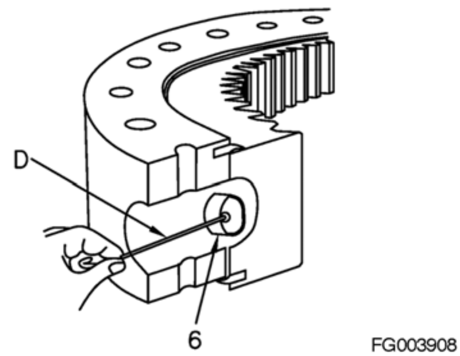


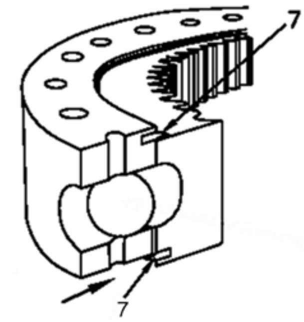
Figure 9

REASSEMBLY

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.

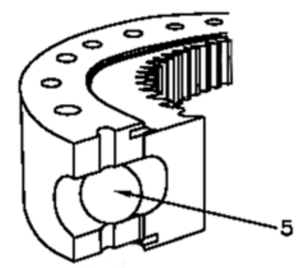


FG005123

Figure 10

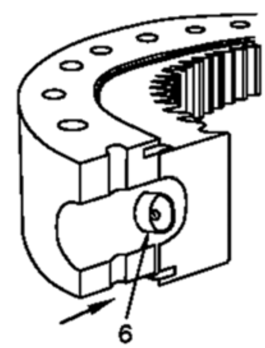
2. Hoist the outer race by crane horizontally and match it with the inner race coaxially.

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



FG005225

Figure 11



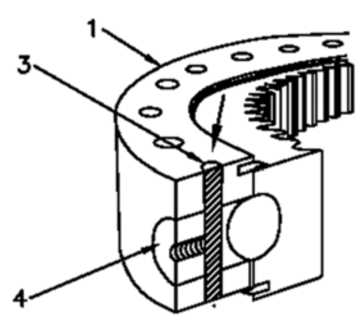
FG005124

Figure 12

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

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

   Fill grease through the grease fitting.



FG005125

Figure 13

Center Joint

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Center Joint

GENERAL

General Description

The center joint 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.

Overview

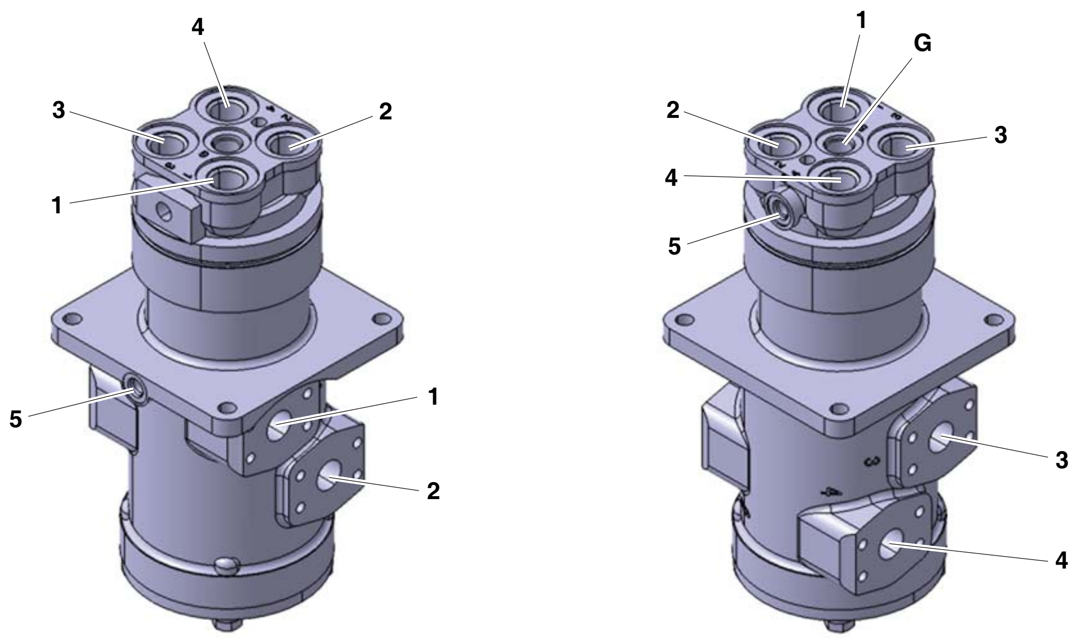


Figure 1

EX1301734

Port	Name	Size	
		Body	**Spindle**
1, 2	Traveling Right	SAE 1"	PF 3/4" O-ring
3, 4	Traveling Left	SAE 1"	PF 3/4" O-ring
5	Pilot	PF 1/4" O-ring	
G	Drain	PF 1/4" O-ring	

Parts List

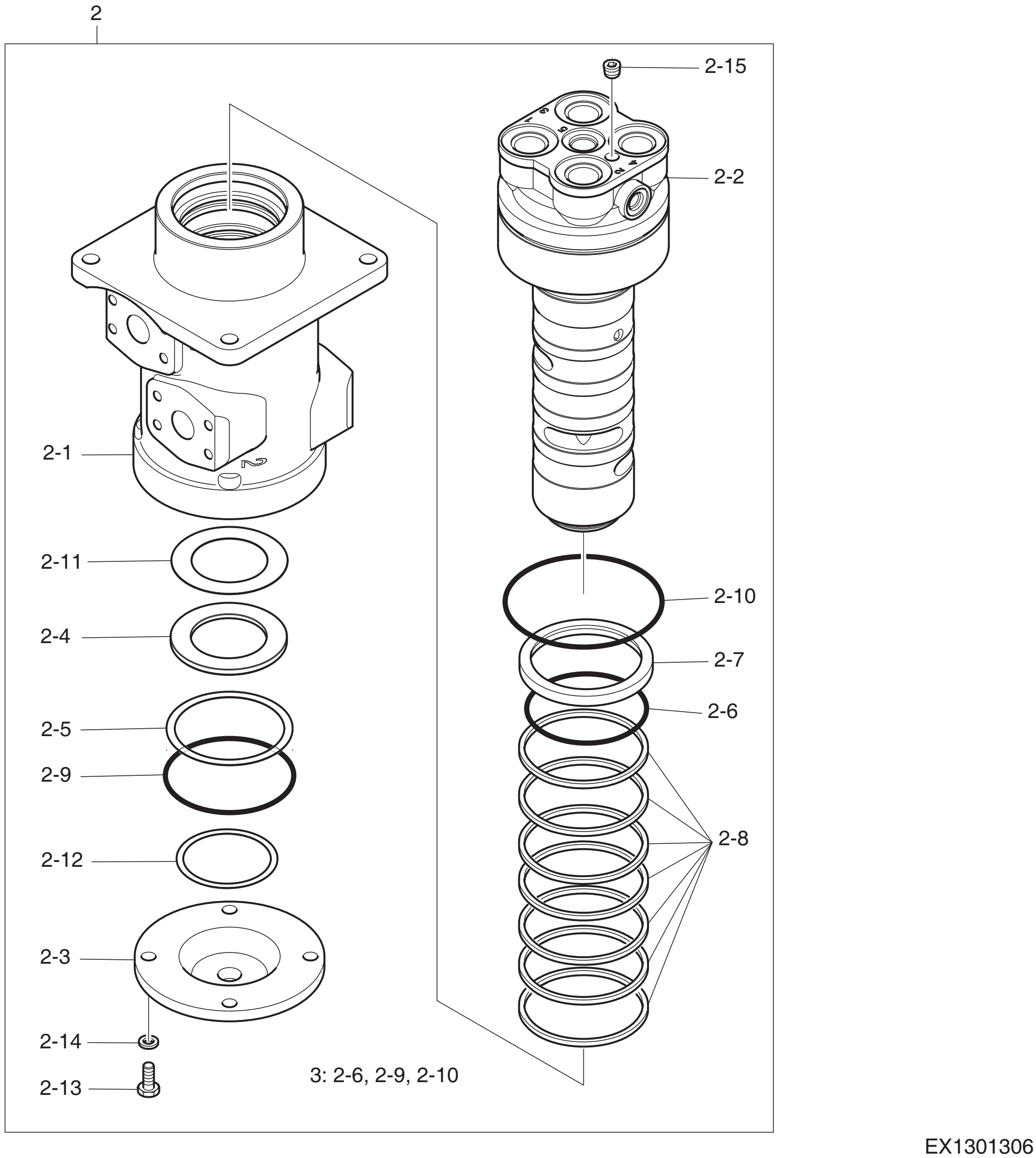


Figure 2

Reference Number	Description
2	Center Joint
2-1	Hub
2-2	Spindle
2-3	Cover
2-4	Spacer
2-5	Retainer Ring
2-6	O-ring
2-7	Dust Seal
2-8	Slipper Seal

Reference Number	Description
2-9	O-ring
2-10	O-ring
2-11	Shim
2-12	Shim
2-13	Bolt
2-14	Spring Washer
2-15	Plug
3	Center Joint Seal Kit

SECTION VIEW

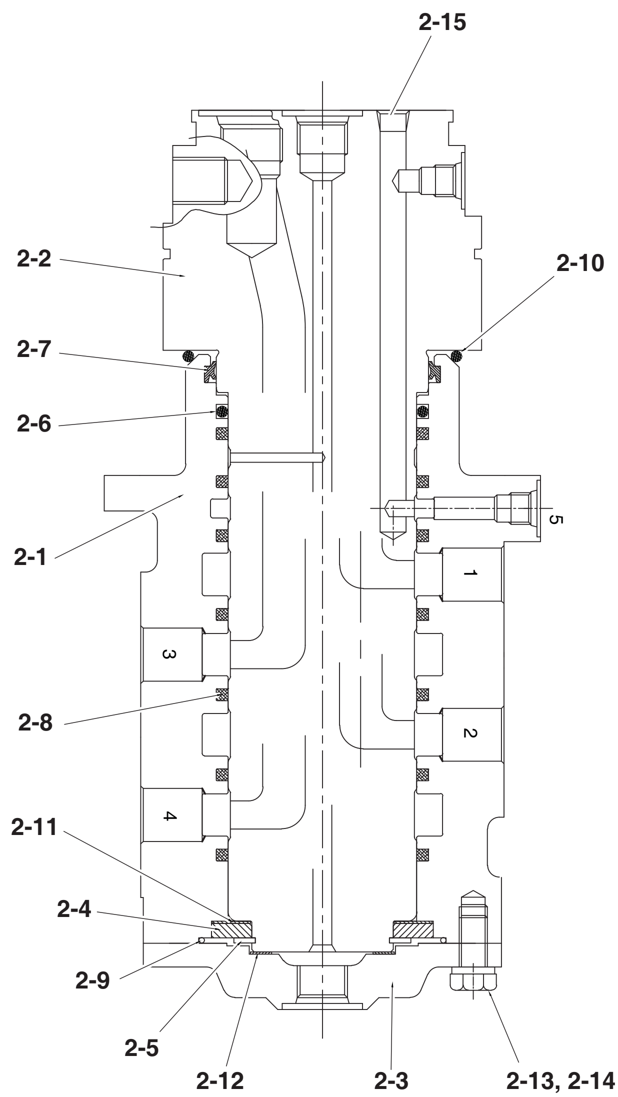


Figure 3

Reference Number	Description
2-1	Hub
2-2	Spindle
2-3	Cover
2-4	Spacer
2-5	Retainer Ring
2-6	O-ring
2-7	Dust Seal
2-8	Slipper Seal

Reference Number	Description
2-9	O-ring
2-10	O-ring
2-11	Shim
2-12	Shim
2-13	Bolt
2-14	Spring Washer
2-15	Plug

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Park the machine on flat level ground.
2. Extend the boom and arm, as shown in Figure 4 and lower the boom until the attachment is 10 cm above the ground.
3. Stop the engine.

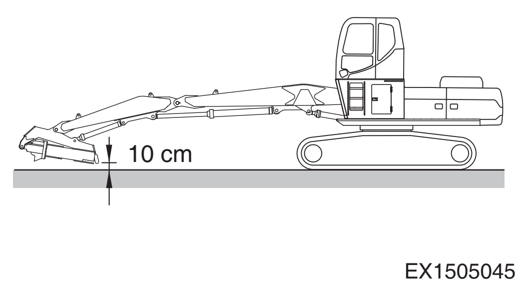


Figure 4

4. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 5)
5. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

6. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
7. Move safety lever to "LOCK" position. (Figure 5)
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Attach a maintenance warning tag on controls.
10. Turn battery disconnect switch to "OFF" position. (Figure 6)

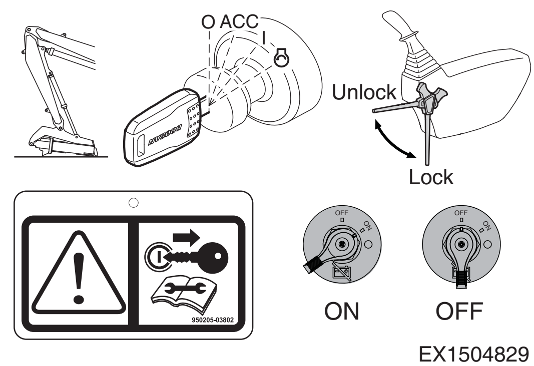


Figure 5

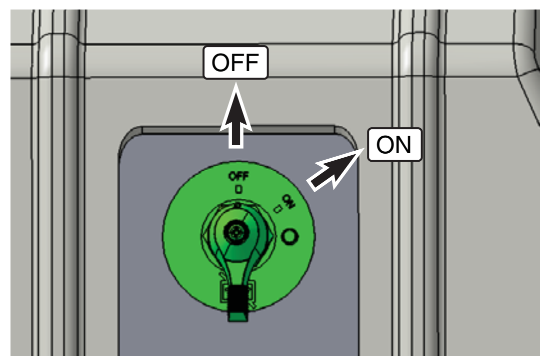


Figure 6 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*

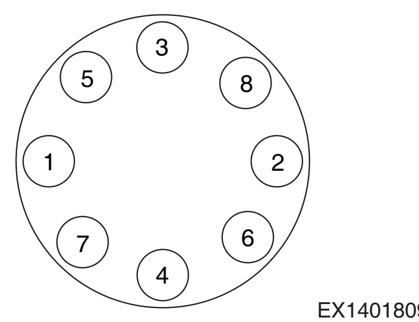


Figure 7

WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

11. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.

    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

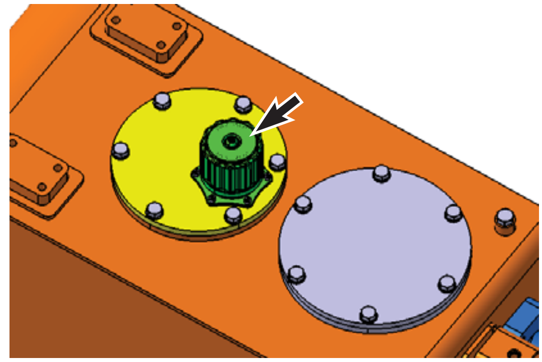


Figure 8 EX1404054

12. Remove bolts (1, Figure 9) (6 ea) with under covers (2) (2 ea) from frame.

    - Tool: 24 mm ( )
    - Torque: 264.8 N.m (27 kg.m, 195.3 ft lb)
    - Under cover (1 ea) weight: about 30 kg (66.1 lb)

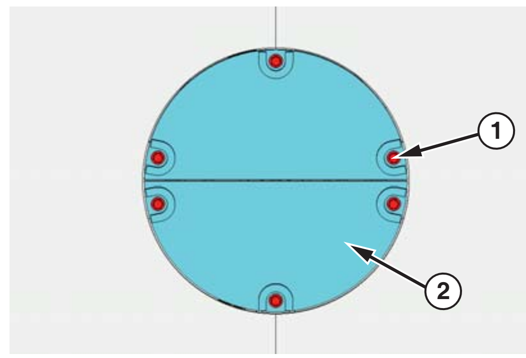


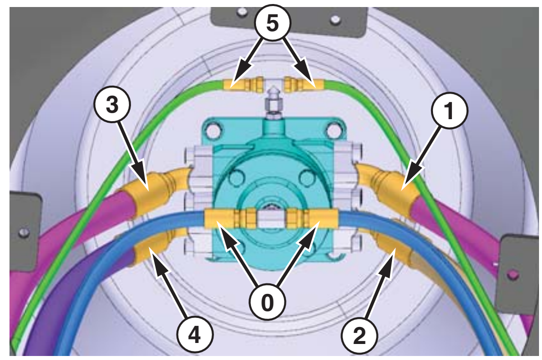
Figure 9 Bottom of Track Frame EX1505046

13. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 10 EX1504170

14. Remove hoses and adapters (Figure 11) from center joint.

NOTE: *Attach identification tags to the removed hoses for reassembling. After disconnecting hoses, plug them to prevent dirt or dust from entering. Disconnect the hoses from the bottom to top of center joint.*



DS1602640

Figure 11 Hub of Center Joint

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	(mm)	Torque		
					N.m	kg.m	ft lb
0	Drain	UNF 13/16"-16-2B	24		55.9	5.7	41.2
		UNF 13/16"-16-2B	24		55.9	5.7	41.2
1	to Travel Motor (LH) "A"	SAE 1", D24.5		10	107.9	11.0	79.6
2	to Travel Motor (LH) "B"	SAE 1", D24.5		10	107.9	11.0	79.6
3	to Travel Motor (RH) "B"	SAE 1", D24.5		10	107.9	11.0	79.6
4	to Travel Motor (RH) "A"	SAE 1", D24.5		10	107.9	11.0	79.6
5	Pilot (2-speed)	UNF 9/16"-16-2B	19		25.5	2.6	18.2
		UNF 9/16"-16-2B	19		25.5	2.6	18.2

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
0	Tee	PF 1/2"	UNF 13/16"-16	27	93.1	9.5	68.7
5		UNF 9/16"-18	UNF 9/16"-18	19	25.5	2.6	18.8
5	Adapter	PF 1/4"	UNF 9/16"-18	19	39.2	4.0	28.9
0	O-ring	S8000185 (4D P18)	S8030081 (1B F-08)				
1, 2, 3, 4		DS2856003 (1", ID:33.2, OD:40.2, 1B)					
5		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

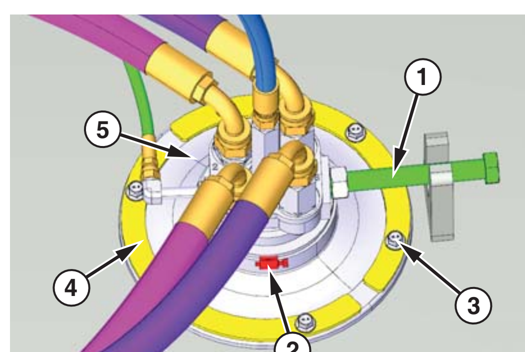
* A: Opposite side of hose, B (C): Hose side

15. Remove bolt (1, Figure 12) and clamp (2).

    - Tool: 30 mm, 8 mm ( )
    - Torque (clamp): 6 N.m (0.6 kg.m, 4.4 ft lb)

16. Remove bolts (3, Figure 12) (6 ea) with plates (4) (2 ea) and lubber cover (5).

    - Tool: 14 mm ( )
    - Torque: 63.7 N.m (6.5 kg.m, 47 ft lb)

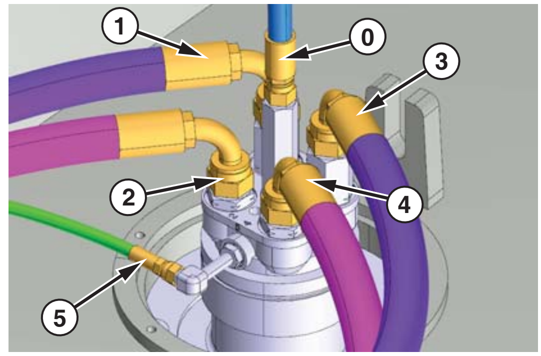


DS1602641

Figure 12 Spindle of Center Joint

17. Remove hoses and adapters (Figure 13) from center joint.

NOTE: *Attach identification tags to the removed hoses for reassembling. After disconnecting hoses, plug them to prevent dirt or dust from entering. Disconnect the hoses from the bottom to top of center joint.*



DS1602755

Figure 13 Spindle of Center Joint

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	Torque		
				N.m	kg.m	ft lb
0	Drain	UNF 13/16"-16-2B	24	55.9	5.7	41.2
1	from Control Valve "B1"	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
2	from Control Valve "A1"	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
3	from Control Valve "B6"	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
4	from Control Valve "A6"	UNF 1 3/16"-12-2B	36	124.5	12.7	91.8
5	from Solenoid Valve "TR2"	UNF 9/16"-18-2B	19	25.5	2.6	18.2

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
0	Adapter	PF 1/2"	UNF 13/16"-16	27	93.1	9.5	68.7
1, 2, 3, 4		PF 3/4"	UNF 1 3/16"-12	36	176.4	18.0	130.1
5		PF 1/4"	UNF 9/16"-18	19	39.2	4.0	28.9
0	O-ring	S8000185 (4D P18)	S8030081 (1B F-08)				
1, 2, 3, 4		S8000235 (4D P22.4)	S8030125 (4D F-12)				
5		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

18. Install the eyebolts (PF 1/2") and tie with rope the center joint to remove it (Figure 14).

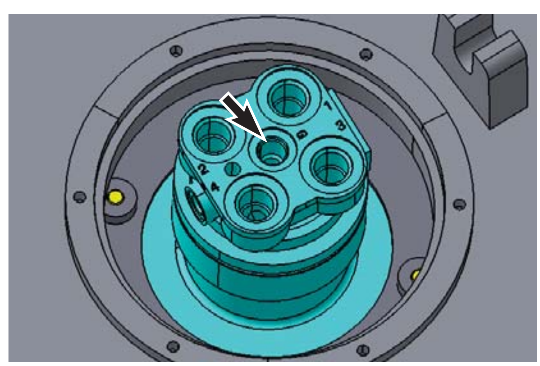


Figure 14

EX1402386

19. Remove bolts and washers (1, Figure 15) (4 ea).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

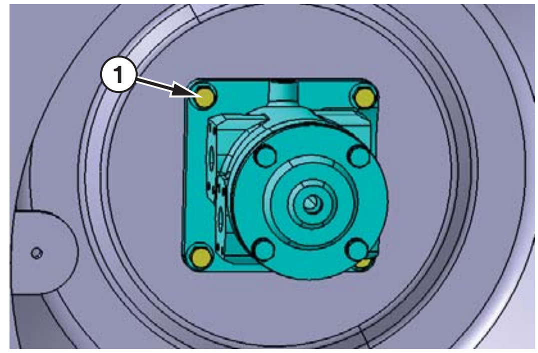
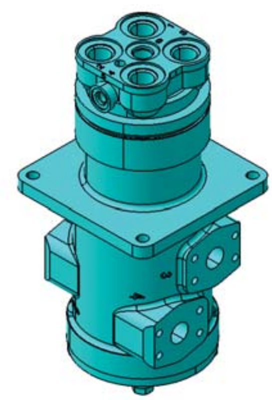


Figure 15 Bottom of Track Frame EX1402387

20. Remove center joint from the frame slowly and carefully.
    - Center joint weight: about 36 kg (79 lb)



EX1402389

Figure 16

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

1. Perform installation in the reverse order to remove.
2. When installing the hoses, install the drain hose as first action.
3. To prevent the water from penetrating, apply silicon on the mounting part of center joint.

COMPLETING WORK

1. Start the engine and run at low idling for about 5 minutes.
2. Perform the machine performance test.

DISASSEMBLY

IMPORTANT

Do not unbolt the center joint from the lower frame until an adequate number of piping block off plates are available, for disconnected piping lines. Be sure that system pressure has been relieved - including the hydraulic accumulator and tank reserve pressure - before disassembly is started.

WARNING

AVOID DEATH OR SERIOUS INJURY

Because of its weight, use a hoist or a similar device to lift the assembly.

WARNING

AVOID DEATH OR SERIOUS INJURY

The hydraulic oil will be hot after machine operation. Allow the system to cool before attempting to service any of the hydraulic components.

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. Remove oil remaining in each port with air.
4. Use a 19 mm wrench to loosen cover bolts and washers (13 and 14, Figure 17) and remove cover (3).

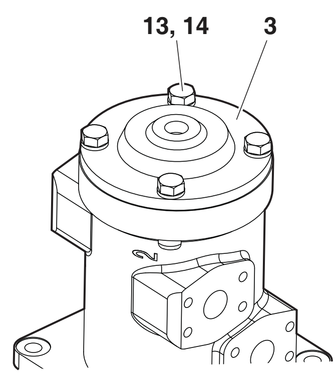


Figure 17 EX1402520

5. Remove the shim (12, Figure 18) and O-ring (9).

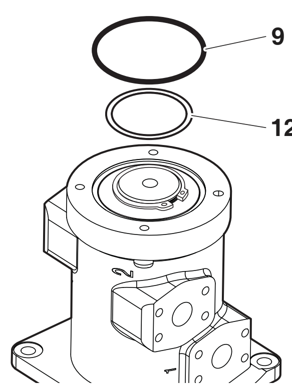


Figure 18 EX1402521

6. Use a pliers to remove retaining ring and disassemble the spacer (4, Figure 19) and shim (11) at the back of the retaining ring (5).

IMPORTANT

Care must be taken not to make a scratch or damage the surface of the spindle when disassembling the spindle of the hub.

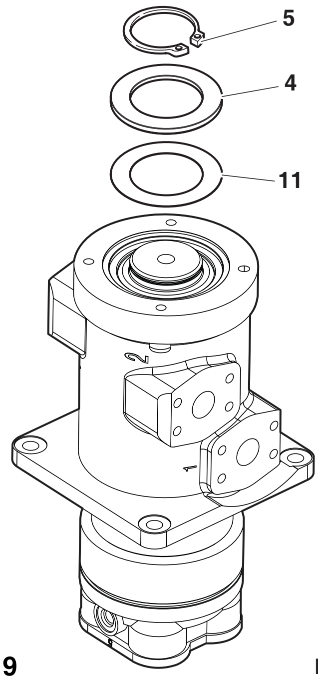
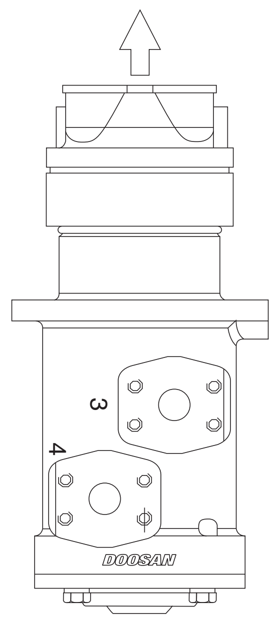


Figure 19 EX1402522

7. Disassemble the spindle from the hub.

   It can be disassembled easily by fixing the hub, tightening at least 2 ~ 10 mm eyebolts on the spindle, and lifting it with a hoist slowly. (Figure 20)

8. If the spindle doesn't separate easily when the retaining ring are removed, use a wooden block and hammer to drive it out of the housing.



FG013230

Figure 20

IMPORTANT

Care must be taken not to damage the inside of the hub because it is likely to be damaged when disassembling the slipper seal. It may be disassembled more easily with a screwdriver whose tip is bent as shown in Figure 21.

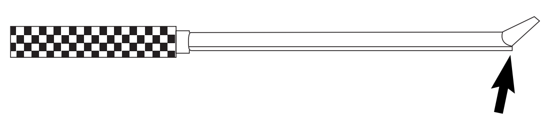


Figure 21 FG021966

9. Remove the O-ring (10, Figure 22) (1 ea), dust seal (7) (1 ea), O-ring (6) (1 ea) and slipper seal (8) (7 ea) from the hub (1).
10. Remove foreign substance on pieces disassembled and wash them out.
11. Replace disassembled O-rings, dust seal and slipper seals with new ones, for they cannot be reused.
12. Clearance between the spindle and body of the center joint must be tight. Replace or repair either component if there is more than 0.1 mm (0.0039") of measurable wear.

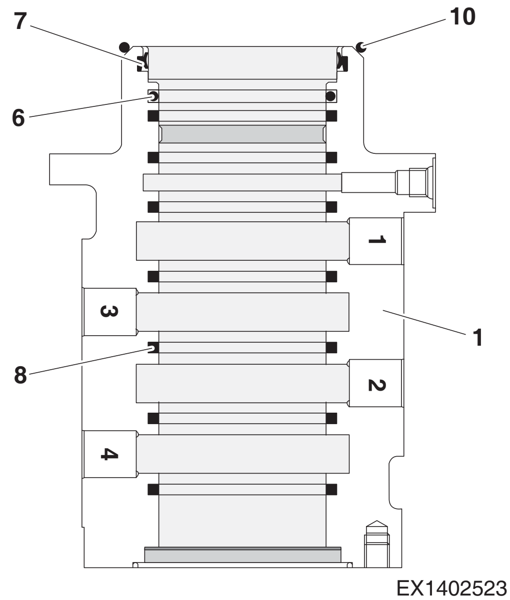


Figure 22

REASSEMBLY

IMPORTANT

Apply a very light film of white grease inner surface of the hub.

1. Assemble the slipper seal (8, Figure 23) (7 ea), O-ring (6) (1 ea), O-ring (6) (1 ea) and dust seal (7) (1 ea) into the hub.

CAUTION

AVOID INJURY

After assembling the slipper seal, a manual test must be performed to ensure that every part is assembled properly.

IMPORTANT

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

IMPORTANT

Applying oil to the surface of the spindle will help prevent damage to the slipper seal.

2. Fix the position of the spindle and press the hub carefully into spindle with both being parallel each other. (Figure 24)
3. Use a plastic (or rubber) hammer to tap the hub until it is inserted completely.

IMPORTANT

Tap the Hub in a zigzag pattern so it does not tilt to one side.

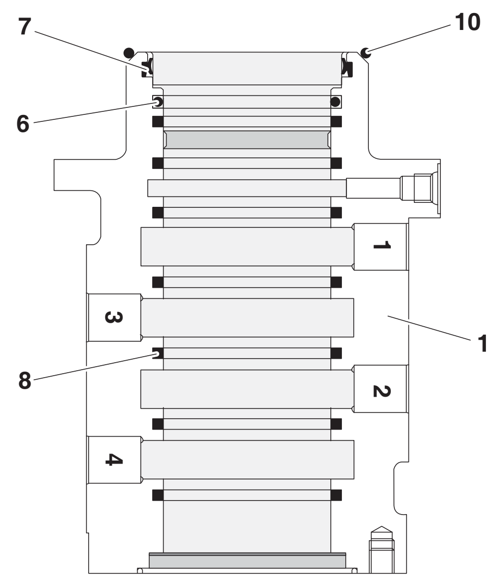


Figure 23

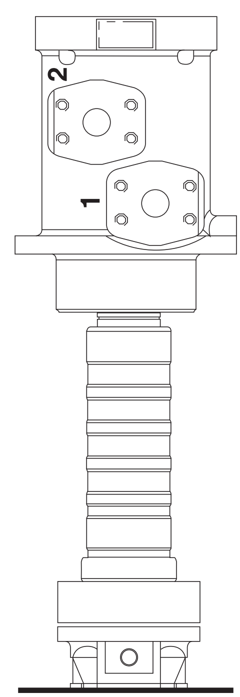


Figure 24

4. Assemble the shim (11, Figure 25), spacer (4) and install the retaining ring (5).

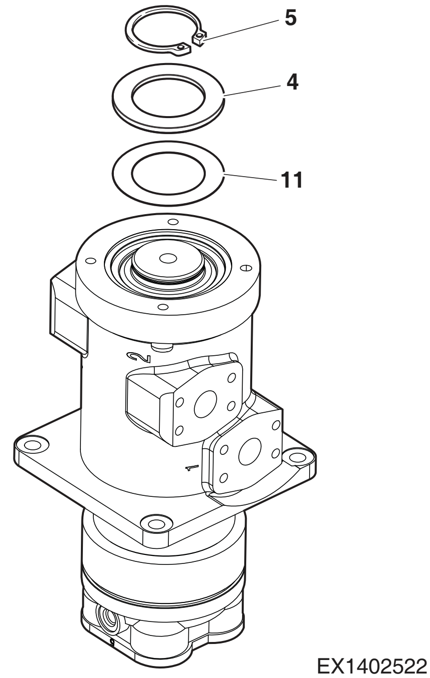


Figure 25

5. Apply the grease inner surface of cover (3, Figure 26) to fix the shim (12). And install the O-ring (9) to hub.

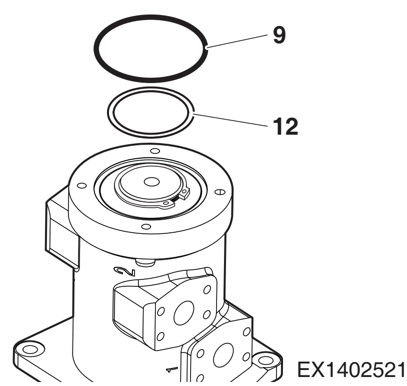


Figure 26

6. Install the bolts and washers (13 and 14, Figure 27) with cover (3) to hub.
   - Tool: 19 mm ( )
   - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
7. 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 check hydraulic tank fluid level.

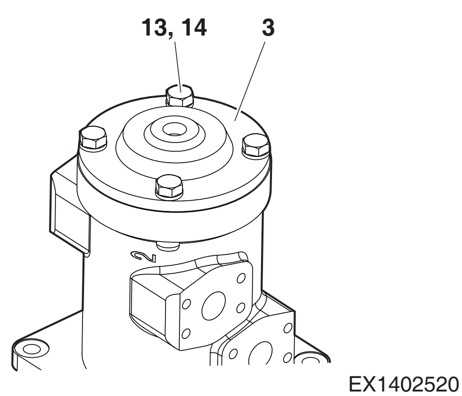


Figure 27

IMPORTANT

After the completion of the assembly, a start-up and a rotation torque test must be performed for the slipper seal to seat in its place properly.

TROUBLESHOOTING, TESTING AND ADJUSTMENT

Inspection

The center joint must 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 can 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 must 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 28).*

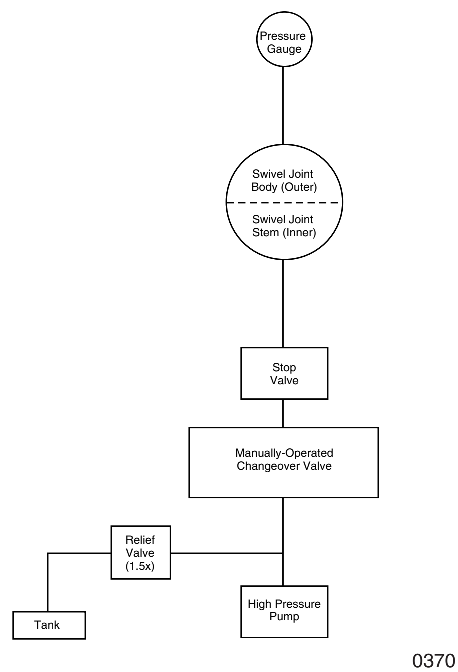


Figure 28

Travel Device

SAFETY INSTRUCTIONS

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Travel Device

GENERAL

Specification

		1 Speed	2 Speed
Travel Motor	Type	Axial Piston 2-speed	
	Displacement	180.1 cc/rev	105 cc/rev
	Crossover Relief Valve Setting	343 bar (350 kg/cm^2, 4,978 psi)	
	Max. Supply Flow	215.6 L/min (57 U.S. gpm)	
	Motor Shaft Speed	1,197 rpm	2,054 rpm
	Motor Shaft Torque	927 N.m (94.6 kg.m, 684 ft lb)	540 N.m (55.1 kg.m, 398 ft lb)
Reduction Gear	Type	3 - Stage Planetary Gear	
	Reduction Gear Ratio	63.8	
	Max. Output Speed	18.8 rpm	32.2 rpm
	Max. Output Torque	59,222 N.m (6,039 kg.m, 43,680 ft lb)	34,529 N.m (3,521 kg.m, 25,467 ft lb)
	Weight	380 kg (Included Motor)	
Traveling Performance	Traveling Speed	2.5 km/hr	4.4 km/hr
	Traction Force (EFF. = 75% / 65%)	24.7 ton	12.9 ton
	Gradeability	70%	
Parking Brake	Control Type	Main Pressure, Mechanical	
	Brake Torque	35,743 N.m (3,645 kg.m, 26,362 ft lb)	
	Brake Release Pressure	10.4 ±1.5 bar (10.6 ±1.5 kg/cm^2, 151 ±21 psi)	

Overview

Travel device consists of a travel motor and gearbox.

Travel motor includes rotary parts, parking brake and high/low speed changeover mechanism.

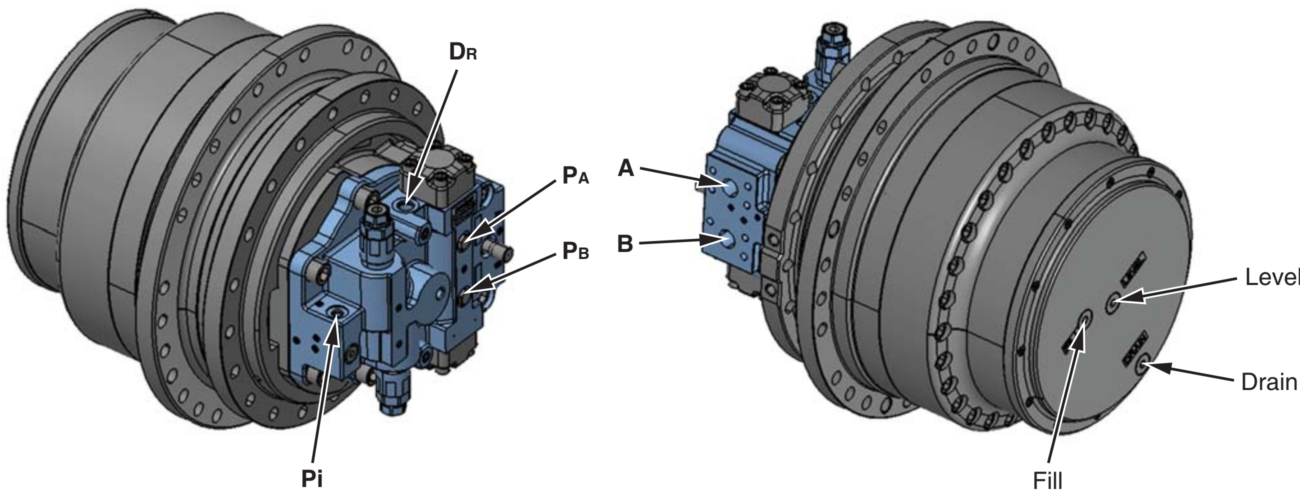


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Figure 1

Port

Port	Name	Size
A	Inlet, Outlet	SAE 1", 6000 psi, ø25, 27.8 x 57.2
B	Inlet, Outlet	SAE 1", 6000 psi, ø25, 27.8 x 57.2
Pi	Pilot (High-speed)	PF 1/4", O-ring
P_A, P_B	Gauge	
D_R	Drain	PF 1/2", O-ring
	Fill	
	Level	
	Drain	
	Lifting	M16 - Depth 27

Hydraulic Circuit

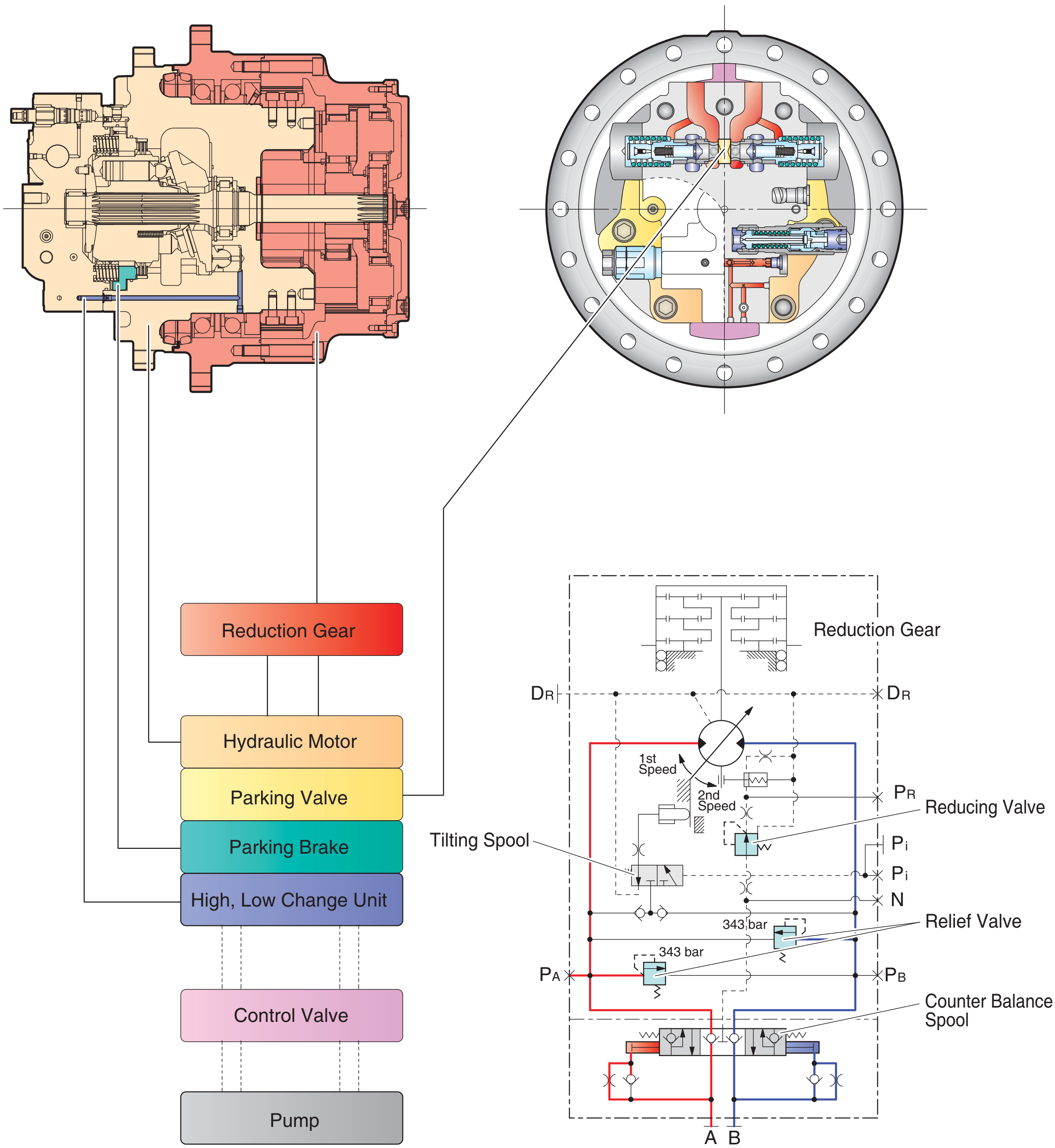

Figure 2

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Parts List

Travel Motor

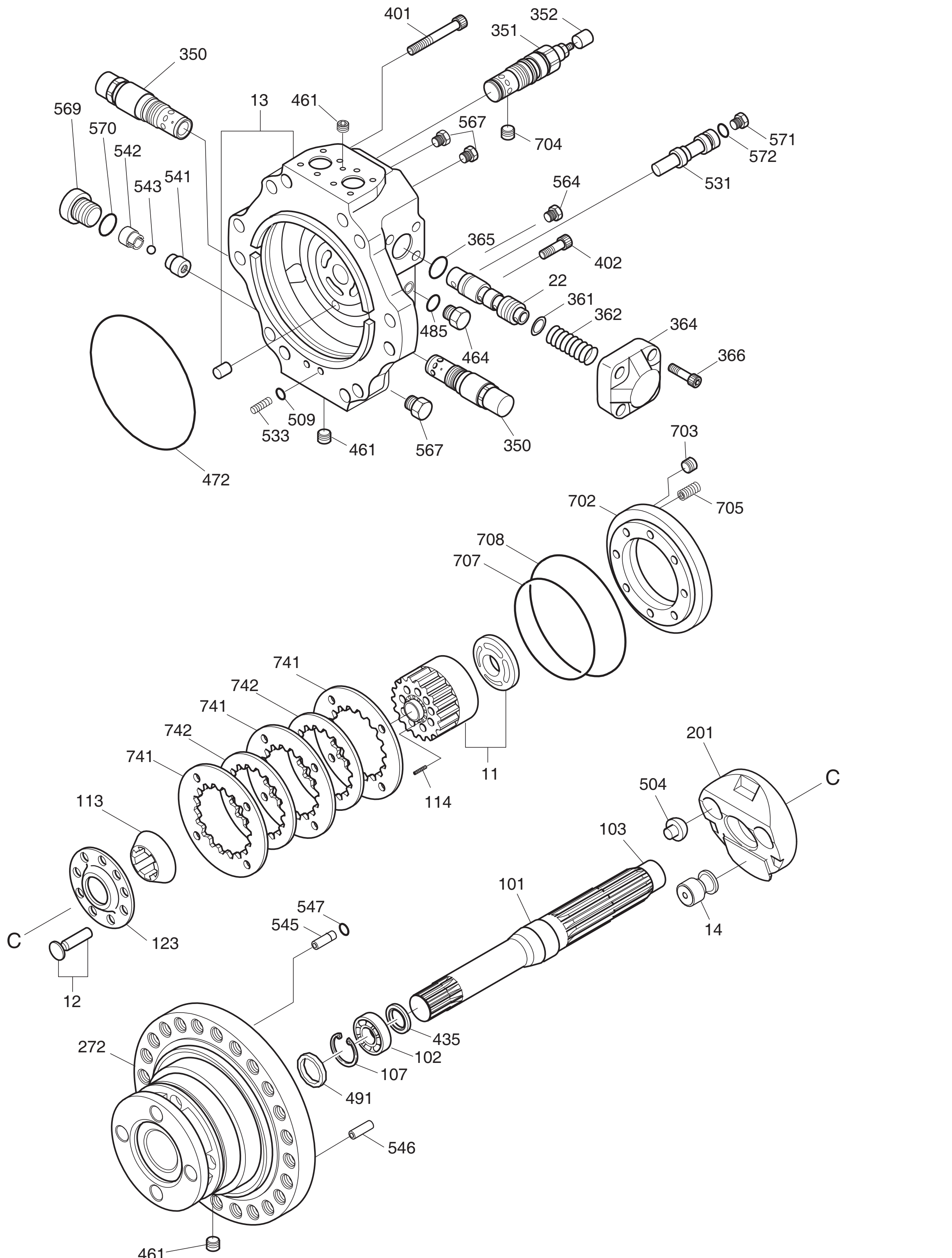


Figure 3

Reference Number	Description
11	Cylinder Assembly
12	Piston And Shoe Assembly
13	Valve Casing Assembly
14	Tilting Piston Assembly
22	Spool; Counter Balance
101	Shaft; Drive
102	Bearing; Roller
103	Bearing; Needle
107	Ring; Stop
113	Bush
114	Spring; Cylinder
123	Plate; Set
201	Plate; Swash
272	Case, Shaft
350	Valve, Relief
351	Valve; Reducing
352	Cover
361	Washer
362	Spring; Counter Balance
364	Cover; Counter Balance
365	O-ring
366	Bolt; Socket M12 x 1.75 x 45
401	Bolt; Socket
402	Bolt; Socket
435	Ring; Snap
461	Plug
464	Plug
472	O-ring

Reference Number	Description
485	O-ring
491	Seal; Oil
504	Ball; Pivot
509	O-ring
531	Spool; Tilting
533	Spring; Tilting
541	Seat
542	Stopper
543	Ball; Steel
545	Orifice
546	Orifice
547	O-ring
564	Plug
567	Plug
569	Plug
570	O-ring
571	Plug
572	O-ring
702	Piston, Brake
703	Orifice
704	Orifice
705	Spring; Brake
707	O-ring
708	O-ring
741	Plate; Separator
742	Plate; Friction
*	Seal Kit; Motor

*: 365, 472, 485, 491, 509, 547, 570, 572, 707, 708

Travel Reduction Gear

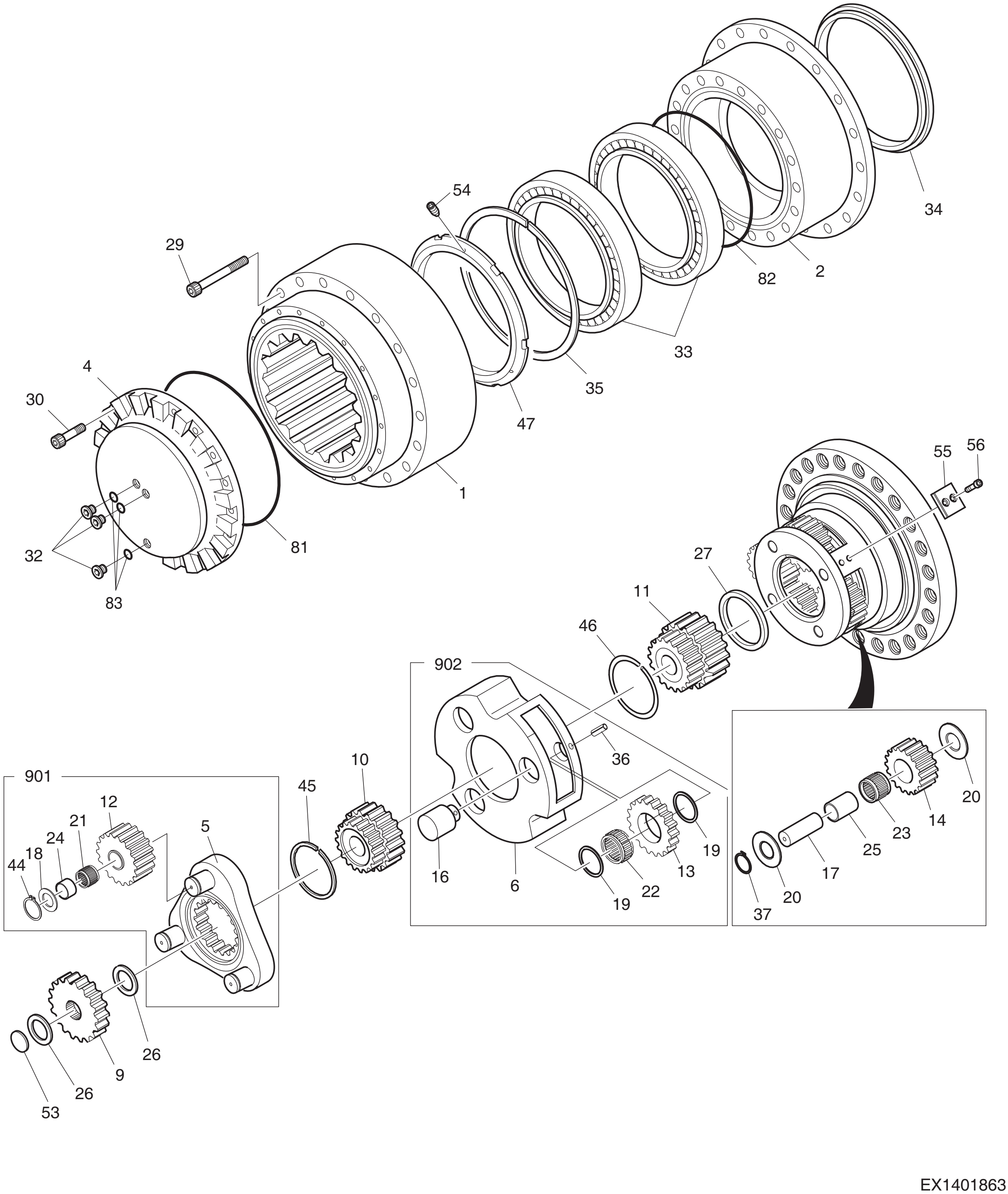


Figure 4

Reference Number	Description
1	Gear; Ring
2	Housing
4	Cover, Side
5	Carrier No. 1
6	Carrier No. 2
9	Gear; Sun No. 1
10	Gear; Sun No. 2
11	Gear; Sun No. 3
12	Gear; Planetary No. 1
13	Gear; Planetary No. 2
14	Gear; Planetary No. 3
16	Pin No. 2
17	Pin No. 3
18	Plate; Side E
19	Plate; Side A
20	Plate; Side F
21	Cage; Needle
22	Cage; Needle
23	Cage; Needle
24	Ring; Inner
25	Bush; Floating
26	Ring; Thrust 60

Reference Number	Description
27	Ring; Thrust 90
29	Bolt; Socket M16 x 100
30	Bolt; Socket
32	Plug
33	Bearing; Angular
34	Seal; Floating
35	Shim 1.0
36	Pin; Spring
37	Ring
44	Ring; Snap
45	Clip
46	Clip
47	Ring, Nut
53	Washer 1.0 t
54	Screw; Set
55	Stopper; Nutring
56	Bolt, Socket
81	O-ring
82	O-ring
83	O-ring
901	Carrier No. 1 Sub Assembly
902	Carrier No. 2 Sub Assembly

Theory of Operation

Hydraulic Motor

1. Generation of rotational force.

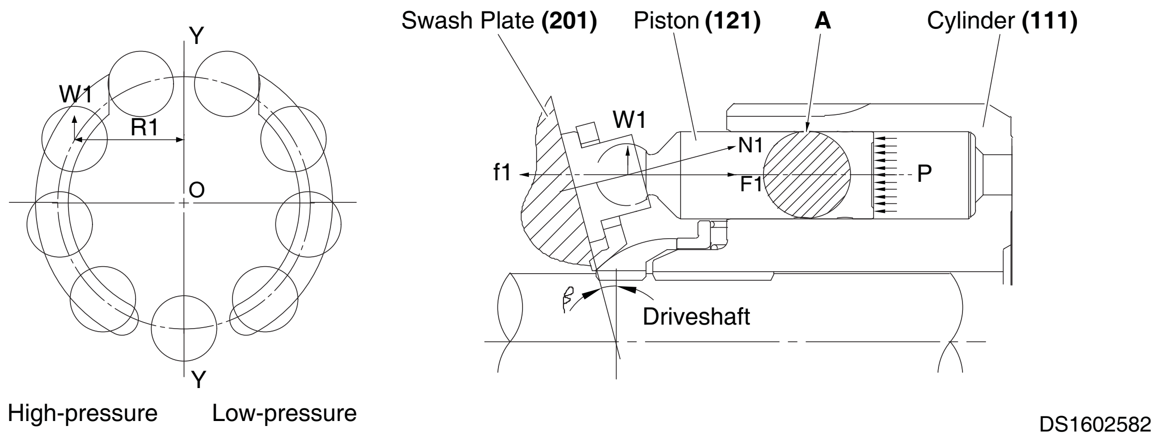


Figure 5

High pressure oil supplied from the hydraulic pump flows through valve casing (303) and valve plate (131) into cylinder block (111). (Refer to Figure 3 for indication numbers).

The internal design allows the high pressure oil to flow to one side of the center line "Y-Y" at the top and the bottom dead center piston (121).

The high pressure oil acts upon pistons and generates force "F1" (F1 = P x A (P: Supply pressure, A: Pressure area)). The force "F1" generates perpendicular force "N1" and radial force "W1" against swash plate (201), which has a tilting angle of "β." "W1" generates torque "T" (T = W1 x R1) against the line "Y-Y" of bottom and top dead center of piston.

The resultant (∑ W1 x R1) of torques which are generated from pistons (4 ~ 5 ea.) of high pressure side by high pressure oil generates rotating force. This torque is transmitted to cylinder block (111) through piston, and then rotating force is transmitted to drive shaft because cylinder block is combined with drive shaft by spline.

2. Operation of relief valve

The relief valve operates as follows:

A. The relief valve maintains constant starting pressure of hydraulic motor and, in response to accelerated speed of inertial object, bypasses excess oil flow at motor's input port to return circuit.

B. If inertial object stops its movement, relief valve brakes delivery section to forcibly stop inertial object.

The chamber "A" is always connected to port "A" of motor. If pressure at port "A" is increased, and pressure becomes greater than spring pressure setting of poppet "A", poppet "A" is moved off seat "A" to allow oil to flow from chamber "A" to port "B."

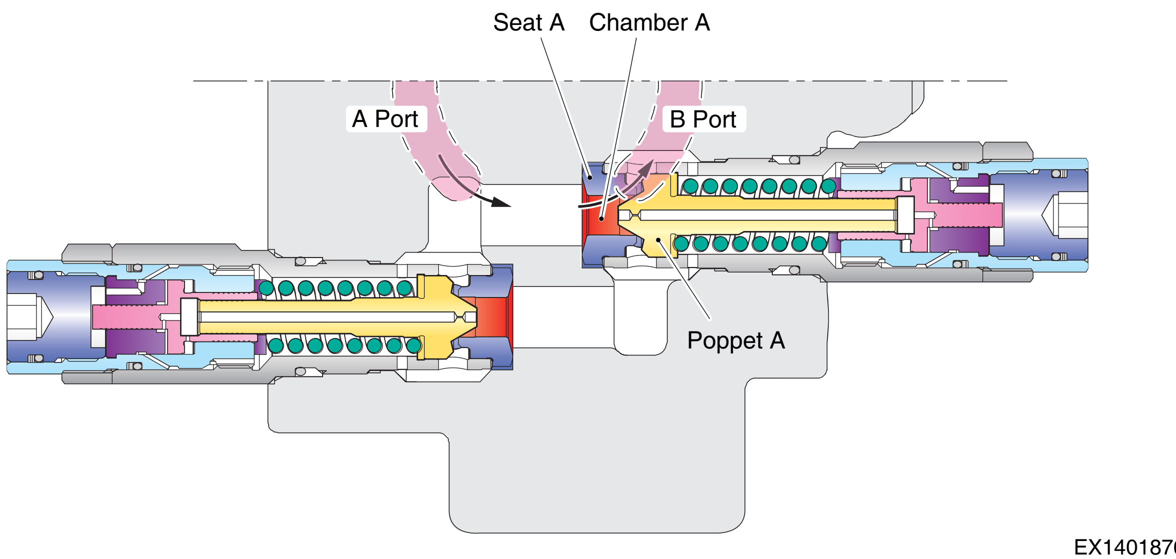


Figure 6

3. Parking brake operation

Pressurized oil opens counterbalance spool (22) in valve casing (303). Oil entering through counter balance spool (22) in valve casing (303), forces brake piston (702) to release the brake. When hydraulic oil pressure, is not present, the brake is spring applied by springs.

Braking force is generated by separator plate (741) and shaft casing (272), which are assembled to shaft casing (272), and friction plate (742), which is connected between brake piston (702) and periphery of cylinder block (111) by splines.

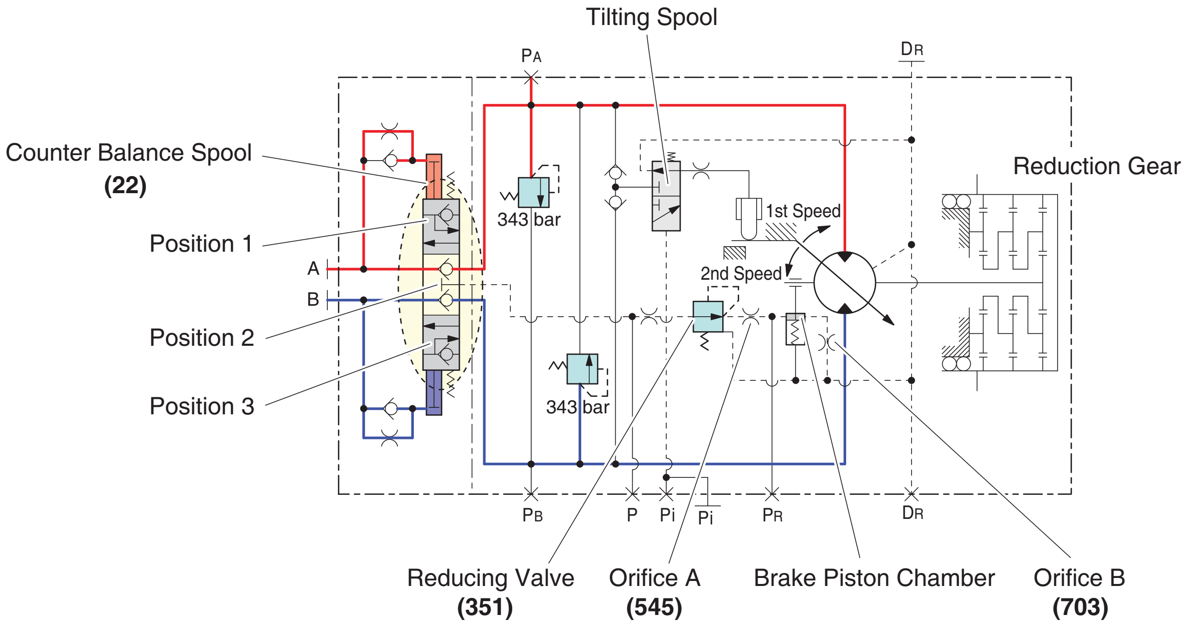
If hydraulic oil pressure is released, brake springs (705) cause brake piston to generate frictional force by pushing friction plates and separator plates together. This friction force restrains drive shaft (101) connected to cylinder block by splines and applies braking force.

NOTE: *When counterbalance spool is in travel mode (Position 1 or 3).*

The pressurized oil flowing from port A or port B is depressurized at reducing valve (351), passing through orifice A (545) and flowing into brake piston chamber. At this time, a minute amount of working oil is drained to orifice B (703), but as pressurized oil is always supplied from counterbalance valve, pressure of brake piston chamber always overpowers spring force and thus releases brake.

NOTE: *When counterbalance is in neutral position (Position 2).*

Since there is no supply of pressurized oil, pressure in piston chamber is decreased and brake spring force overpowers piston chamber pressure to force spool to return to neutral position. This causes motor to stop until brake is operated, so that damage to friction plates is prevented.



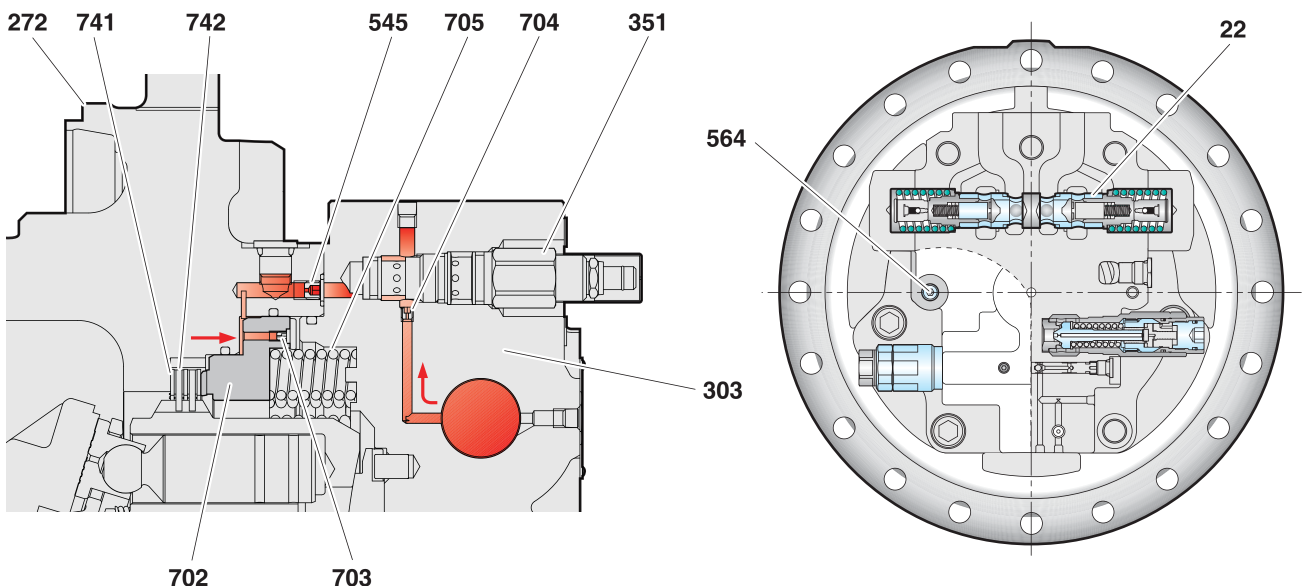


Figure 7

- How to release parking brake

Release Operation	Tool
Remove two plugs (564) from valve casing (303). Insert a bolt (M10 x 135 L) to tighten it to thread of brake piston, and brake will be released. This state becomes same as brake release pressure is applied.	6 mm

If you release brake without applying brake release pressure, follow instructions below:

CAUTION

AVOID INJURY

If hydraulic motor does not rotate even after brake is released, pump or other part is suspected of malfunction and thus it is difficult to generate working pressure. At this time, if you haul system with hydraulic motor not disassembled, connect a short hose, etc. between pressure measurement ports P_A and P_B to maintain a low hauling speed.

4. Operation of counterbalance valve

   Port (BV) is connected to hydraulic pump, while port (AV) is connected to tank. Pressurized oil from hydraulic pump passes through (BV) to (CV), from (CV) to (C), opening check valve poppet and supplying to hydraulic motor through (BM) port and then rotate the motor.

   Also, if hydraulic pressure delivered from pump is increased, pressurized oil flowing from gallery (G) passes spring chamber (E), ball check valve, and then reaches damping chamber (M).

   If pressure in chambers (E) and (M) overpowers spring (362) force which is designed to maintain neutral position of spool, spool moves in Right → Left direction.
   Working oil in (N) chamber flows through orifice (Q) to (F) chamber, while working oil in chamber (F) passes (G) to (AV) and then is drained to tank.

   If hydraulic pressure delivered from pump is lowered, pressure in (E) and (M) chambers also is lowered.
   As a result, spool is returned in direction Left → Right by spring (362) of chamber (F).
   Working oil in (M) chamber passes orifice (R) and is delivered to (E) chamber, while working oil in (E) chamber is delivered from path (G) to (BV) port. As a result, spool moves in direction of Left → Right.

   If pressure in (BV) port is lowered down to tank pressure, pressure in (E) and (F) chambers also becomes same as tank pressure. As a result, spool returns to neutral position.

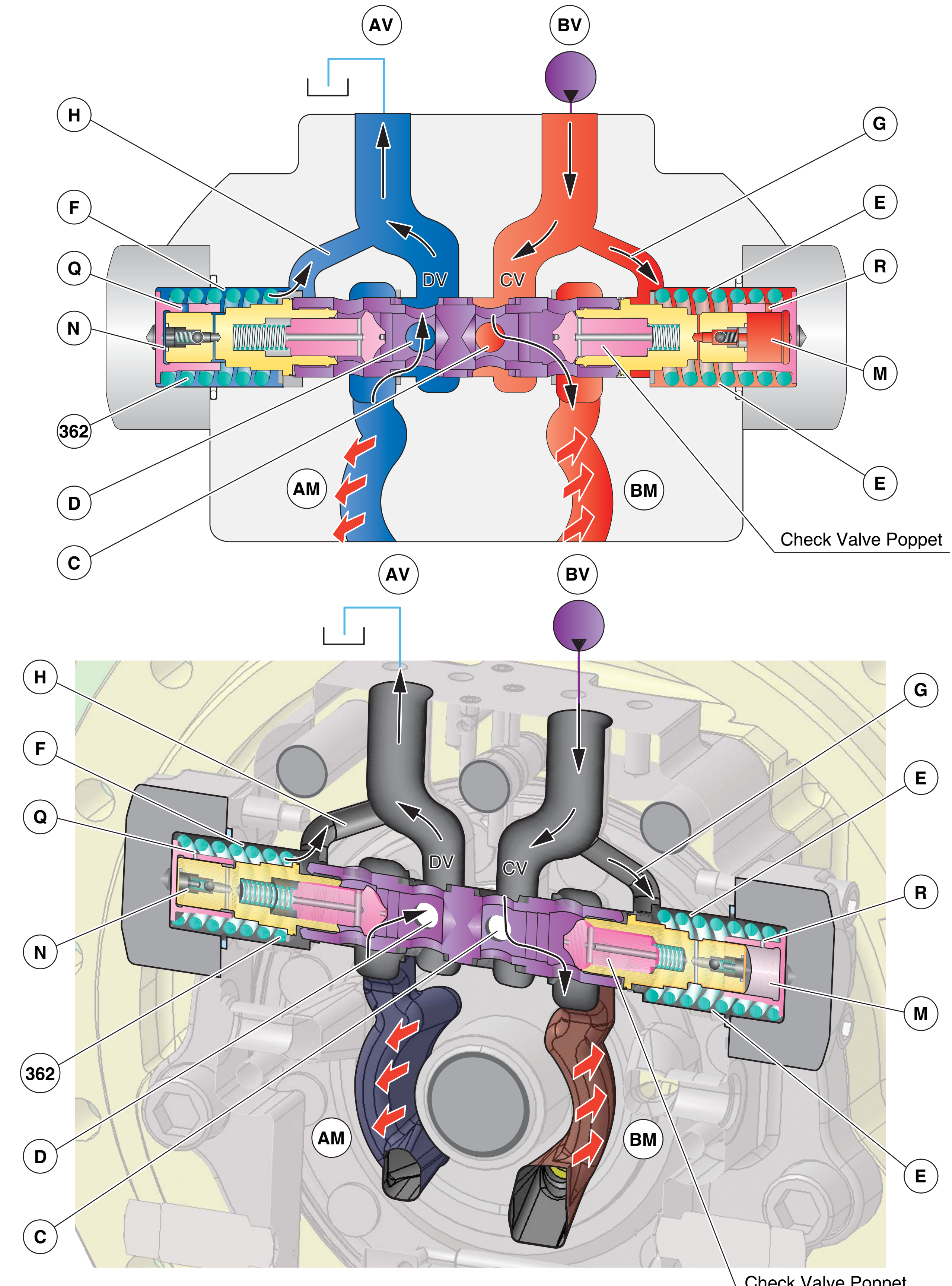


Figure 8

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5. Operation of high-speed

This is a supporting device for swash plate (201) on which shoe slides. It has a hemispherical pivot ball (504) arranged along its both ends which bears load against swash stopper.

Changing in tilting angle of this swash plate changes capacity. This device has tilting pistons (502) arranged along swash stopper section and uses tilting control valve to control inflow/outflow of working oil from / to piston chamber, and thus it can determine tilting angle (large or small) of swash plate.

A. External pilot pressure Pi = 0 kg/cm^2 (0 bar) (Large tilting)
High pressure acting to motor from high pressure select function assembled to valve casing (303) acts to P port of tilting spool (531). This pressure becomes save pressure.
As spool (531) assembled into tilting switching section is in tight contact with plug (571) through spring (533), high-pressure in P port gets blocked.

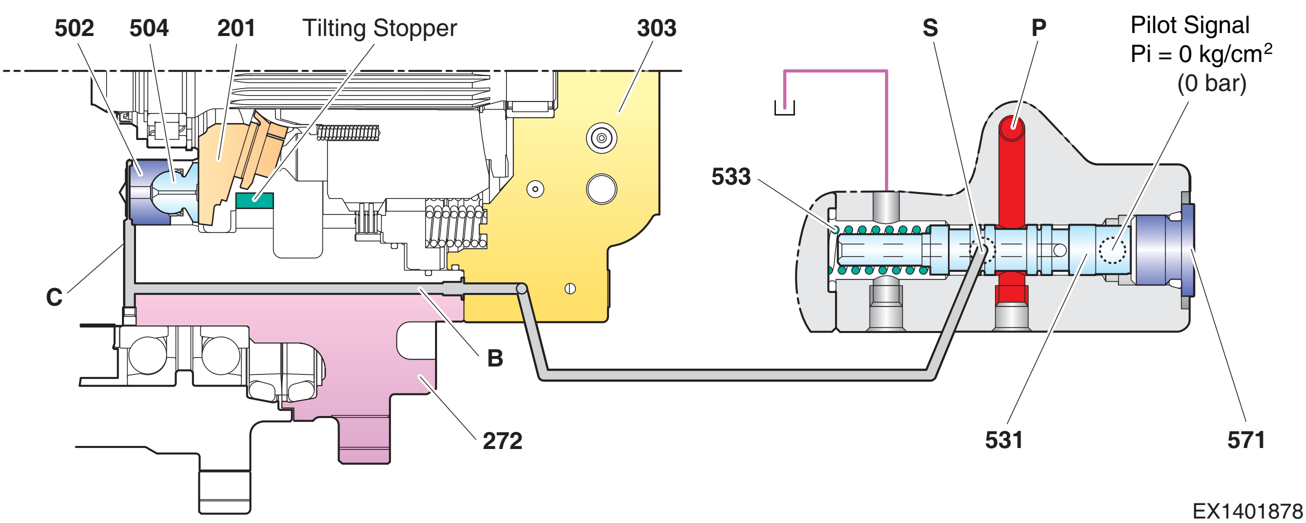


Figure 9

B. External pilot pressure Pi ≥ 20 kg/cm^2 (20 bar) (Small tilting)
If force acting to tilting spool (531) overpowers spring (533) force, spool is switched to left direction. High pressure oil passes P port to S port of tilting spool, path B, then acting to C chamber. The tilting piston (502) moves right through this high-pressure oil and swash plate moves right. The swash plate moves all way to position of tilting stopper of shaft casing (272) until it becomes fixed in that position.

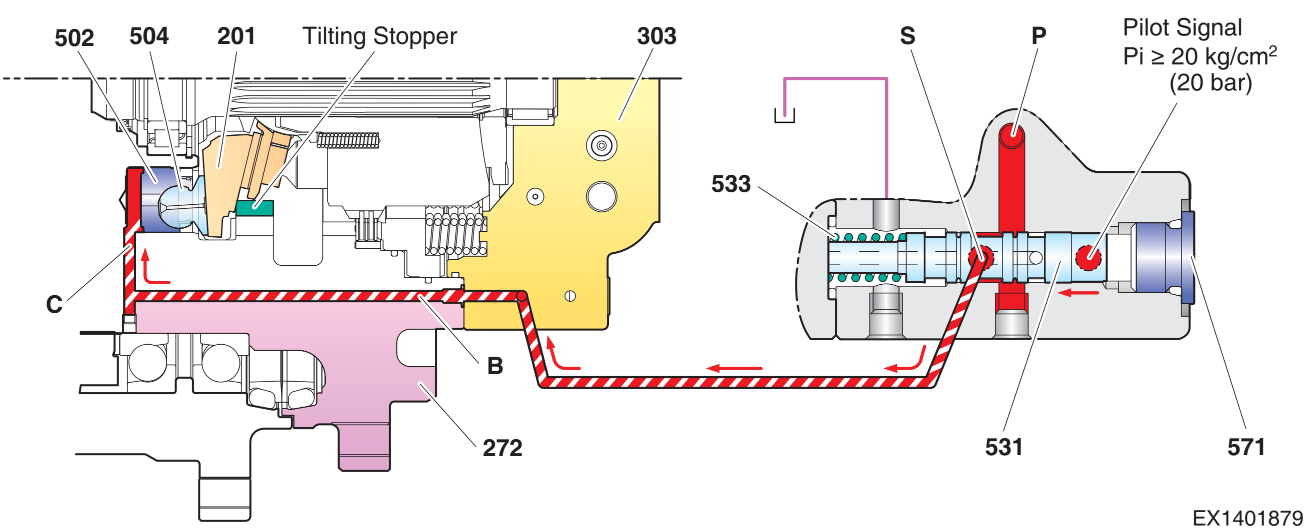


Figure 10

Operation of Reduction Gear

The reduction gear comprises 3-level planetary gear and differential gear as shown in Figure 11.

It has floating type sun gear, and therefore tooth profile error and carrier pin hole pitch variation may affect life of gear.

Input rotation of hydraulic motor is transmitted to No. 1 sun gear (S1) and No. 1 sun gear (S1) drives No. 1 planetary gear. As this No. 1 planetary gear (P1) attempts to rotate No. 1 ring gear (R1) by using force in same direction of tangential force as No. 1 sun gear (S1) but No. 1 ring gear is fixed, No. 1 planetary gear generates reaction force against rotation force to rotate No. 1 carrier (C1). In other words, No. planetary gear (P1) does not rotate but revolves. Rotation force of No. 1 carrier (C1) is transmitted to No. 2 sun gear(S2) through level 1 output. (The No. 1 carrier and No. 2 sun gear are connected through spline.)

On same principle as above, revolution of No. 2 planetary gear (P2) is transmitted to No. 3 sun gear through No. 2 carrier (C2). Here, as No. 3 pin supporting No. 3 planetary gear (P3) is fixed, No. 3 planetary (P3) rotates as well as revolves to drive No. 3 ring gear (R3). As a result, driving force of Nos. 1, 2, and 3 ring gears combines to drive rotary drum.

Reduction gear ratio is as follows:

$$i = \frac{(Zs1 + Zr1)(Zs2 + Zr2)(Zs3 + Zr3)}{Zs1 \times Zs2 \times Zs3} - 1$$

NOTE: *Z: dimensions of each gear*
Rotative direction is opposite to input side.

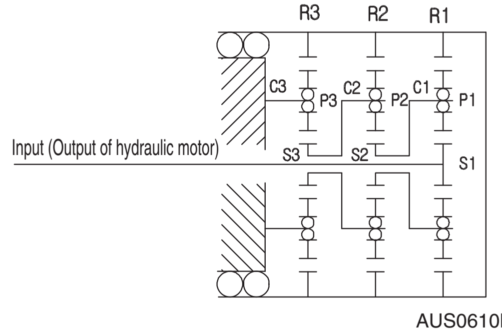


Figure 11

Cautions for Operation

Installation Method

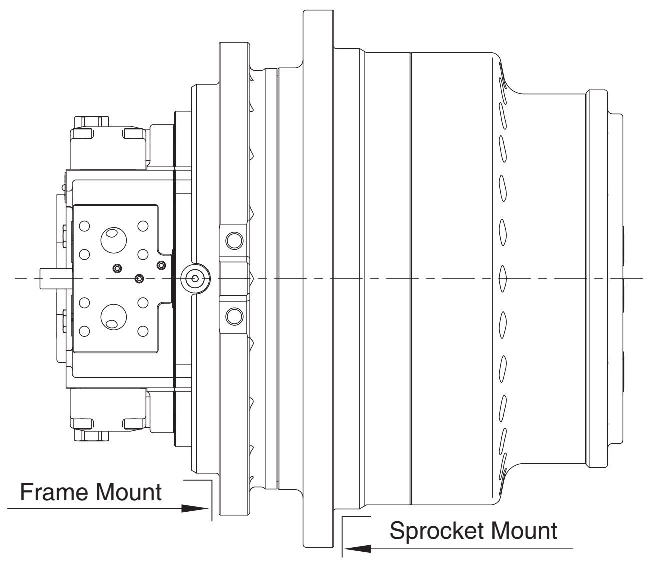


Figure 12

Tightening torque of mounting bolts

Classification	Qty.	Bolt Size	Tightening Torque		
			N.m	**kg.m**	**ft lb**
Frame Mount	26	M20 x 2.5 x 75	539	55	398
Sprocket Mount	24	M20 x 2.5 x 60	539	55	398

NOTE: *The bolts must be Strength Class 10.9 equivalent or better. When assembling, do not hit the travel motor with hammer, etc., but use bolt holes.*
Take care not to damage the assembling part of the gearbox.

Piping

1. Turning direction is indicated in outside dimension drawing. Be careful of piping direction.
   - Turning direction

Inlet	Outlet	Direction Seeing from Valve Casing
A	B	Left Turning
B	A	Right Turning

2. Cover piping port with a cloth when transporting. When carrying out piping work, use care that foreign material does not enter system.
3. The drain piping with plugs tightened at two places are supplied from factory. Use either of two plugs. Add a sufficient amount of oil into casing before piping work. In addition, carry out piping work so that drain pressure can be reduced.

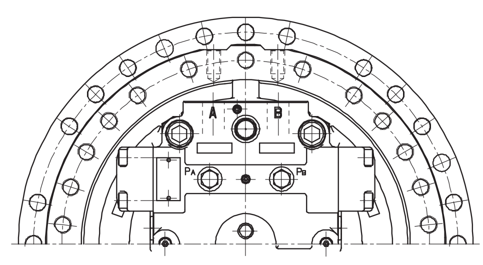


Figure 13

4. Entry of foreign material into oil may cause premature wear on sliding parts, resulting in stick or seizure. To prevent such defects, be sure to install a filter of 10μm or less within circuit.

Hydraulic Oil

Because the hydraulic motor case is drained at the time of shipping, make sure to fill up the case with hydraulic oil before operation.

Selecting Hydraulic Oil

Take the followings into consideration when selecting the hydraulic oil for travel motor:

1. Use VG46-VG68 grade or equivalent.
2. Use wear resistant hydraulic oil.
3. Please contact us when hydraulic oil other than the one in the table below is to be used;

Grade	Viscosity (40°C)	46CST	68CST
	ISO VG	VG46	VG68

Inspection, Replacement of Hydraulic Oil

The standard replacement period of hydraulic oil is as follows (may vary by operating condition);

The table below shows the standard replacement period of hydraulic oil.

- Volume of hydraulic motor oil: about 2 ~ 2.5 L
- Replacement period: 2,000 hr or 1 year

Lubricant

The reduction gear is filled with lubricant (gear oil) at the time of shipping, however, check the oil level before operation.

1. Selecting gear oil

   Use the gear oil with SAE #90 of equivalent extreme pressure additive (API Classification GL-5 Grade or better).

2. Replacement period of gear oil

   A. First replacement (first time after starting operation): 250 hr

   B. Second and later replacement: 1,000 hr or 1 year

      However, if gear oil reduces fast than normal, find out and correct the cause before refilling oil.

3. Replacement volume of gear oil: 6 L (1.6 U.S. gal)

4. Replacement method of gear oil

5. Needed tool: 10 mm ()

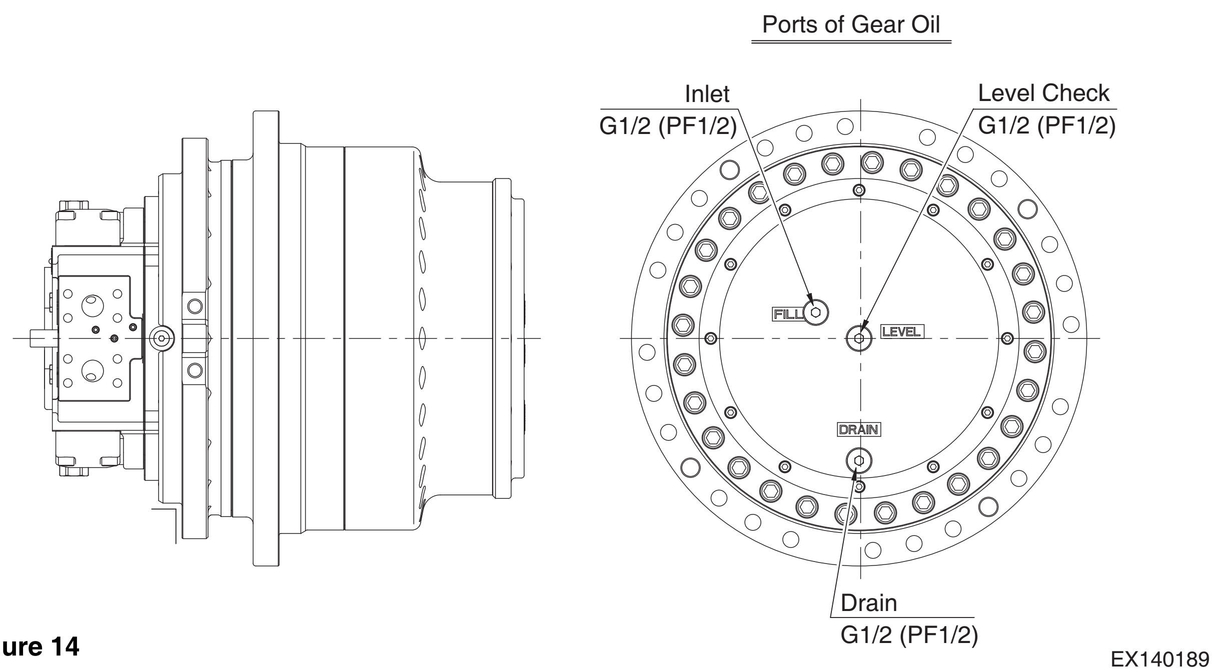


Figure 14

Added or replaced oil must be of the same kind. Do not mix with a different type or grade of oil.

A. Let the oil refill port and drain port be perpendicular to the horizontal plane.

B. For replacement, unplug the two ports and drain the gear oil.

C. Refill gear oil until oil overflows from oil level check port.

D. Wind Teflon or thread tape on the plug before plugging the ports again.

Maintenance/Service

Check the following items while operating the travel motor.

1. Stop the product before service or inspection except when checking the noise level of clause 3 below. Otherwise, you may get physical injury including burn.
    A. Oil leak (hydraulic oil, gear oil)
    B. Loose bolt
    C. Abnormal noise
    D. Abnormally high case temperature
    (Standard external surface temperature of case during continuous operation: 80°C max.)
    E. Replacement period of gear oil (See "Lubricant" on page -20.)
    F. Hydraulic motor allowable drain: 0.5 lpm (pressure 5 bar (5 kg/cm^2) max., at 25 rpm)
2. The case may be very hot right after operation. Measure the temperature with a contact type thermometer.

PRECAUTION

Tools for Disassembly and Assembly

Hydraulic Motor

Tool Name	B (mm)	Applying Part Name
Hex L-wrench	2	Orifice (703)
	2.5	Orifice (704)
	4	Plug (461), Orifice (545, 546)
	6	PT Plug (564), PF Plug (569)
	8	PF Plug (571)
	10	Socket Bolt (366)
	17	Socket Bolt (401, 402)
Socket Wrench Spanner	19	VP Plug (567)
	22.4	Reducing Valve (351)
	27	VP Plug (464)
	42	Relief Valve (350)
Pliers (for Hole TRP-90)		
Pliers (for Shaft)		
Hammer, Plastic Hammer		
Steel Bar (7 x 7 x 200)		Bearing (102, 103)
Monkey Wrench		
Toque Wrench		
Driver (JISB 4609)		
Jig for Assembling of Oil Seal		
Bearing		
Seal Tape		

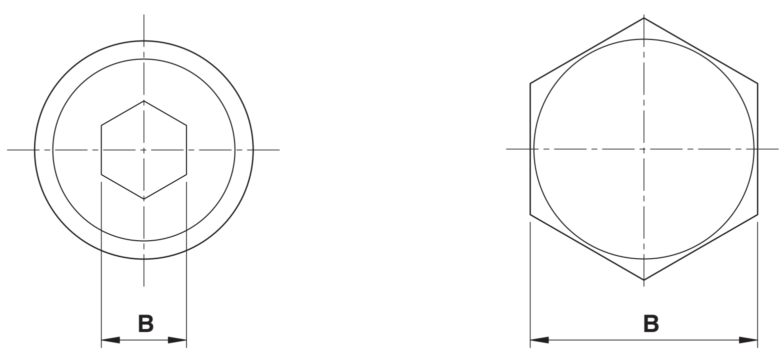
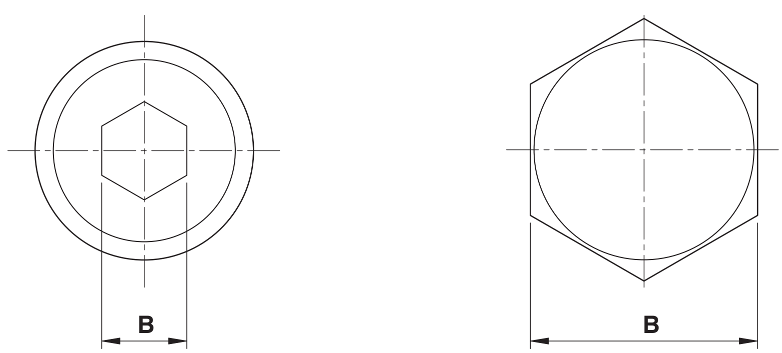


Figure 15

Reduction Gear

Tool Name	B (mm)	Applying Part Name
Hex L-wrench	4	Socket Screw (54)
	84	Socket Bolt (30)
	10	Plug (32)
	14	Socket Bolt (29)
Pliers (for Shaft)		Snap Ring (44, 37)
Eye Bolt (M8)		Ring Gear (1)
Eye Bolt (M10)		No. 2 Carrier (6)
Eye Bolt (M16)		Housing (2)
Eye Bolt (M20)		Shaft Casing (272)
Hammer, Plastic Hammer		Also Wood Hammer Is Possible
Driver (-)		Jig for Assembling of Floating Seal
Press (1 ton)		Angular Bearing (33)
Depth Gauge (100 mm in Depth)		for Adjusting Washer (53)
Punch		Spring Pin, Set Screw Caulking
Torque Wrench		
Tap (M16)		for Removing Loctite from Threaded Part
Oilstone		Finish
Loctite (Three Bond 1373B)		Set Screw (54)
Loctite		Socket Bolt (29)
Jig for Assembling Nut Rings		Nut ring (47)



B Size (rear side width)

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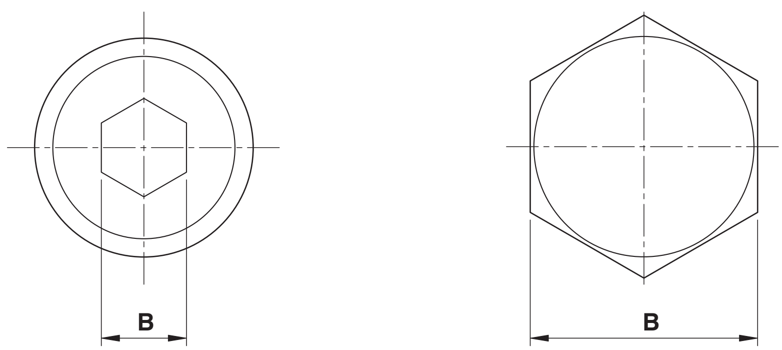
Figure 16

Tightening Torque

Section	No.	Name	Size	B (mm)	Tightening Torque		
					N.m	kg.m	ft lb
Hydraulic Motor	366	Socket Bolt	M12 x 45	10	98.0	10.0	72.0
	401	Socket Bolt	NPTF 1/16	17	431.2	44.0	316.8
	402	Socket Bolt	M20 x 100	17	431.2	44.0	316.8
	461	Plug	NPTF 1/16	4	8.8	0.9	6.5
	464	VP Plug	PF 1/4	27	107.9	11.0	79.6
	545	Orifice	NPTF 1/16	4	6.9	0.7	5.0
	546	Orifice	NPTF 1/16	4	6.9	0.7	5.0
	564	Plug	PF 1/4	6	21.6	2.2	15.8
	567	VP Plug	PF 1/4	19	36.3	3.7	26.6
	569	Plug	PF 1/4	6	36.3	3.7	26.6
	571	Plug	PF 3/8	8	73.5	7.5	54.0
	703	Orifice	M4 x 0.7	2	3.9	0.4	2.9
	704	Orifice	M5 x 0.8	2.5	6.9	0.7	5.0
Reduction Gear	29	Socket Bolt	M16 x 100	14	294.0	30.0	216.0
	30	Socket Bolt	M8 x 20	6	34.3	3.5	25.2
	32	Plug	PF 1/2	10	107.9	11.0	79.6
	54	Set Screw	M8 x 16	6	49.0	5.0	36.0



B Size (rear side width)

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Figure 17

REMOVAL

WARNING

AVOID DEATH OR SERIOUS INJURY

Contact with hydraulic fluid can harm your health. (e.g. eye injuries, skin damage or poisoning, if inhaled).

- **While performing removal and installation, wear safety gloves, safety glasses and suitable working clothes.**
- **If hydraulic fluid should come into contact with your eyes or penetrate your skin, consult a doctor immediately.**

WARNING

FIRE CAN CAUSE SERIOUS INJURY OR DEATH

Hydraulic fluid is highly flammable.

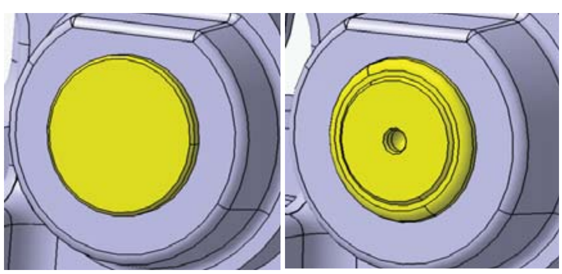
- **Keep open flames and ignition sources away from the workplace.**

IMPORTANT

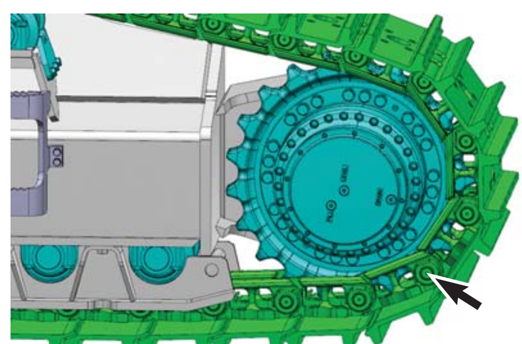
Fluid such as engine oil, hydraulic fluid, coolants, grease, etc. must be disposed of in an environmentally safe manner. Some regulations require that certain spills and leaks on the ground must be cleaned in a specific manner. See local, state and federal regulations for the correct disposal.

1. Position machine on a smooth level surface with adequate space. Move machine until master pin is positioned at approximately 4 o'clock.

   NOTE:

   Regular Pin Master Pin
   EX1400095



DS1602756

Figure 18

CAUTION

AVOID INJURY

Pressure of grease in adjuster cylinder is too high. Take precautions in opening valve against valve bounce or grease vent.

2. Loosen grease valve, and then slacken the tension of track.

   NOTE: *Since the inner pressure of the adjustment cylinder is high, loosen the grease valve slowly.*

   If the grease does not come out adequately, start the engine and move the machine forwards and backwards.

   - Tool: 27 mm ( )
   - Torque: 137 N.m (14 kg.m, 101 ft lb)

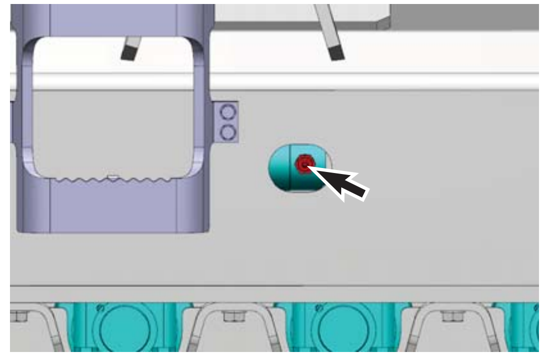


Figure 19 DS1602757

3. Remove master pin using jig or tool.

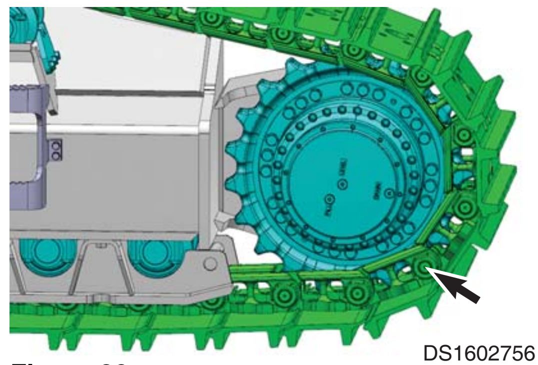


Figure 20 DS1602756

4. Put two blocks between track and guard (1, Figure 21) to widen the gap between sprocket and lower track.

   NOTE: *The gap between sprocket and track link must be over 50 mm (2 in).*

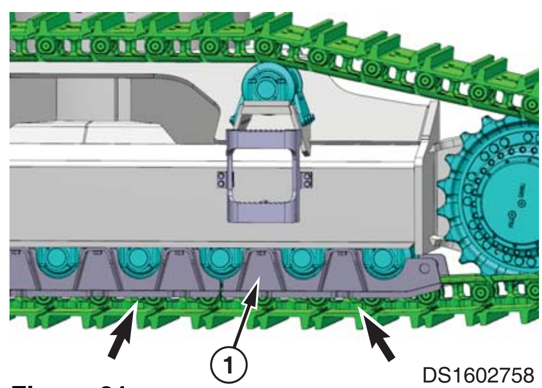


Figure 21 DS1602758

5. Place travel device to the direction of the arrow slowly and remove upper track.

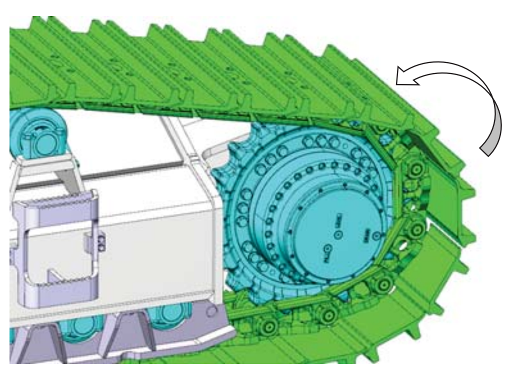


Figure 22 DS1602759

6. Turn the upper structure 90° and jack up the machine.

   NOTE: *Jack up the machine until the track is slightly off the ground.*

   Set the angle between boom and arm in 90 ~ 110° and support the machine by using a block.

7. Stop engine.

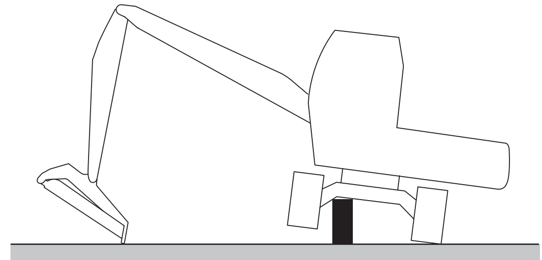


Figure 23 EX1300535

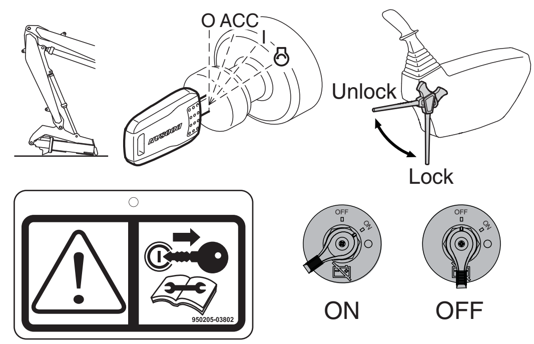
8. Move safety lever to "RELEASED" (UNLOCK) position. (Figure 24)
9. Turn starter switch to "I" (ON) position.

WARNING

AVOID DEATH OR SERIOUS INJURY

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

10. Operate the joystick levers and pedals several times to release the remaining pressure in the hydraulic piping.
11. Move safety lever to "LOCK" position. (Figure 24)
12. Turn key to "O" (OFF) position and remove from starter switch.
13. Attach a maintenance warning tag on controls.
14. Turn battery disconnect switch to "OFF" position. (Figure 25)



EX1504829
Figure 24

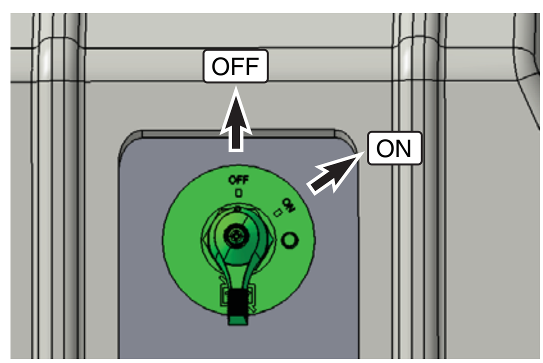


Figure 25 WE1500101

NOTE: *Removal (installation) procedure of the bolts.*

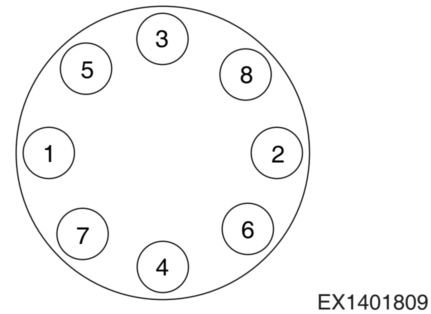


Figure 26

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

Release any pressure in the hydraulic oil tank before doing any work.

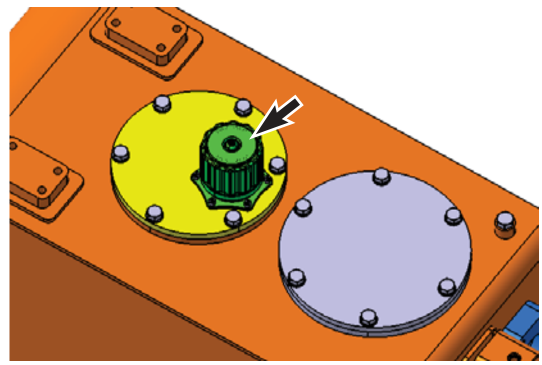


Figure 27 EX1404054

15. Loosen the oil tank air breather slowly to release the pressure inside the hydraulic oil tank.

    Pulling the breather cap upward, the check valve (0.45 bar) opens, and the air is discharged to the atmosphere from the top of the hydraulic oil tank.

16. Remove bolt (24 ea) with sprocket from travel device (Figure 28).
    - Tool: 30 mm ( )
    - Torque: 539.3 N.m (55 kg.m, 397.8 ft lb)
    - Sprocket weight: 84 kg (185 lb)

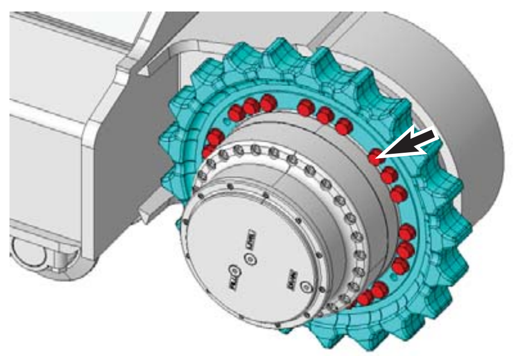
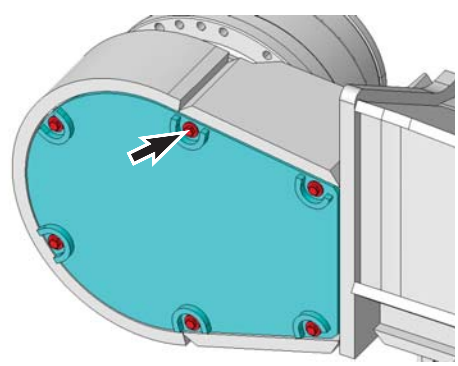


Figure 28 EX1505083

17. Remove cover from track frame (bolt: 6 ea, washer: 6 ea).
    - Tool: 19 mm ( )
    - Torque: 107.9 N.m (11 kg.m, 79.6 ft lb)
    - Weight: about 21 kg (46 lb)



EX1505084

Figure 29

18. When disconnecting the hose, oil left in the hose may flow out. Therefore, place the end of the hose into a suitable container to prevent contamination of the ground and environment.

Figure 30 EX1504170

19. Remove hoses and adapters (Figure 31) from travel device.

NOTE: *Attach identification tags to the removed hoses for reassembling.*
After disconnecting hoses, plug them to prevent dirt or dust from entering.
Disconnect the hoses from the bottom to top of travel device.

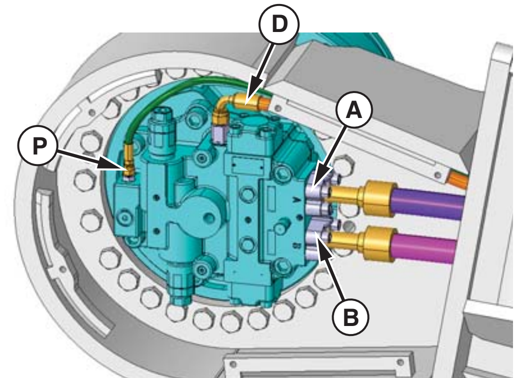


Figure 31 EX1505085

- Hoses and plugs ports

Port	Name	Plug/Flange Size (Hose)	(mm)	(mm)	Torque		
					N.m	kg.m	ft lb
A	Inlet, Outlet	SAE 1", 6000 psi, D25		10	107.9	11.0	79.6
B	Inlet, Outlet	SAE 1", 6000 psi, D25		10	107.9	11.0	79.6
D	Drain	UNF 13/16"-16-2B	24		55.9	5.7	41.2
P	Pilot	UNF 9/16"-18-2B	19		25.5	2.6	18.8

- Fitting

Port	Name	Size		(mm)	Torque		
		A	B (C)		N.m	kg.m	ft lb
D	Adapter	PF 1/2"	UNF 13/16"-16	27	83.4	8.5	61.5
P	Adapter	PF 1/4"	UNF 9/16"-18	19	34.3	3.5	25.3
A, B	O-ring	DS2856003 (1", ID:33.2, OD:40.2, 1B)					
D		S8000185 (4D P18)	S8030081 (1B F-08)				
P		S8000115 (4D P11)	2180-1216D11 (ID:7.65, W:1.78, 1B)				

* A: Opposite side of hose, B (C): Hose side

20. Remove bolts (22 ea) from track frame except 4 bolts in the direction of 12 o'clock

 - Tool: 30 mm (wrench)
 - Torque: 539.4 N.m (55 kg.m, 397.8 ft lb)

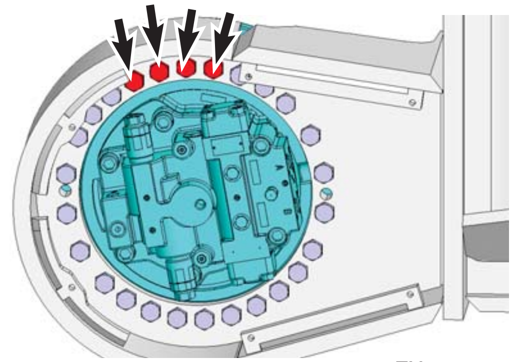


Figure 32 EX1505086

21. Install the sprocket bolts (2 ea) to travel device, and tie the rope to the bolts to lift it.

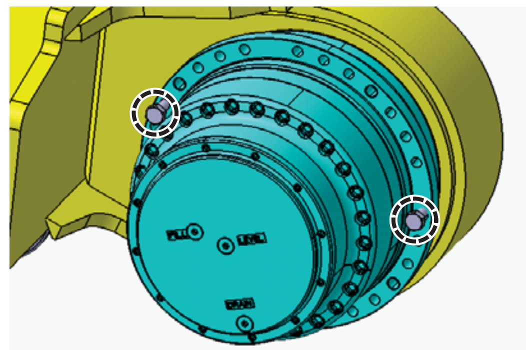


Figure 33 EX1401775

22. Remove remaining bolts (4 ea) of track frame side, and then hoist and remove travel device from track frame very slowly.

 - Weight: about 380 kg (838 lb)

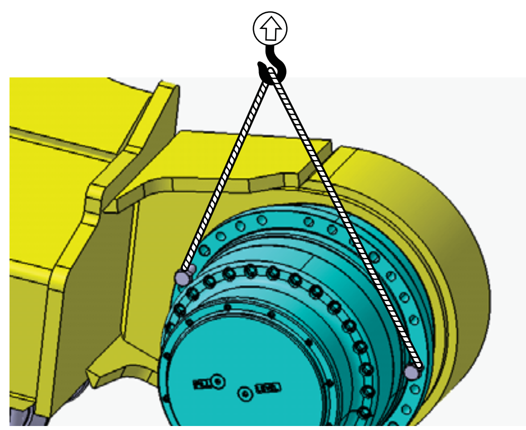


Figure 34 EX1401776

INSTALLATION

WARNING

INCORRECT INSTALLATION CAN CAUSE DEATH OR SERIOUS INJURY

Any change in the connections will lead to malfunctions (e.g. lift instead of lower).

- **When connecting hydraulic components, observe the specified piping according to the hydraulic schematic diagram of the machine.**

IMPORTANT

When replace the travel device, both sides of travel devices are same grades.

1. Perform installation in the reverse order to remove.
2. When installing the hoses, install the drain hose first.

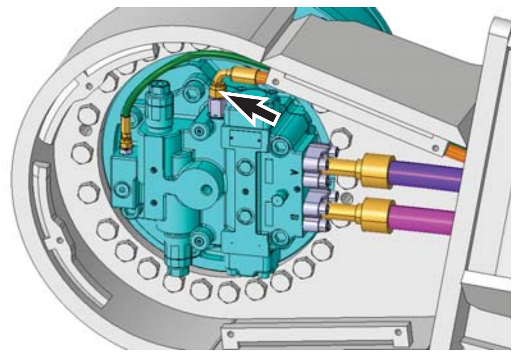


Figure 35 EX1505086

COMPLETING WORK

1. Air testing of reduction gear

   Remove one of the plugs (32) of the reduction gear and apply compressed air 0.3 bar (0.3 kg/cm²) through the plug hole under water for two minutes. There must be no observable air bubble.

   → Refill gear oil 7 L (1.85 U.S. gal) (SAE #90 equivalent, API classification GL-5 Grade or better)

2. Air testing of hydraulic motor

   Seal all the pipe ports of the hydraulic motor except one through which compressed air 0.3 bar (3 kg/cm²) is injected under water for two minutes. There must be no observable air bubble.

   → Hydraulic oil refill 2 ~ 2.5 L (0.53 ~ 0.66 U.S. gal)

3. Start the engine and run at low idle for about 5 minutes.
4. Perform the machine performance test.

Checkup After Assembly

Air Test for Reduction Gear

Remove one plug (32) from reduction gear section and apply compressed air 0.3 bar (0.3 kg/cm^2) through threaded hole for 2 minutes under water. No air bubbles should be generated.

Air Test for Motor

Seal tightly all ports, except one location, of piping port of motor and apply compressed air 3 bar (3 kg/cm^2) from opened port for 2 minutes under water. Air bubble should not be generated.

NOTE: *Working oil volume: 1.5 L*

PERFORMANCE TEST

Be sure to add a sufficient amount of working oil into motor case before carrying out performance test. Be sure to carry out performance test below after finishing servicing of TM motor.

If Test Equipment Is Available

If any built-in part has been replaced, be sure to carry out performance test after conducting test operation in accordance with following conditions:

1. Conditions for test operation
   A. Rotating it right and left for 1 minute at no-load pressure of 20 rpm.
   B. Rotating it right and left for 1 minute at no-load pressure of 10 rpm, 196 bar (200 kg/cm^2).
   C. Rotating it right and left for 1 minute on no-load pressure of 20 rpm.
2. Test conditions
   A. Working oil: Wear-resistant working oil equivalent to ISO VG #46
   B. Lube oil: Gear oil
   C. Temperature
      1) Ambient temperature - Room temperature
      2) Working oil service temperature - 50 ±5°C
      3) Reduction gear case temperature - 40 ~ 80°C
   D. Oil drain pressure: 0.8 bar (0.8 kg/cm^2) or less

SECTION VIEW

Travel Motor

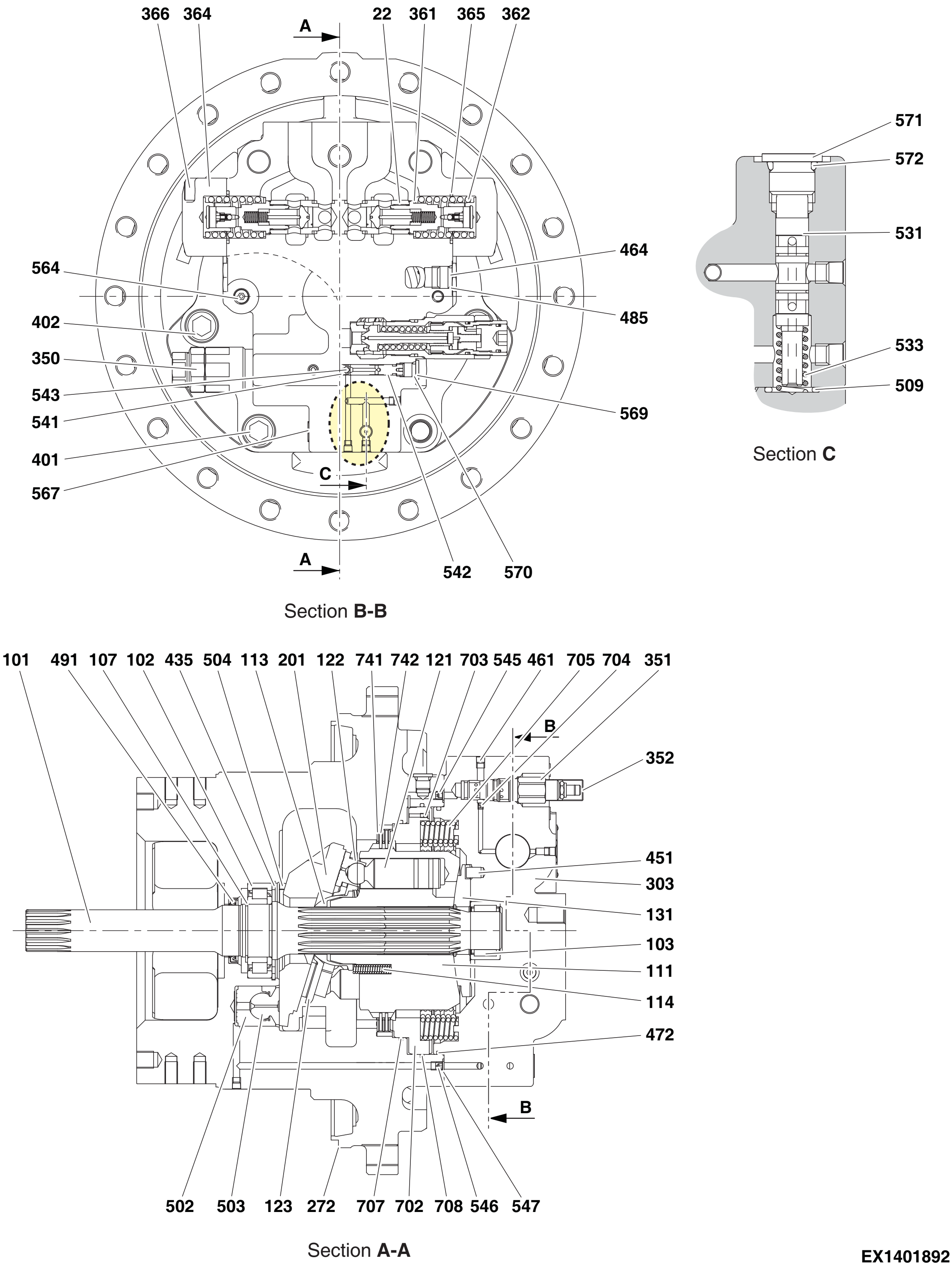


Figure 36

Reference Number	Description
22	Spool; Counter Balance
101	Shaft; Drive
102	Bearing; Roller
103	Bearing; Needle
107	Ring; Stop
111	Cylinder
113	Bush
114	Spring; Cylinder
121	Piston
122	Shoe
123	Plate; Set
131	Valve Plate
201	Plate; Swash
272	Case, Shaft
303	Valve Casing
350	Valve, Relief
351	Valve; Reducing
352	Cover
361	Washer
362	Spring; Counter Balance
364	Cover; Counter Balance
365	O-ring
366	Bolt; Socket M12 x 1.75 x 45
401	Bolt; Socket
402	Bolt; Socket
435	Ring; Snap
461	Plug
464	Plug
472	O-ring

Reference Number	Description
485	O-ring
491	Seal; Oil
502	Piston
503	Shoe
504	Ball; Pivot
509	O-ring
531	Spool; Tilting
533	Spring; Tilting
541	Seat
542	Stopper
543	Ball; Steel
545	Orifice
546	Orifice
547	O-ring
564	Plug
567	Plug
569	Plug
570	O-ring
571	Plug
572	O-ring
702	Piston, Brake
703	Orifice
704	Orifice
705	Spring; Brake
707	O-ring
708	O-ring
741	Plate; Separator
742	Plate; Friction
*	Seal Kit; Motor

*: 365, 472, 485, 491, 509, 547, 570, 572, 707, 708

Travel Reduction Gear

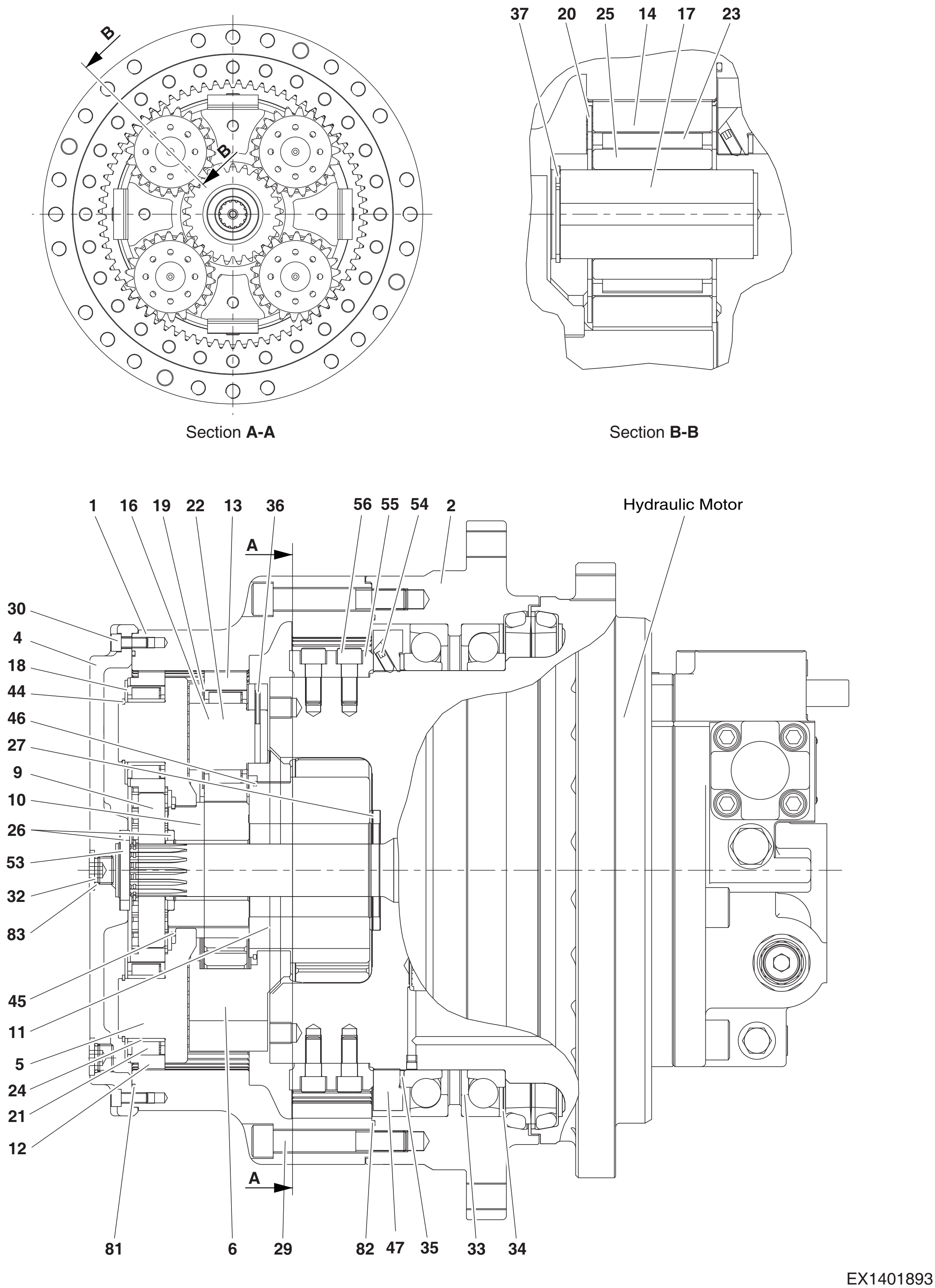


Figure 37

Reference Number	Description
1	Gear; Ring
2	Housing
4	Cover, Side
5	Carrier No. 1
6	Carrier No. 2
9	Gear; Sun No. 1
10	Gear; Sun No. 2
11	Gear; Sun No. 3
12	Gear; Planetary No. 1
13	Gear; Planetary No. 2
14	Gear; Planetary No. 3
16	Pin No. 2
17	Pin No. 3
18	Plate; Side E
19	Plate; Side A
20	Plate; Side F
21	Cage; Needle
22	Cage; Needle
23	Cage; Needle
24	Ring; Inner
25	Bush; Floating

Reference Number	Description
26	Ring; Thrust 60
27	Ring; Thrust 90
29	Bolt; Socket M16 x 100
30	Bolt; Socket
32	Plug
33	Bearing; Angular
34	Seal; Floating
35	Shim 1.0
36	Pin; Spring
37	Ring
44	Ring; Snap
45	Clip
46	Clip
47	Ring, Nut
54	Screw; Set
55	Stopper; Nutring
56	Bolt, Socket
81	O-ring
82	O-ring
83	O-ring

DISASSEMBLY

General Caution Matters

1. Use care so that contact surface of seals such as O-ring and oil seals, gears, pins, bearings, and sliding surface may not be damaged.
2. If disassembling this motor with it mounted on machine, use care that dust or foreign materials may not enter it.
3. The numbers in ( ) behind part name indicate part indication No. on assembly cross section diagram.
4. The piping side of motor should be called Rear, while output side Front.

Reduction Gear

1. Choose a good place for disassembly work.

   NOTE: *Choose a clean place. Place a rubber pad on work bench so that parts will not be damaged.*

2. Remove dust or foreign materials from surface of reduction gear.
3. Drain gear oil.

   NOTE: *Drain gear oil into clean container and check it for contamination. Never reuse this gear oil.*

4. Place side cover (4) facing up and remove socket bolts (30). Remove side cover (4) and O-ring (81).

Figure 38

5. Remove No. 1 sun gear (9).

Figure 39

6. Remove No. 1 carrier (5) with No. 1 planetary gear (12) and No. 2 sun gear (10) assembled.

Figure 40

7. Disassemble No. 1 carrier subassembly.

   A. Remove snap ring (44), disassemble side plate (18), No. 1 planetary gear (12), and needle cage (21).

   NOTE: *If any flaking is found on surface of inner race (24), remove race from No. 1 carrier and replace it with a new one. At same time, replace No. 1 planetary gear and needle cage.*

Figure 41

   B. Remove snap ring (45), and remove No. 1 carrier (5) from No. 2 sun gear (10).

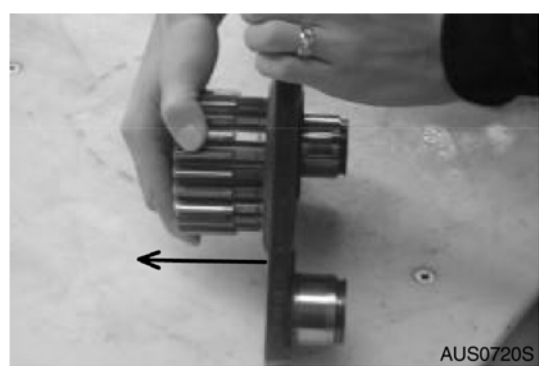


Figure 42

C. Remove thrust ring (26).

Figure 43

8. Disassemble No. 2 carrier (6), No. 2 planetary gear (13) and No. 3 sun gear (11).

NOTE: *Attach two M10 eyebolts and lift No. 1 carrier with a crane.*

Figure 44

9. Disassembly of No. 2 carrier subassembly.

A. Remove spring pin (36), and remove No. 2 pin (16) from No. 2 carrier.

NOTE: *Check for following before disassembly, and if there is abnormality, disassemble it.*

1. Check surface of planetary gear teeth for flaking or pitting.

2. Check for unusual noise or eccentricity while gently rotating planetary gear.

Figure 45

B. Remove side plate (19), No. 2 planetary gear (13), and needle cage (22) from No. 2 carrier.

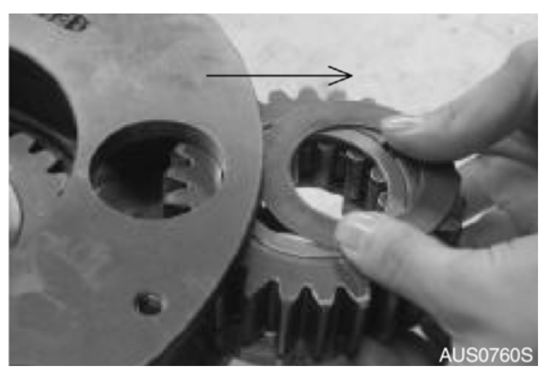


Figure 46

C. Remove snap ring (46), and No. 2 carrier (6) from No. 3 sun gear (11).

Figure 47

10. Remove socket bolt (29), attach two M8 eyebolts, then use a crane to disassemble ring gear (1). Remove O-ring (82) from housing (2).

    NOTE: *Use a hex wrench and pipe to disassemble it. It has been coated with loctite for assembly.*

Figure 48

11. Remove snap ring (37), and No. 3 pin (17) from shaft casing (272) on motor side.

Figure 49

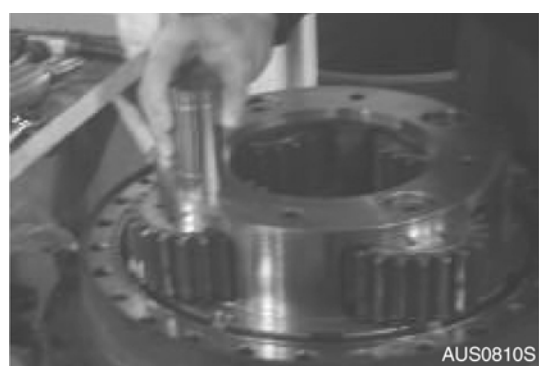


Figure 50

12. Remove side plate (20), No. 3 planetary gear (14), needle cage (23), and floating bush (25) from shaft casing (272).

Figure 51

13. Remove set screw (54) from nut ring (047). Remove nut ring (47) from shaft casing (272).

Figure 52

NOTE: *After disconnecting nut ring from set screw, blow set screw assembly part to remove foreign materials and then disassemble nut ring by using jig for disassembling it.*

Figure 53

14. Remove housing (2), angular bearing (33), and floating seal (34) from shaft casing (272).

NOTE: *Attach two M16 eyebolts and use a crane to lift it.*

Figure 54

15. Remove floating seal (34) from housing (2). Do not damage it.

    NOTE: *Be careful not to damage O-ring surface and seat.*

Figure 55

16. Remove floating seal (34) from shaft casing (272). Do not damage it.

    NOTE: *Be careful not to damage O-ring surface and seat.*

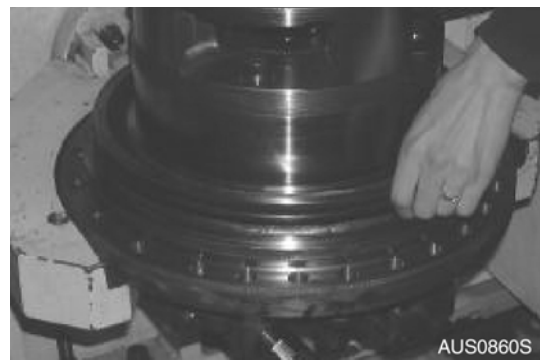


Figure 56

17. Remove angular bearing (33) from housing (2).

    NOTE: *After disassembling bearing, it should be replaced.*

Figure 57

Hydraulic Motor

Disassembly of Main Body of Motor Section

1. Place output side of hydraulic motor facing down and fix it.

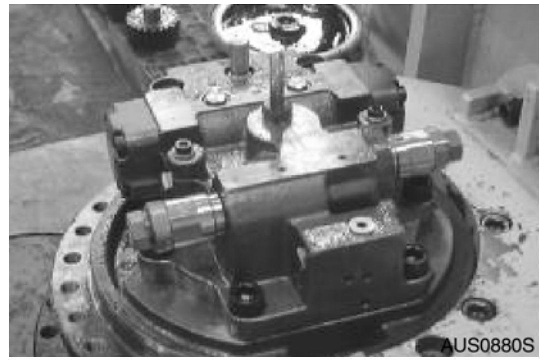


Figure 58

2. Remove relief valve (35), decompression valve (351), and adjustment cover (352) from valve casing (303). Remove plug.

Figure 59

Figure 60

3. After removing plug (564) from valve casing (303), insert M10 x 135 bolts into holes (2) for releasing brake restraint and tighten them to subassemble valve casing and brake piston.

Figure 61

4. Remove socket bolts (401, 402) tightened with valve casing (303).

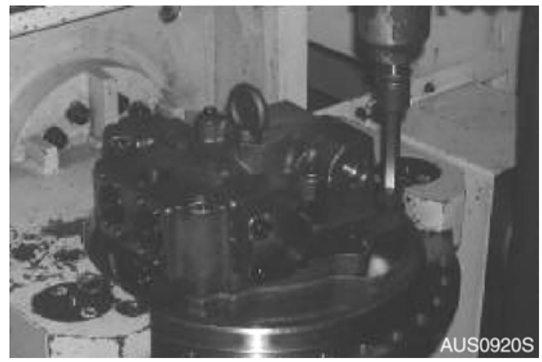


Figure 62

5. Remove socket bolts, and valve plate (131) together with valve casing subassembly.

Figure 63

6. Remove friction plate (742) and mating plate (741).

   NOTE: *Be sure to place motor in a level position.*

Figure 64

7. Remove cylinder block and piston assembly

   NOTE: *Be sure to place motor in level position.*

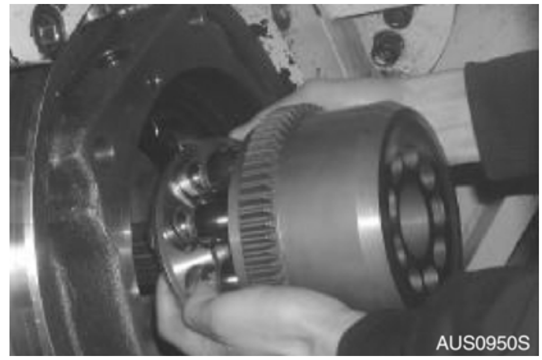


Figure 65

8. Remove swash plate (201).

Figure 66

9. Remove pivot ball (504) and tilting piston assembly.

Figure 67

Figure 68

10. Remove snap ring (435). Tap front side of drive shaft (101) with plastic hammer to remove it from shaft casing (272).

NOTE: *Do not disassemble roller bearing (102), if it does not need to be replaced.*

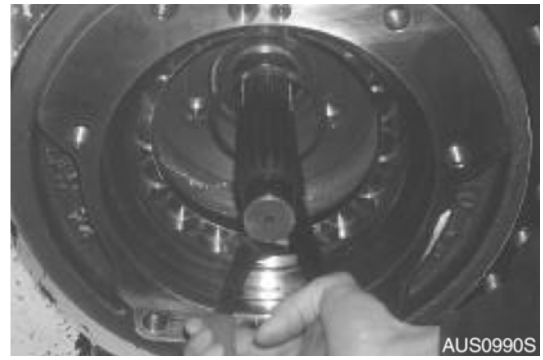


Figure 69

11. Remove oil seal (491) from shaft casing (272).

NOTE: *Never reuse oil seal (491). Replace it with a new one when assembling.*

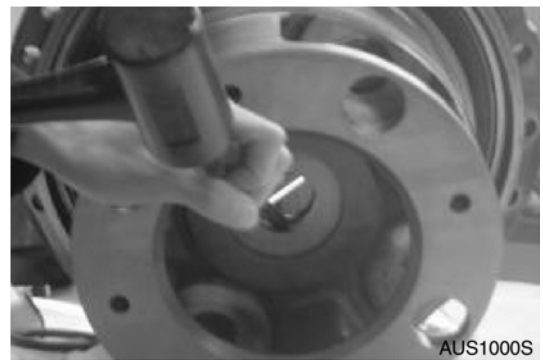


Figure 70

Disassembly of Valve Casing Subassembly

1. Remove bolts for releasing brake restraint. Remove brake piston and valve casing.

Figure 71

2. Remove plug (571). Remove tilting spring (533) and tilting spool (531).

Figure 72

3. Remove socket bolt (366). Remove cover (364) and counterbalance valve assembly.

NOTE: *If counterbalance spool and counterbalance spring have been damaged, replace them with new ones.*

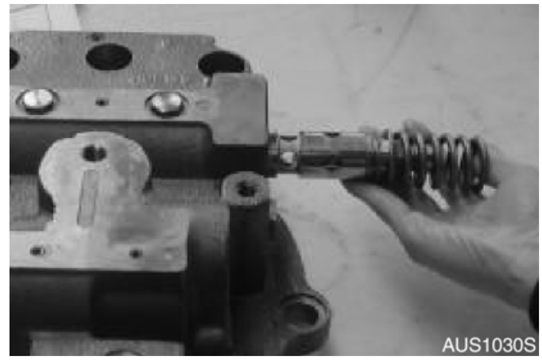


Figure 73

4. Remove plug (569) and high pressure select valve assembly.

NOTE: *Do not disassemble tilting switching system if it functions properly. Do not disassemble needle bearing (103) if it is OK.*

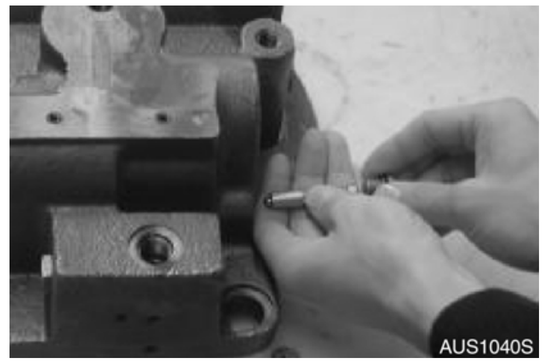


Figure 74

Disassembly of Cylinder Block Assembly

1. Remove cylinder block assembly with set plate (123), piston (121) and shoe (122) as one assembly.

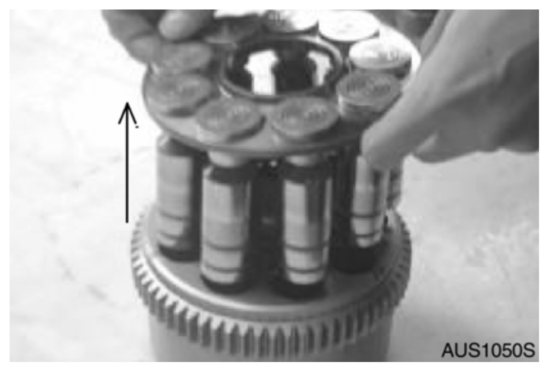


Figure 75

2. Remove spherical bushing (113) and cylinder spring (114).

NOTE: *The disassembly operation is up to here. Do not disassemble pin (451: for valve plate positioning) pressed into valve casing.*

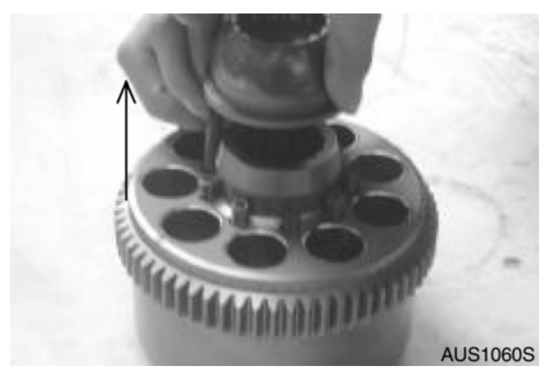


Figure 76

CLEANING AND INSPECTION

Maintenance Standard

Change parts with standard of following table. If parts have damages of external appearance, change without following table.

Changing Standard of Hydraulic Motor Part

Parts Name and Inspection Item		Standard Dimension	Recommended Value of Replacement	Remedy
Clearance (D-d) between piston and cylinder bore		0.52 mm	0.077 mm	Replace
Clearance between piston and shoe (δ)		0.1 mm	0.3 mm	
Shoe thickness		5.5 mm	5.3 mm	
Height (H-h) of spherical bushing and retainer place assembly		23.8 mm	23.3 mm	Replace with set
Free length of cylinder spring		40.9 mm	40.3 mm	Replace
Over pin diameter (4.5) of drive shaft	Drive spline	43.91 mm	43.31 mm	Even if one each of recommended value of replacement is not reached, replace.
	Cylinder spline	49.06 mm	48.46 mm	
Over pin diameter (4.5) of spline inside of cylinder and spherical bushing		35.25 mm	35.75 mm	Replace
Thickness of separate plate		1.5 mm	1.3 m	
Thickness of friction plate		3.9 mm	3.7 mm	
Free length of brake spring		42.4 mm	41.4 mm	
Base tangent length of cylinder outside (7 each)		50.02 mm	49.42 mm	
Over pin diameter (4.5) of inside gear of friction plate		152.97 mm	153.57 mm	
Roughness of sliding surface	Swash plate/ shoe	0.4-Z	3-Z	Lap each
	Cylinder block/ Valve plate	0.4-Z	3-Z	Joint lapping
Roller bearing/needle bearing				If there are flaking on sliding surface, replace.
O-ring/Oil seal				When disassembling, replace as a rule.
Kinds of bolt				If there are crushing parts, replace.

1. Clearance between piston and cylinder bore: D-d

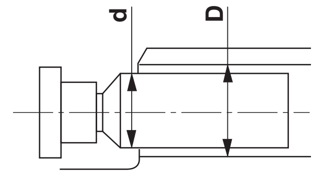


Figure 77

2. Thickness of shoe: t

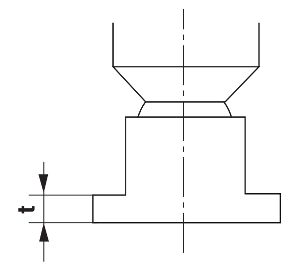


Figure 78

3. Vibration of vertical direction of piston and shoe: δ

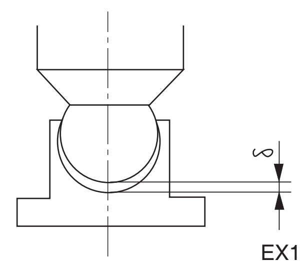


Figure 79

4. Height difference of spherical bushing and pressure plate: H-h

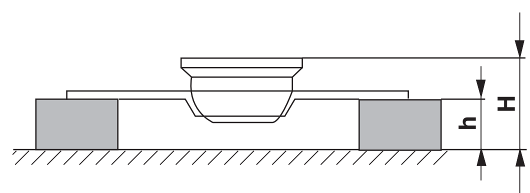


Figure 80

REASSEMBLY

General Caution Matters

1. Clean each part with clean oil and then dry it with compressed air. Do not use an oil cloth, but if it is necessary to use one, be sure to use a clean one and use care that dust or dirt does not collect on it.
2. Use a torque wrench when tightening each bolt and plug. Apply tightening torque as shown in "Tightening Torque" on page 3-24.
3. If it is necessary to use a hammer, etc., use a plastic hammer to gently tap work piece into position.
4. Numbers in ( ) behind part name indicate part indication No. on assembly cross section diagram.

Hydraulic Motor

Reassembling of Drive Shaft Subassembly

1. Press roller bearing (102) onto drive shaft (101).
   Install snap ring (107).

   NOTE: *Heat-fit roller bearing.*

   NOTE: *Do not damage sliding part of oil seal of drive shaft. Use care that snap ring is properly seated into groove.*

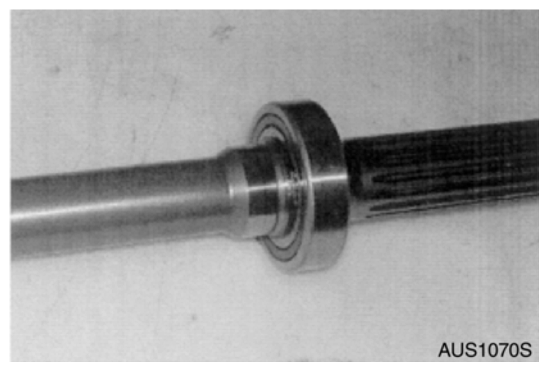


Figure 81

Assembly of Valve Casing Subassembly

1. Tighten plugs (461, 564) to valve casing (303) to specified torque.
   - Torque
     - Plug (461): 8.8 N.m (0.9 kg.m, 6.5 ft lb)
     - Plug (564): 21.6 N.m (2.2 kg.m, 15.8 ft lb)

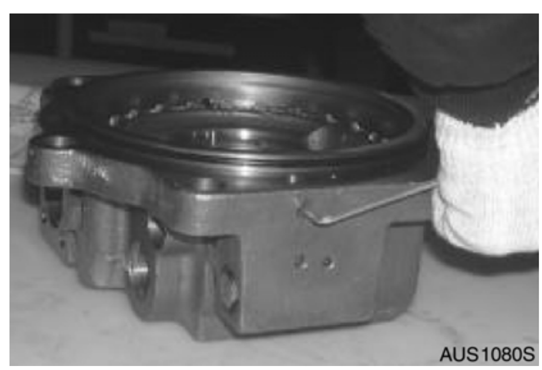


Figure 82

2. Install pin (451).

Figure 83

3. Install needle bearing (103) (if assembling it newly) if removed during disassembly.

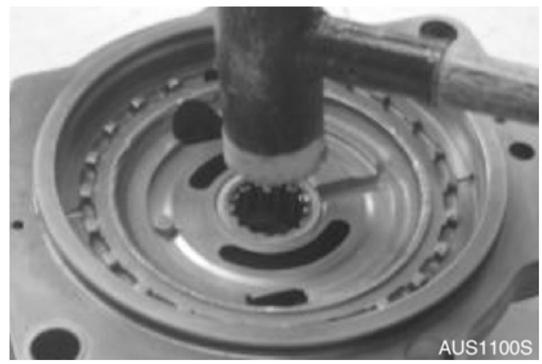


Figure 84

Assembly of Valve Casing Subassembly

1. Assemble seat (541), steel ball (543), stopper (542), and plug (569).

   NOTE: *Be careful of assembly direction of seat and stopper.*

   - Torque (Plug (569)): 36.3 N.m (3.7 kg.m, 26.6 ft lb)

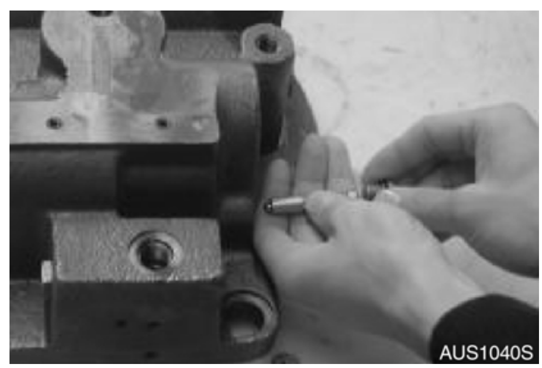


Figure 85

2. Assemble counterbalance spool (360), washer (361), and counterbalance spring (362).

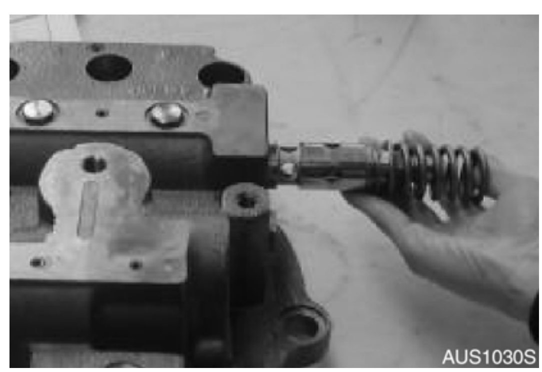


Figure 86

3. Attach cover (364) with socket bolt (366).
   - Torque (Socket bolt (366)): 98 N.m (10 kg.m, 72 ft lb)

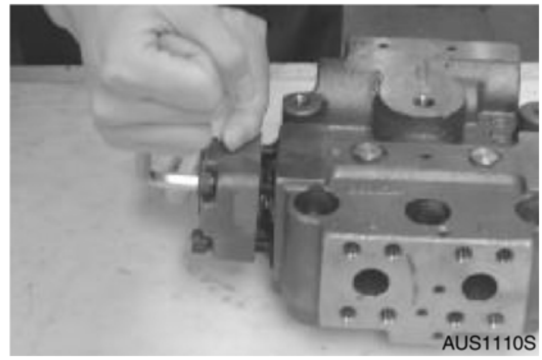


Figure 87

4. Install tilting spool (531), tilting spring (533), and plug (571).
   - Torque (Plug (571)): 73.5 N.m (7.5 kg.m, 54 ft lb)

Figure 88

5. Install orifice (703) into brake piston.
   - Torque: 3.4 N.m (0.4 kg.m, 2.5 ft lb)

Figure 89

6. Attach brake spring (705) to brake piston (702) and insert M10 x 135 socket bolts into holes for releasing brake restraint of valve casing (303) to assemble subassembly.

   NOTE: *After completing assembly of assembly, remove M10 x 135 L socket bolts (2).*

Figure 90

Assembly of Cylinder Subassembly

1. Assemble cylinder spring (114) and spherical bushing (113) onto cylinder block (111).

   NOTE: *Align cylinder with spline of spherical bushing.*

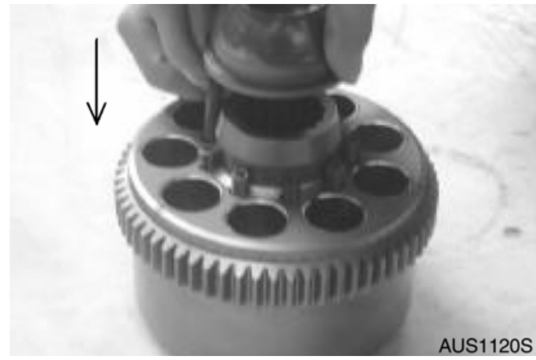


Figure 91

2. Insert piston (121) and shoe (122) assembly into plate (123) and assemble it on cylinder block.

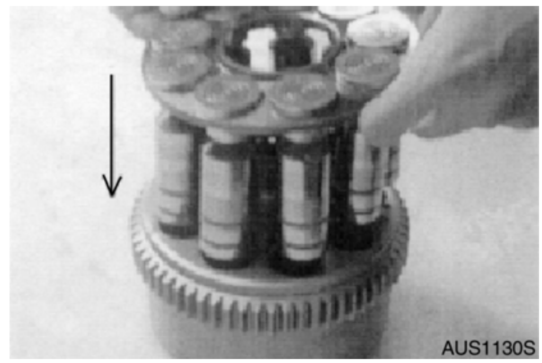


Figure 92

3. Assemble plug (461) and orifices (545 and 546) on shaft casing (272) to specified tightening torque.
   - Torque:
     - Plug (461): 8.8 N.m (0.9 kg.m, 6.5 ft lb)
     - Orifices (545 and 546): 7 N.m (0.7 kg.m, 5 ft lb)

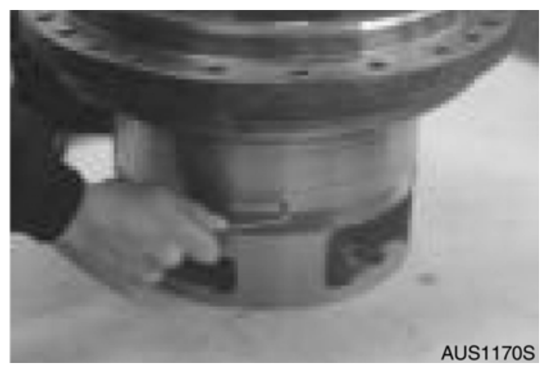


Figure 93

Figure 94

4. Use assembly jig for oil seal (491) to assemble oil seal (491) to shaft casing (272).

Figure 95

5. Fit drive shaft subassembly and assemble snap ring (435).

   NOTE: *Use key for outer race of roller bearing (102) and gently tap it with a hammer to assemble it.*

Figure 96

Figure 97

6. Assemble tilting piston subassembly and pivot ball (504).

Figure 98

Figure 99

7. Coat rear side of swash plate (201) with and then assemble it to shaft casing (272).

   NOTE: *Check swash plate for smooth movement.*

Figure 100

8. Turn shaft casing (272) so it is in a horizontal position and then assemble cylinder block subassembly.

   NOTE: *Be care not to drop swash plate.*

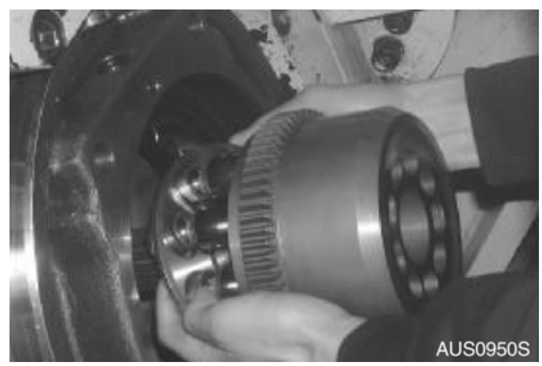


Figure 101

9. Turn shaft casing (272) so it is in a vertical position.

Figure 102

10. Assemble mating plate (741) and friction plate 742) onto shaft casing (272) and cylinder (111), respectively.

Figure 103

11. Assemble O-rings (707, 708) into shaft casing (272).

    NOTE: *When reassembling, replace O-ring with a new one.*

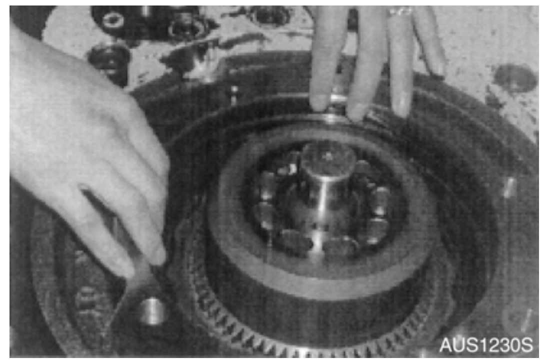


Figure 104

12. Position valve plate (131, Figure 106) on valve casing subassembly and tighten socket bolts (401 and 402) to shaft casing.

Figure 105

NOTE: *Coat rear side of valve plate with grease, so that valve plate does not become disconnected.*

NOTE: *Use guide bolt.*

NOTE: *Coat needle bearing roller with grease, so that it can be easily assembled onto shaft.*

NOTE: *Use a crane when assembling valve casing to shaft casing.*

- Torque (Socket bolts (401 and 401)):
  431.2 N.m (44 kg.m, 316.8 ft lb)

Figure 106

13. Assemble plug, relief valve (35), and decompression valve (351) into valve casing subassembly to specified torque.
    - Torque
        – Relief valve (35):
          176.4 N.m (18 kg.m, 129.6 ft lb)
        – Reducing valve (351):
          44.1 N.m (4.5 kg.m, 32.4 ft lb)

Figure 107

14. Install adjustment cover (352).

Figure 108

15. Loosen bolts for releasing brake and then assemble plug (564).
    - Torque (Plug (564)): 21.6 N.m (2.2 kg.m, 15.8 ft lb)

Figure 109

Reduction Gear

1. Assemble angular bearing (33) to housing (2).

   NOTE: *Use key and hammer to assemble angular bearings apiece at a time before pressing.*

   NOTE: *When reusing housing, use M16 tap to completely remove adhesive such as Teflon from M16 thread.*

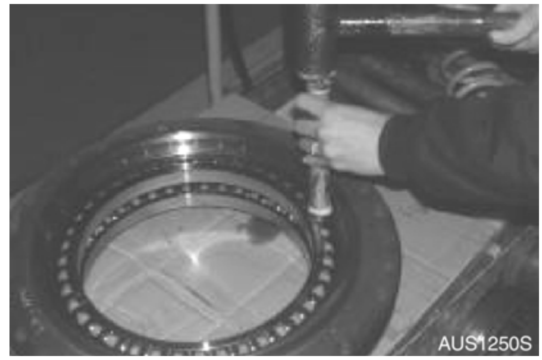


Figure 110

2. Assemble O-ring of floating seal (34) to seat and then to housing (2).

   NOTE: *Lightly coat O-ring with grease.*

   NOTE: *When reassembling, use a new O-ring.*

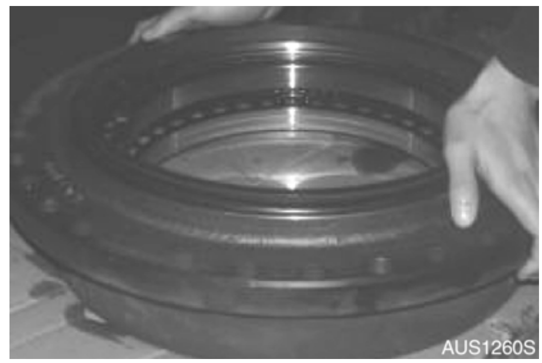


Figure 111

3. In same manner, assemble floating seal to shaft casing (272) of hydraulic motor.

   NOTE: *When reassembling, use a new O-ring.*

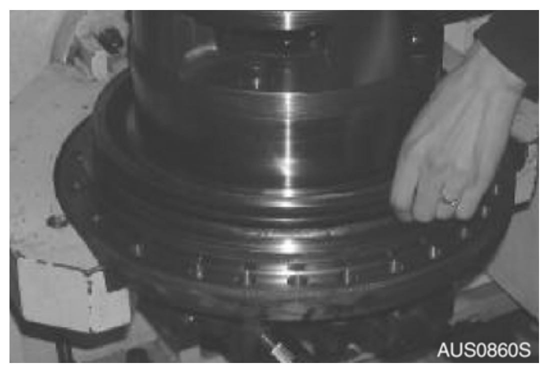


Figure 112

4. Lift housing subassembly with floating seal facing down, and then insert inner diameter of angular bearing into outside of shaft casing.

   NOTE: *Do not damage sliding surface of floating seal.*

Figure 113

5. Position shim (35) on nut ring (47).

   NOTE: *Coat surfaces with grease between nut ring and shim.*

Figure 114

6. With bearing inserted, insert nut ring (47) with shim (35) into shaft casing. Use assembly jig to tighten it to specified torque.

   NOTE: *Tighten nut ring to shaft casing to maximum torque (490 N.m (50 kg.m)) and then disassemble it and reassemble it again to specified torque.*

   - Specified torque: 323.4 N.m (33 kg.m, 237.6 ft lb)

Figure 115

7. Apply loctite in set screw hole of nut ring (47). Install set screw (54) in nut ring and caulk it to prevent it from backing out.

   NOTE: *Loctite specification: Three Bond 1373B.*

   - Specified torque: 49 N.m (5 kg.m, 36 ft lb)

Figure 116

Figure 117

8. Install thrust ring (27) on shaft casing (272).

   NOTE: *Use care to assembly direction for thrust ring (Guide groove should face up.).*

Figure 118

9. Install needle cage (23) inside No. 3 planetary gear (14) and assemble side plate (20) on both sides, then insert gear assembly into shaft casing.

   NOTE: *Align pin hole of shaft casing with center of planetary gear.*

Figure 119

10. Insert No. 3 pin (17) into shaft casing. Install snap ring (37).

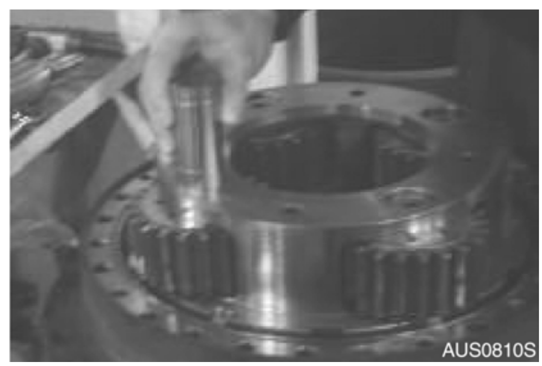


Figure 120

Figure 121

11. Install O-ring (82) on housing (2), and lift ring gear (1) with a crane and position it on outer race of No. 3 planetary gear (14), then assemble housing (2).

NOTE: *Lightly coat O-ring with grease. When reassembling, use a new O-ring.*

Figure 122

12. Install socket bolts (29) to secure housing (2) and ring gear (1) together.

- Torque: 294 N.m (30 kg.m, 216 ft lb)

NOTE: *Use loctite: #636 on bolt threads.*

Figure 123

13. Assembly of No. 2 carrier subassembly

A. Assemble No. 2 carrier (6) to No. 3 sun gear (11), and install clip (46).

B. Place No. 2 carrier with No. 3 sun gear facing down.

Figure 124

C. Install needle cage (22) inside No. 2 planetary gear (13). Place a side plate (19) on each side, then insert gear assembly into No. 2 carrier.

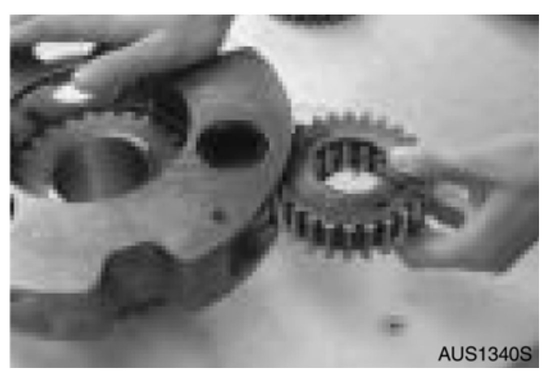


Figure 125

NOTE: *Align carrier pin with center of planetary gear.*

Figure 126

D. Insert spring pin (36) into pin hole of No. 2 carrier and caulk it at two places with a punch so that it may not be fallen out.

Figure 127

14. Install two M10 eyebolts in No. 2 carrier subassembly. Using a crane, assemble No. 2 planetary gear and ring gear carefully.

Figure 128

15. Assembly of No. 1 carrier subassembly

    A. Fit inner race (24) in No. 1 carrier (5).

    NOTE: *Heat inner race to ease installation.*

Figure 129

B. Install No. 1 carrier (5) in No. 2 sun gear (10) and secure into position with clip (45).

Figure 130

C. Position thrust ring (26) on No. 2 sun gear (10).

NOTE: *Pay attention to assembly direction of thrust ring (Guide groove should face up.).*

Figure 131

D. Insert needle cage (21) inside No. 1 planetary gear (12), slide it into No. 1 carrier (6). Attach side plate (18), and install snap ring (44).

Figure 132

16. Carefully install No. 1 carrier subassembly and ring gear (1).

Figure 133

17. Position No. 1 sun gear (9) on motor shaft splines and engage No. 1 planetary gears.

Figure 134

18. Using ring gear (1) as a measuring surface, measure distance from it to top side of No. 1 sun gear.
    - The dimension: A (the value after subtracting thickness of jig)

Figure 135

19. Using surface (P.Cl.D. 342) of side cover as measuring surface, measure depth from it to hole surface of P.C.S. 60.2.

Figure 136

- The dimension: B (the value after subtracting thickness of jig)

20. Select a thickness of washer (53) according to following formula:
    - 1.5 ~ 2.0 = (B + A) - (thickness of thrust + thickness of washer)

    NOTE: *Maintain a clearance of 1.5 ~ 2.0 mm in shaft direction for No. 1 sun gear.*

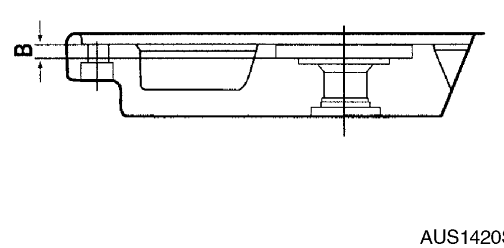


Figure 137

21. Install washer (53) and thrust ring (26), which have been selected using above formula, on side cover (4).

    NOTE: *Be sure to caulk thrust ring with guide groove facing up.*

Figure 138

22. Install new O-ring (81) on ring gear (1). Place side cover (4) onto ring gear, then tighten socket bolts (30) to specified torque.

    - Specified torque: 34.3 N.m (3.5 kg.m, 25.2 ft lb)

    NOTE: *When reassembling, use a new O-ring.*

Figure 139

23. Install plug (32) in side cover (4) to specified torque.

    - Specified torque: 107.9 N.m (11 kg.m, 79.6 ft lb)

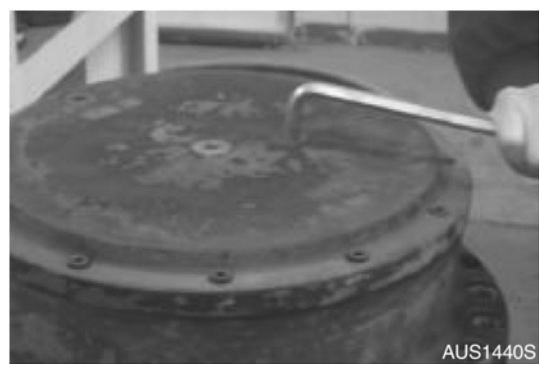


Figure 140

TROUBLESHOOTING

1. Travel motor does not rotate.

Check Item		Cause	Remedies
Delivery pressure rises.			
Overloading.	YES		Eliminate the reason of overload.
↓ NO			
Relase of brake.	YES	Brake ON.	Refer to "2".
↓ YES			
Rotation of motor.	YES #1	Oil flow path in valve casing and shaft casing cracked. Release pressure not rising.	Replace valve casing or shaft casing.
		Orifice blocked.	Replace orifice.
		Excess leak from seal section of brake piston. Brake not operating.	Check the brake piston.
		Release pressure not entering the counterbalance spool.	Check the counterbalance spool.
↓ NO			
Matal power detected from the drain.	YES	Hydraulic motor failed.	Replace motor.
	NO	Gear damaged.	Replace the reduction gear.
Delivery pressure does not rises.			
Hydraulic motor rotates.	YES	Gear damaged and idels.	Replace the reduction gear.
		Relief valve setting pressure low.	Check the relief valve.
	NO	Hydraulic motor damaged	Replace hydraulic motor.

2. Brake is not released.

Check Item	Result	Cause	Remedies
Brake piston moves lightly.		Brake piston seized.	Replace thebrake piston casing.
↓ YES			
Friction and seperate plate swings lightly.	NO	High roughness of spline tooth surface or pin.	Replace non-conforming parts.
	NO	Friction plate or mating plate seized or deformed.	Replace non-conforming parts.
↓ YES			
Refer to “1” #1.			

3. Brake not engaged.

Check Item	Result	Cause	Remedies
Release pressure low.	NO	Problem in circuit.	This circuit has low release pressure.
↓ YES			
Operation of brake piston.	NO	Brake piston seized.	Replace shaft casing and brake piston.
↓ YES			
Damage to spring.	YES		Replace spring.
↓ YES			
Friction plate, separate plate swings lightly.	NO	High roughness of spline tooth surface or pin or friction plate and mating plate deformed.	Replace.
	YES	Braking force deteriorated due to unusual wear of friction plate and separate plate.	Replace the friction plate and separate plate.

4. Oil leakage.

Check Item	Cause	Remedies
Oil leaks out assembled surface.	Loose bolt.	Tighten to the specified torque.
	O-ring damaged or poorly assembled.	Replace and reassemble O-ring.
	Poor roughness and flatness of assembled surface.	Replace any unstable part.
Oil leaks from the casing.	Abnormality in casting (Crack).	Replace.
Oil leaks from the floating seal.	Sliding surface damaged or seized	Replace.
	O-ring damaged and sealing force eteriorated.	Replace.
Oil leaks from the plug.	Plug loosened.	Tighten to the specified torque.
	Poor assembly of seal tape or O-ring.	Replace and reassemble seal tape and O-ring.

5. Temperature of casing is high (Atmospheric temperature +60°C or higher).

Check Item		Cause	Remedies
Reduction gearbox generates heat.			
Shortage of gear oil.	YES	Poor lubrication.	Supply the specified amount of gear oil.
↓ NO			
Bearing damaged.	YES	Abnormal high temperature due to bearing damage.	Replace the bearing.
	NO	Gear damaged or broken.	Replace gear.
Unusual high-temperature of brake section.			
Release of brake.	YES	Bad precision of friction plate and mating plate.	Replace.
	NO	Brake engaged.	Refer to 2.

Track Assembly

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Track Assembly

GENERAL

The track assembly is composed of the following major components:

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

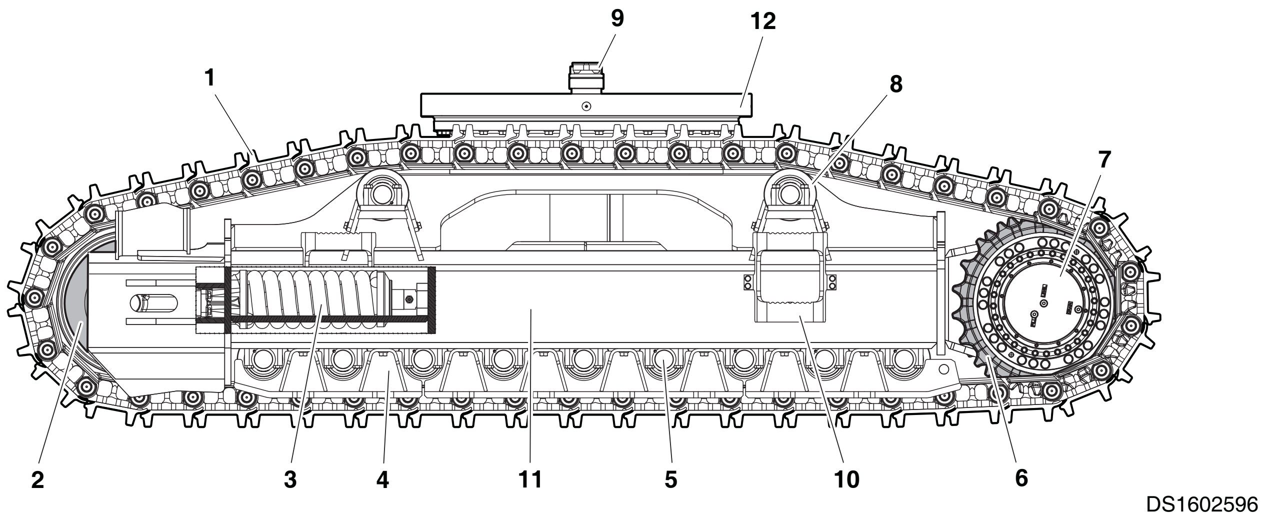


Figure 1

Reference Number	Description
1	Track Shoe
2	Idler
3	Track Spring
4	Track Guard
5	Lower Roller
6	Sprocket

Reference Number	Description
7	Travel Device
8	Upper Roller
9	Center Joint
10	Step
11	Track Frame
12	Swing Bearing

TRACK TENSION

WARNING

AVOID DEATH OR SERIOUS INJURY

Measuring track tension requires two people. One person must be in the operator's seat, operating the controls while the other person makes dimensional checks. Block frame to make sure the machine won't move or shift position during service. Warm up the engine to prevent stalls, park the excavator in an area that provides level, uniform ground support and/or use support blocks when necessary.

NOTE: *The track tension must be adjusted in accordance with the operating conditions. If a lot of dust stick to the track assembly in the working place, keep the track as loose as possible.*

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 2. Place blocking under frame while taking measurement.

   Turn the track backward 1 ~ 2 turns.

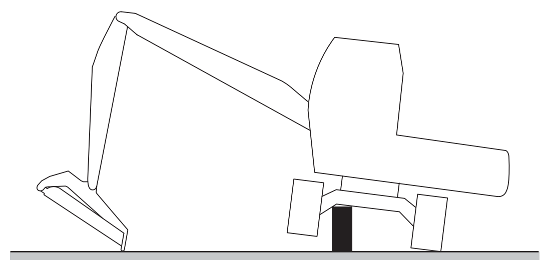
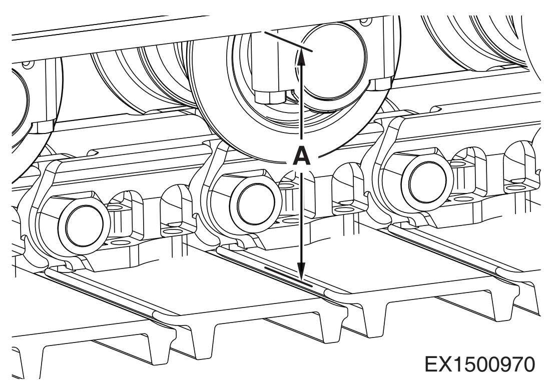

EX1300535

Figure 2

2. Measuring the distance (A, Figure 3) 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 as below table.

   NOTE: *Clean off the tracks before checking clearance for accurate measurements.*

3. Too little sag in the crawler track (less than clearance distance "A" 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.



EX1500970

Figure 3

4. A track that is properly adjusted may have a different sag according to the track options. Contact your dealer for information.

Terrain Type	Distance "A"
Normal	330 ~ 360 mm (13.0 ~ 14.2 in)

WARNING

AVOID DEATH OR SERIOUS INJURY

The track adjusting mechanism is under very high-pressure. NEVER release grease pressure too fast. The track tension grease valve <u>should never be loosened more than one (1) complete turn from the fully tightened down position</u>. Bleed off grease pressure slowly. Keep your body away from the valve always. Always wear eye and face protection when adjusting track tension.

5. Track tension adjustments are made through the grease fitting (1, Figure 4) in the middle of each side frame. Adding grease increases the length of an adjustment cylinder (2). Extending the adjustment cylinder, increases 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 4).

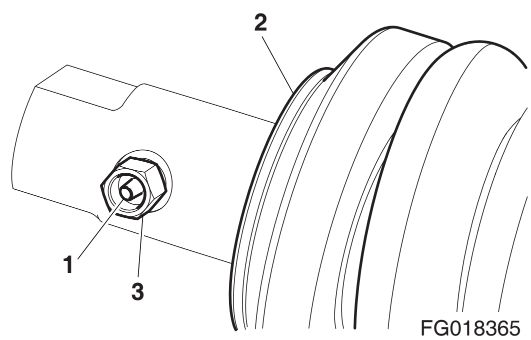


Figure 4

TRACK SHOES AND LINKS

Parts List

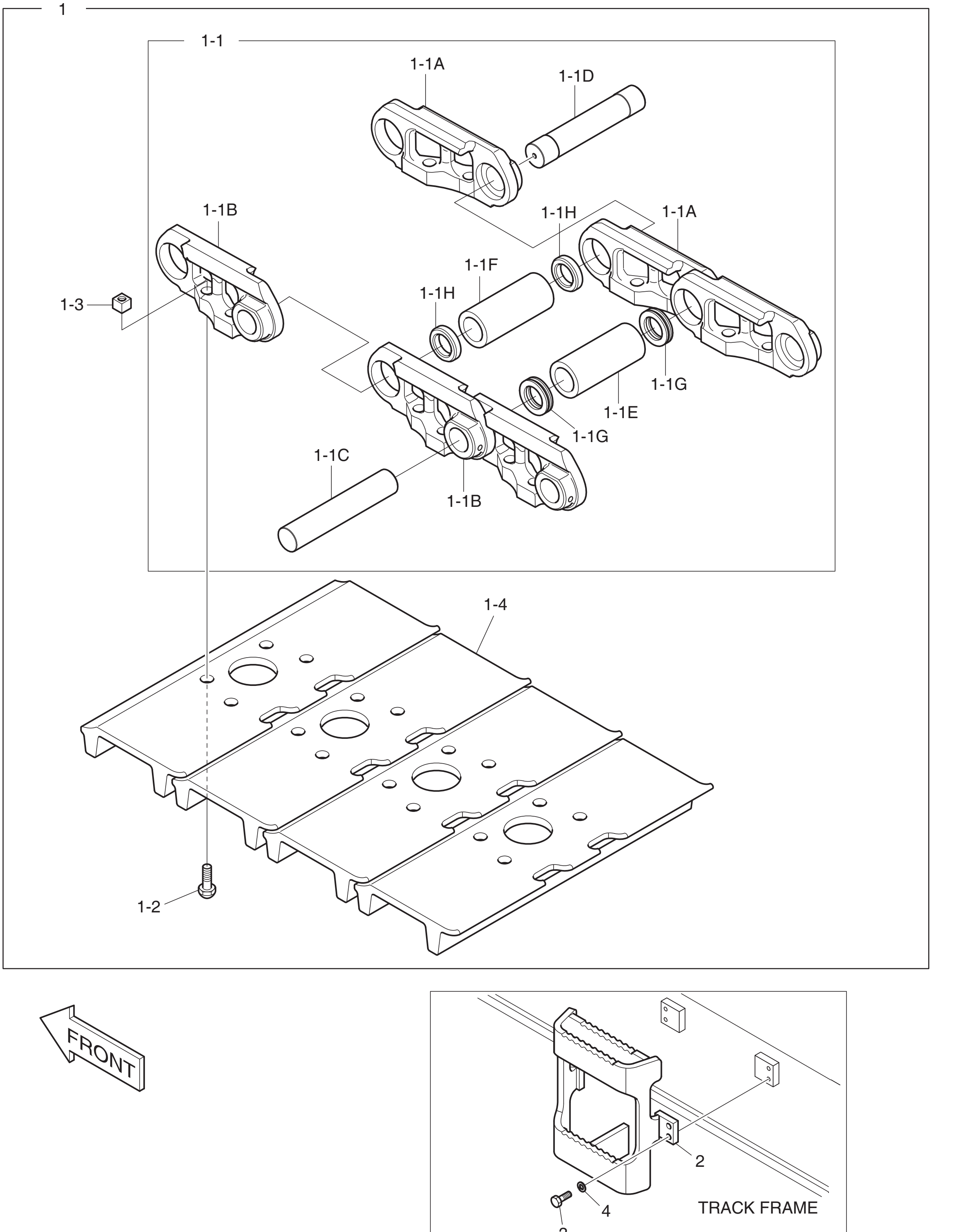


Figure 5

Reference Number	Description
1	Shoe Assembly, Track; 700 mm
1-1	Link Assembly, Track
1-1A	Link, Track (RH)
1-1B	Link, Track (LH)
1-1C	Pin, Track
1-1D	Pin, Master
1-1E	Bush, Regular
1-1F	Bush, Master

Reference Number	Description
1-1G	Seal, Dust
1-1H	Spacer
1-2	Bolt; Track
1-3	Nut
1-4	Shoe, Track (700 mm)
2	Step
3	Bolt
4	Washer

Track Removal

1. Position machine on a smooth level surface with adequate room for forward and reverse travel.

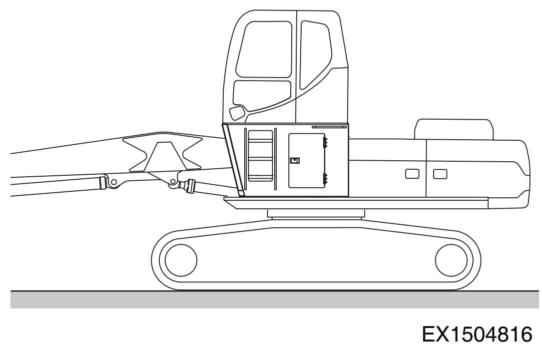


Figure 6

2. Move machine until master pin (4, Figure 7) is positioned at approximately 4 o'clock from top position on front idle roller.
3. Put a wooden block under track shoes, as shown.

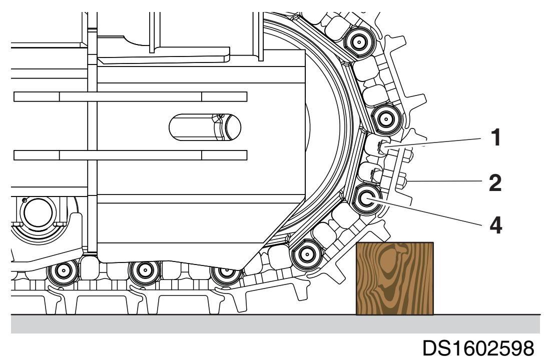


Figure 7

4. Loosen valve (1, Figure 8) for track adjuster to drain grease out. Use socket wrench 27 mm

   NOTE: *Loosen carefully, keeping face, hands, body away from the valve and nipple. Do not loosen valve Quickly.*

5. Remove four nuts and bolts (1 and 2, Figure 7) holding shoe to link. Remove enough shoes to make access to master pin.
6. Remove master pin from master link by hammer or press. Remove pin after detaching shoe.

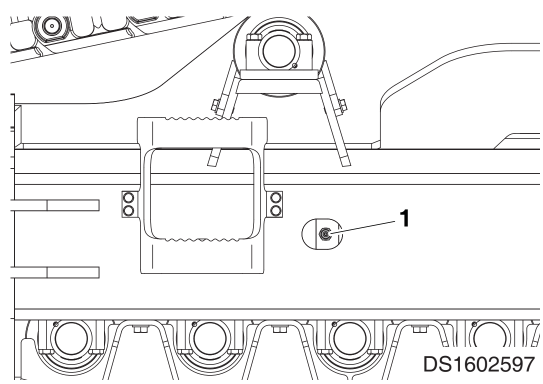


Figure 8

7. Move unit forward until entire track is laying on ground.

NOTE: *Do not drive unit off track.*

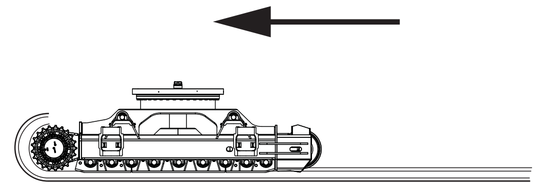


Figure 9

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

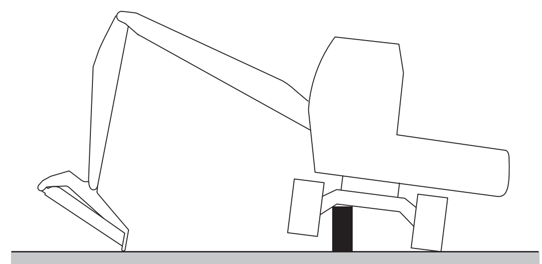


Figure 10

Track Installation

1. Lay rebuilt or new track into position under track frame. End of track must 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.

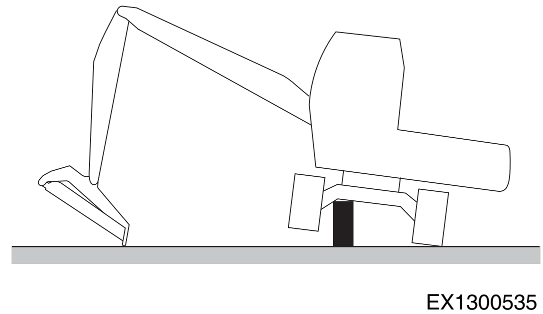


Figure 11

4. Move unit forward while feeding track up over drive sprocket. Continue to pull track back until it engages front idle roller.
5. Align master links and install master pin.
6. Install four nuts and bolts (to fix track shoe).
7. Apply track tension. Refer to "Track Tension" on page 4-4" in this section for procedure.

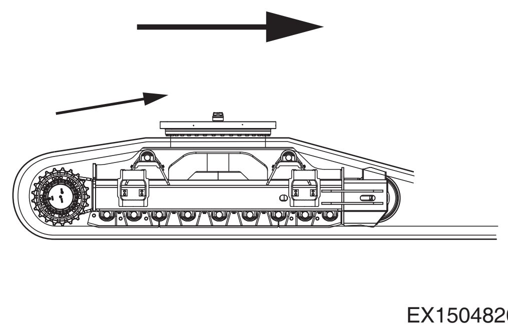


Figure 12

Track Shoe

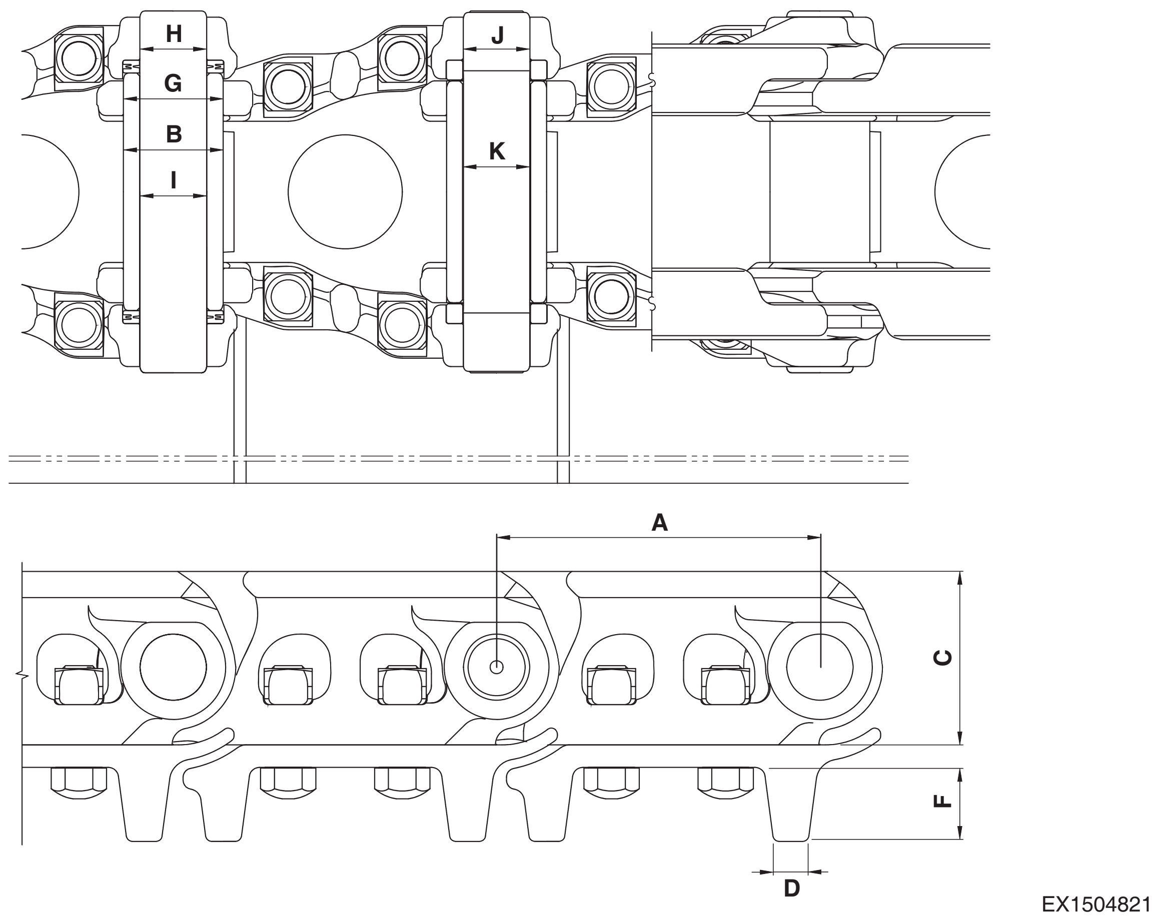


Figure 13

No.	Check Item	Standard Dimension				Recommended Limit for Maintenance	Limit for Use (Repair - P or Replace - R)
A	Link Pitch	216 mm (8.504")					
B	Bushing Outside Diameter	66.9 mm (2.634")				60 mm (2.362")	57 mm (R) (2.244")
C	Link Height	116 mm (4.567")				108 mm (4.252")	103 mm (P) (4.055")
D	Length at Tip	23 mm (0.906")					
F	Height of Tip	49.5 mm (1.949")				28 mm (1.102")	21 mm (0.827")
G	Interference Between Bushing and Link	Bushing	Tolerance	Link	Tolerance	Standard Interference	Repair Limit
		66.91 mm (2.634")	+0.050 0.0	66.5 mm (2.618")	+0.074 0.0	0.336 ~ 0.460	
H	Interference Between Regular Pin and Link	Regular Pin	Tolerance	Link	Tolerance	Standard Interference	Repair Limit
		44.75 mm (1.761")	+0.05 0.0	44.35 mm (1.746")	+0.05 0.0	0.35 ~ 0.45	
I	Clearance Between Regular Pin and Bushing	Regular Pin	Tolerance	Bushing	Tolerance	Standard Clearance	Repair Limit
		44.75 mm (1.761")	+0.05 0.0	45.45 mm (1.789")	+0.500 0.0	0.65 ~ 1.20	
J	Interference Between Master Pin and Link	Master Pin	Tolerance	Link	Tolerance	Standard Interference	Repair Limit
		44.6 mm (1.756")	+0.030 0.0	44.35 mm (1.746")	+0.05 0.0	0.200 ~ 0.280	
K	Clearance Between Master Pin and Bushing	Master Pin	Tolerance	Bushing	Tolerance	Standard Clearance	Repair Limit
		44.3 mm (1.744")	±0.050	45.45 mm (1.789")	+0.500 0.0	1.600 ~ 1.700	

SPROCKET

Wear Limits and Tolerances

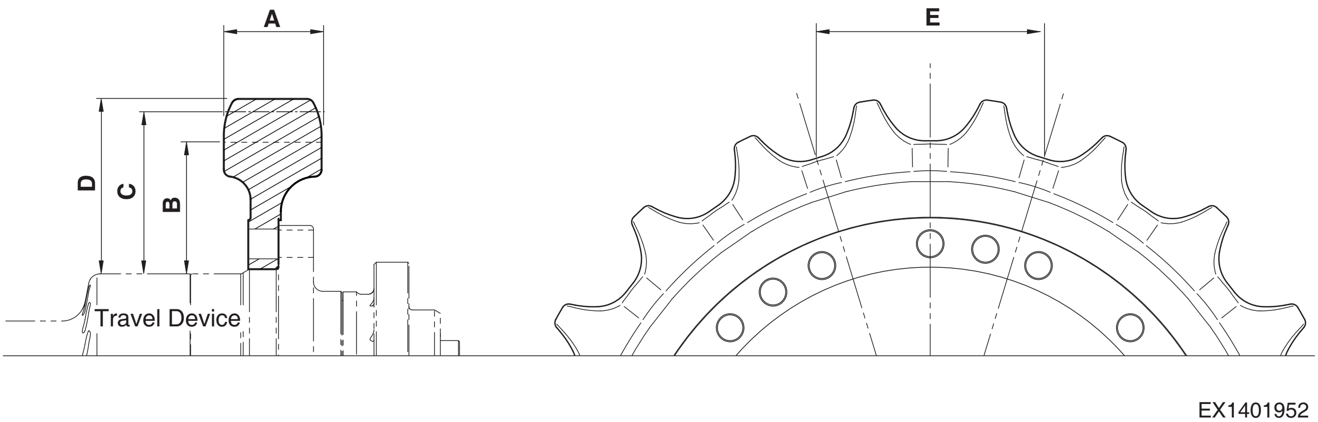


Figure 14

No.	Check Item	Standard Dimension	Allowable Limit for Maintenance	Limit for Use (Repair - P or Replace - R)
A	Tooth Width	84 mm (3.307")	-	-
B	Tooth Bottom Surface	108 mm (4.252")	105 mm (4.134")	104 mm (R) (4.094")
C	Pitch Circle Dimension	141.4 mm (5.567")	-	-
D	Tooth Top Land	146 mm (5.748")	143 mm (5.630")	141 mm (R) (5.551")
E	Accumulated Pitch Tolerance	216 mm (8.504")	-	-

FRONT IDLER

Parts List

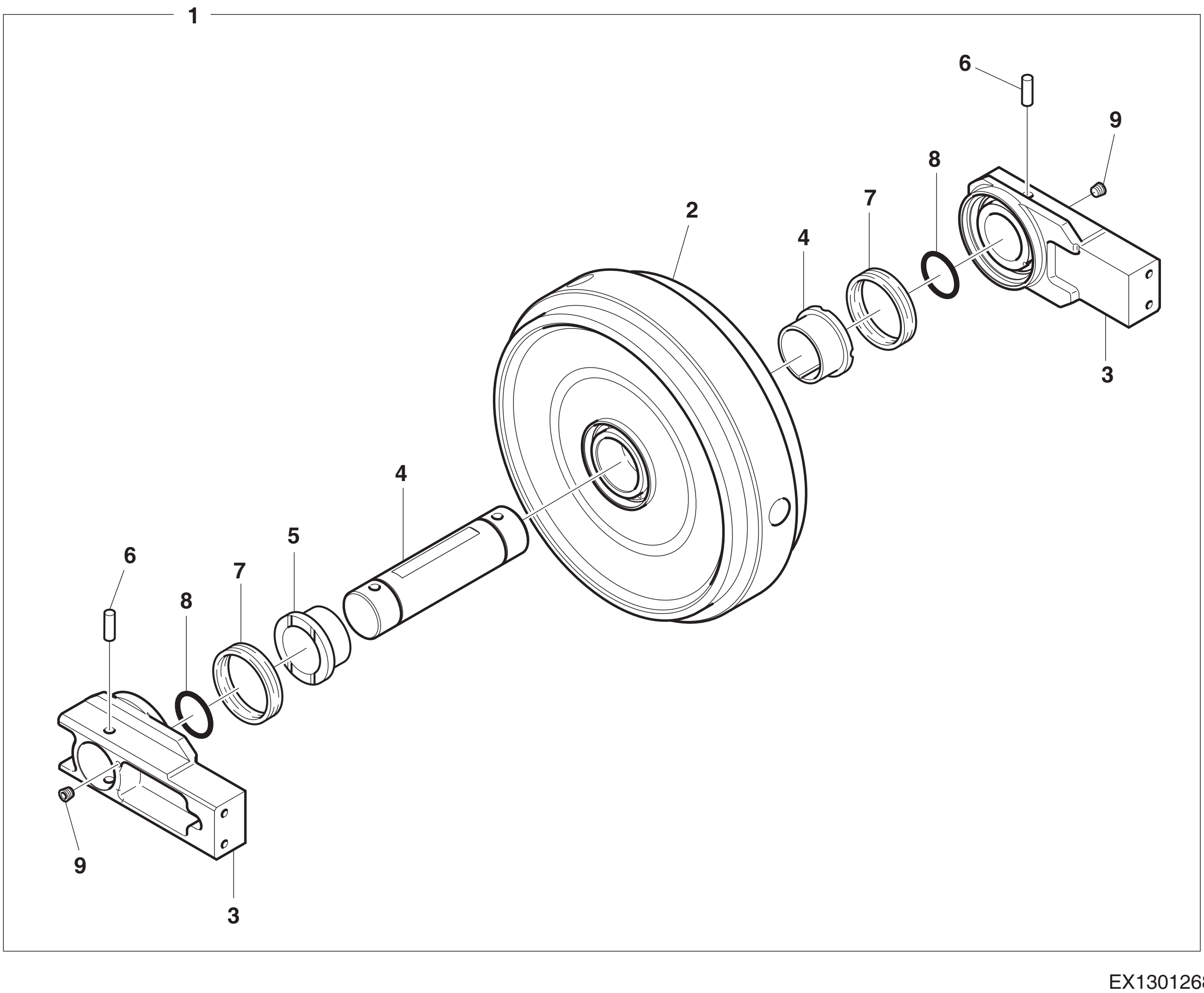


Figure 15

Reference Number	Description
1	Idler Assembly
2	Idler
3	Support
4	Shaft
5	Bushing

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

Front Idler Disassembly

1. Remove plug (9, Figure 16) from idler assembly (1), and drain oil into a suitable container.

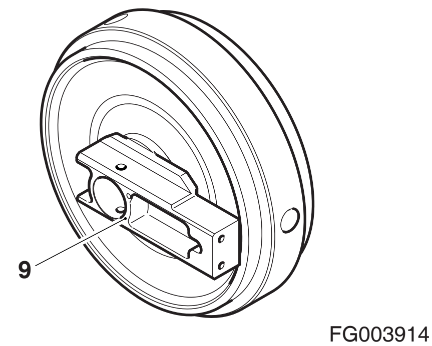


Figure 16

2. Separate the pin (6, Figure 17) from the bearing (3).

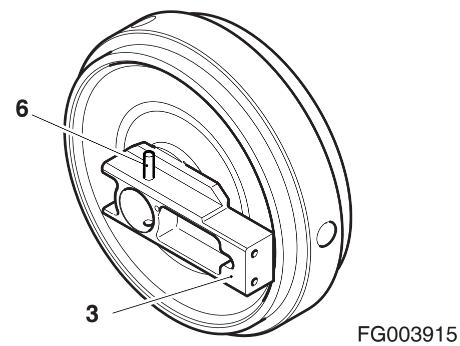


Figure 17

3. Use a press to remove bearing from the axle (4). Separate the O-ring (8, Figure 18) from the axle.

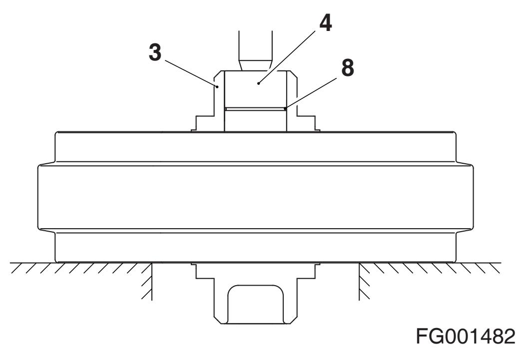


Figure 18

4. Detach the floating seal (7, Figure 19) from the idler (2) and bearing (3).

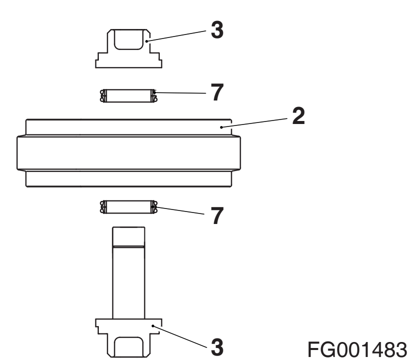


Figure 19

5. Use a press to separate the axle (4, Figure 20), O-ring (8) and bearing (3).

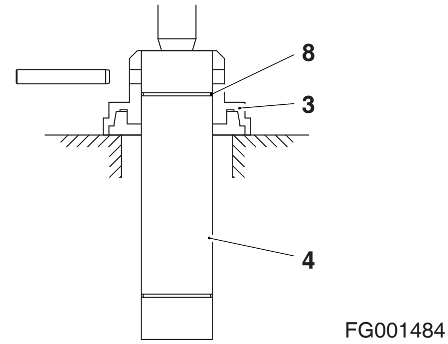


Figure 20

6. Remove bushing (5, Figure 21) with the press and special tool (10).

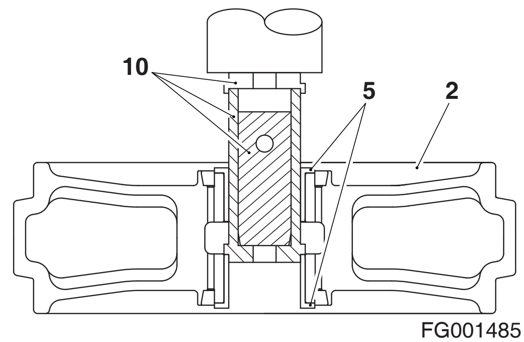


Figure 21

Front Idler Reassembly

1. Degrease, clean and dry all parts before reassembly. Insert bushing (5, Figure 21) into the idler (2).
2. Grease O-ring (8, Figure 22) and insert it into the axle.
3. Align the bearing (3, Figure 22) and axle (4) holes and pin (6) them together.

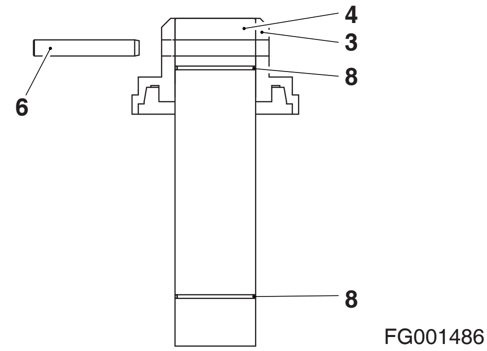


Figure 22

4. Install floating seal (7, Figure 23) inside the idler (2) and bearing (3).

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

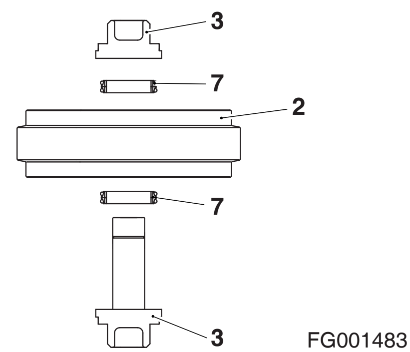


Figure 23

5. Install idler (2, Figure 24) on the axle.
6. Install bearing (3, Figure 24) and pin (6) to the axle.

   NOTE: *Fill the idler assembly with new gear oil (ISO VG 220 EP/VI 130) with approximately 420 cc (14.2 oz).*

7. Install plug (9, Figure 32) on the bearing.

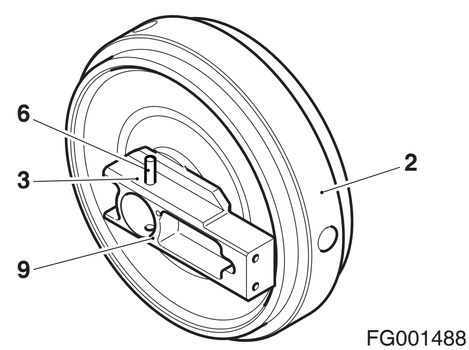


Figure 24

UPPER/LOWER ROLLER

Overview

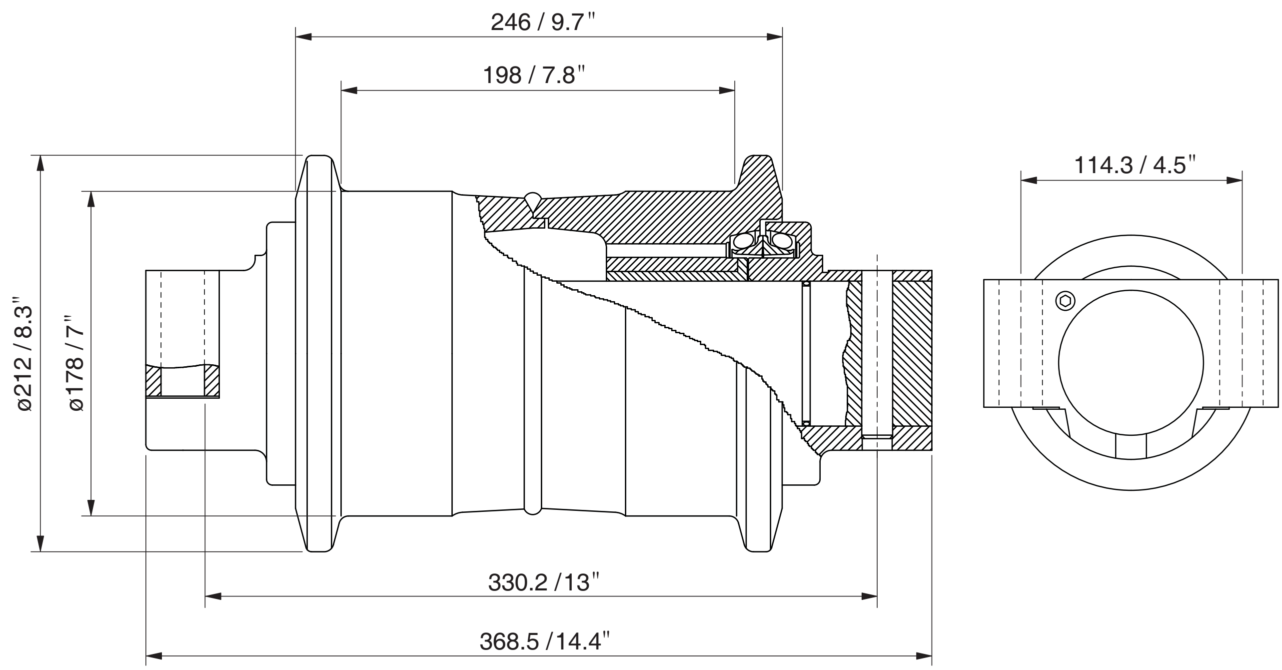


Figure 25 DS1602595

NOTE: *Unit: mm (1 mm = 0.039 in)*

- Weight: 52 kg (114.6 lb)

Parts List

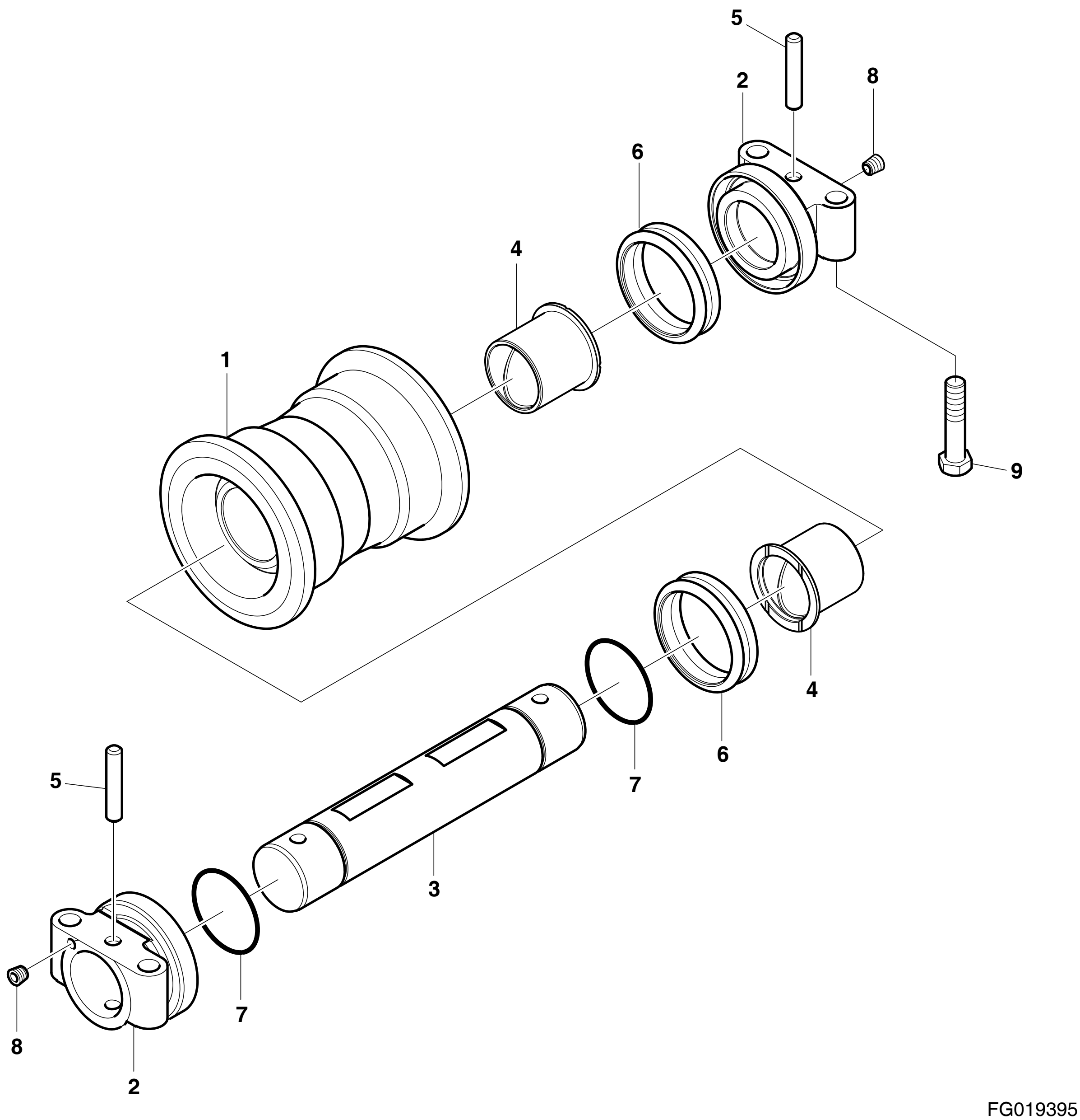


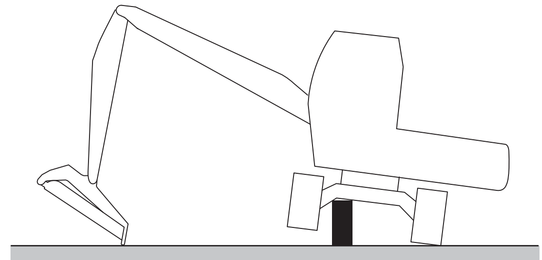
Figure 26

Reference Number	Description
1	Roller
2	Collar
3	Shaft
4	Bushing
5	Pin

Reference Number	Description
6	Floating Seal
7	O-ring
8	Plug
9	Bolt

Upper/Lower Roller Removal

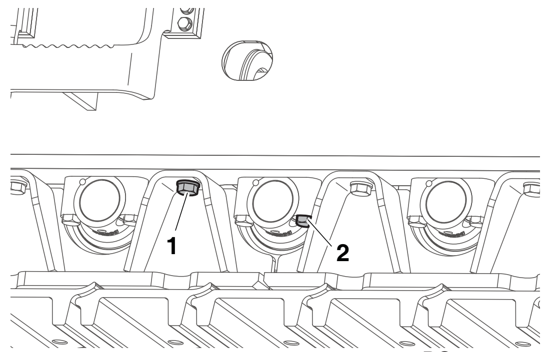
1. Relieve track tension. Refer to "Track Tension" in this section for procedure.
2. Swing upper structure at 90° to frame.
3. Using bucket raise track off ground and place blocking under frame.



EX1300535

Figure 27

4. Remove bolts (1, Figure 28) of track guard.
    - Tool: 30 mm ( )
    - Torque: 490 N.m (50 kg.m, 361 ft lb)
5. Remove four bolts (2, Figure 28) and roller from track frame. There is an alignment pin on each end of roller.
    - Tool: 30 mm ( )
    - Torque: 490 N.m (50 kg.m, 361 ft lb)

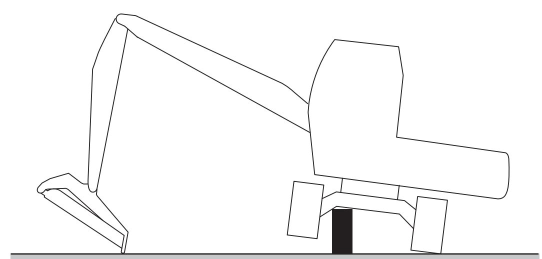


DS1602585

Figure 28

Upper/Lower Roller Installation

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



EX1300535

Figure 29

Upper/Lower Roller Disassembly

1. Remove plug (8, Figure 30) from the collar and drain oil.
2. Pull the pin (5, Figure 30) from the collar.

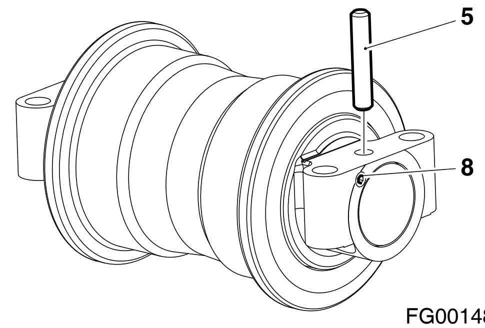


Figure 30

3. Separate the collar (2, Figure 31) from the axle, using press.

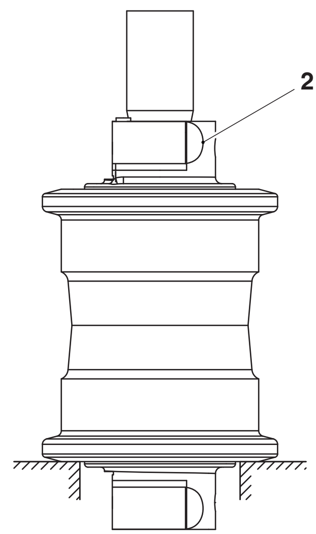


Figure 31

4. Detach O-rings (7, Figure 32) from the axle.
5. Separate floating seals (6, Figure 32) from the collar and roller (1).
6. Detach collar (2, Figure 32) and O-rings (7) from the axle, using press.

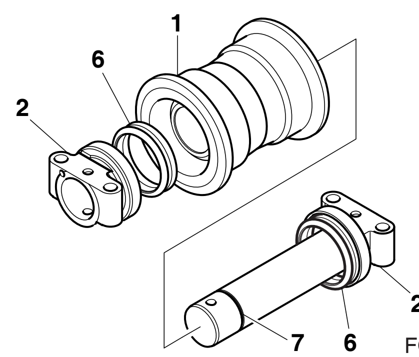


Figure 32

Upper/Lower Roller Reassembly

1. Degrease, clean and dry all parts before reassembly. Insert bushing (4, Figure 33) into roller.

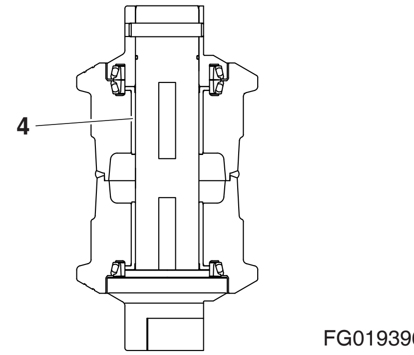


Figure 33

2. Apply grease to the O-rings (7, Figure 33) and insert into axle.
3. Align collar (2, Figure 34) and axle (3) pinholes and pin (5) the collar.

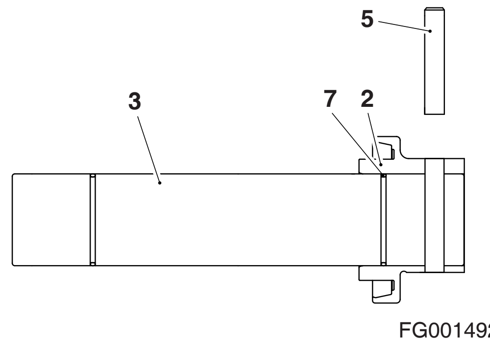


Figure 34

4. Insert floating seals (6, Figure 35) into the roller (1) and collar (2).

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

5. Slide the axle inside the roller.

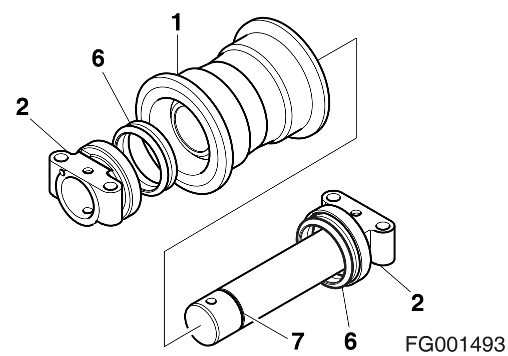


Figure 35

6. Install the collar (2, Figure 36), O-ring (7), and pin (5) on the remaining side.
7. Fill with clean engine oil (SAE #30) with approximately 480 ±30 cc (0.13 U.S. gal).
8. Install plug (8, Figure 36) on the collar.

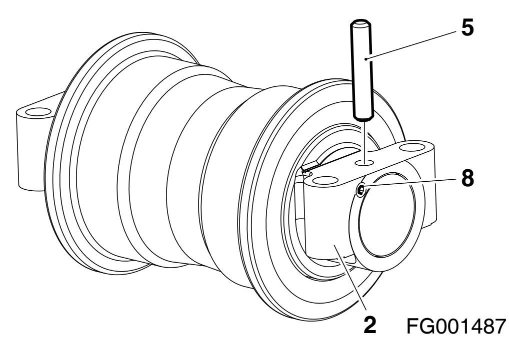


Figure 36

Wear Limits and Tolerances

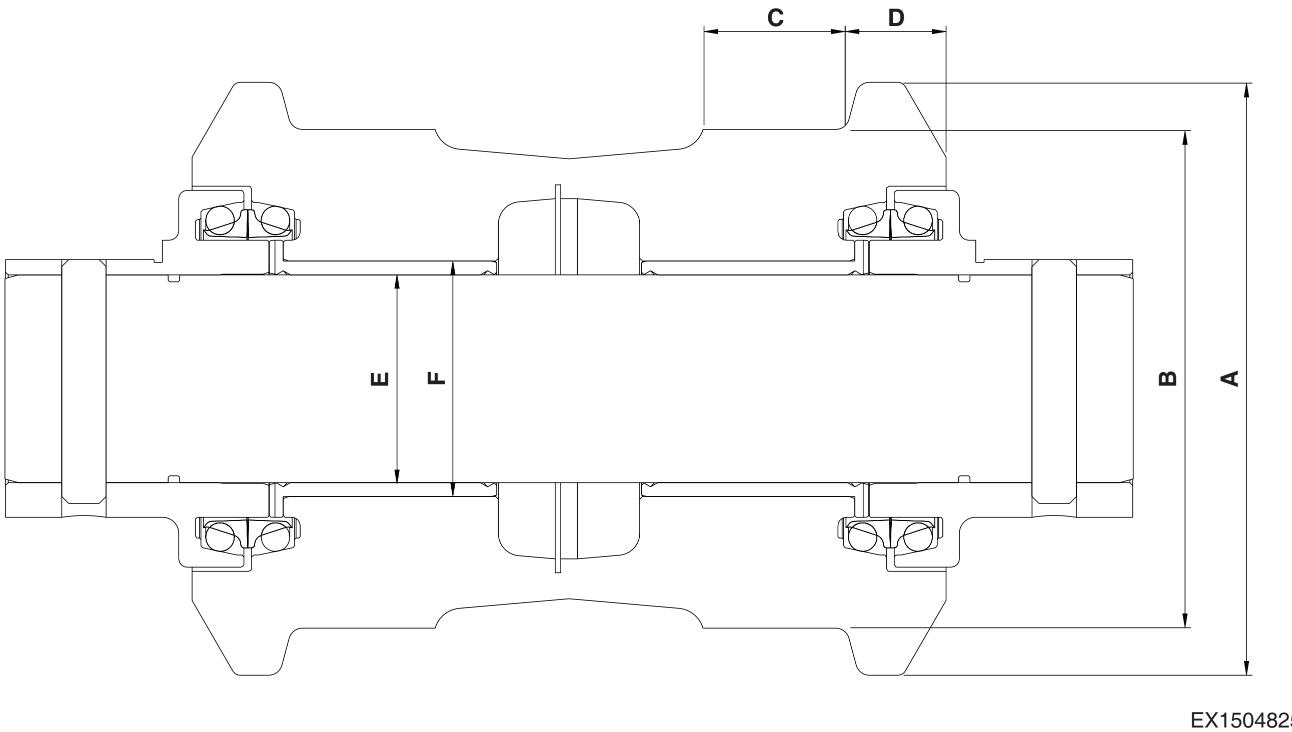


Figure 37

<table>
<tr><th>No.</th><th>Check Item</th><th colspan="3">Standard Dimension</th><th>Recommended Limit for Maintenance</th><th>Limit for Use (Replace - R)</th></tr>
<tr><td>A</td><td>Outside Diameter of flange</td><td colspan="3">212 mm
(8.346")</td><td></td><td></td></tr>
<tr><td>B</td><td>Outside Diameter of Tread</td><td colspan="3">178 mm
(7.008")</td><td>168 mm
(6.614")</td><td>166 mm [R]
(6.535")</td></tr>
<tr><td>C</td><td>Width of Tread</td><td colspan="3">50.5 mm
(1.988")</td><td>57 mm
(2.244")</td><td>60 mm [R]
(2.362")</td></tr>
<tr><td>D</td><td>Width of Flange</td><td colspan="3">24 mm
(0.945")</td><td></td><td></td></tr>
<tr><td rowspan="3">E</td><td rowspan="3">Clearance between shaft and bushing</td><td rowspan="2">Standard Dimension</td><td colspan="2">Tolerance</td><td rowspan="2">Standard Interference</td><td rowspan="2">Repair Limit</td></tr>
<tr><td>Shaft</td><td>Bush</td></tr>
<tr><td>75 mm
(2.953")</td><td>-0.06
-0.09</td><td>+0.40
+0.34</td><td>0.400 ~ 0.490</td><td>1.5 mm [R]
(0.059")</td></tr>
<tr><td rowspan="3">F</td><td rowspan="3">Interference between roller and bushing</td><td rowspan="2">Standard Dimension</td><td colspan="2">Tolerance</td><td rowspan="2">Standard Interference</td><td rowspan="2">Repair Limit</td></tr>
<tr><td>Bush</td><td>Body</td></tr>
<tr><td>82 mm
(3.228")</td><td>+0.19
+0.13</td><td>+0.03
-0.02</td><td>0.10 ~ 0.21</td><td></td></tr>
</table>

TRACK ADJUSTER

Parts List

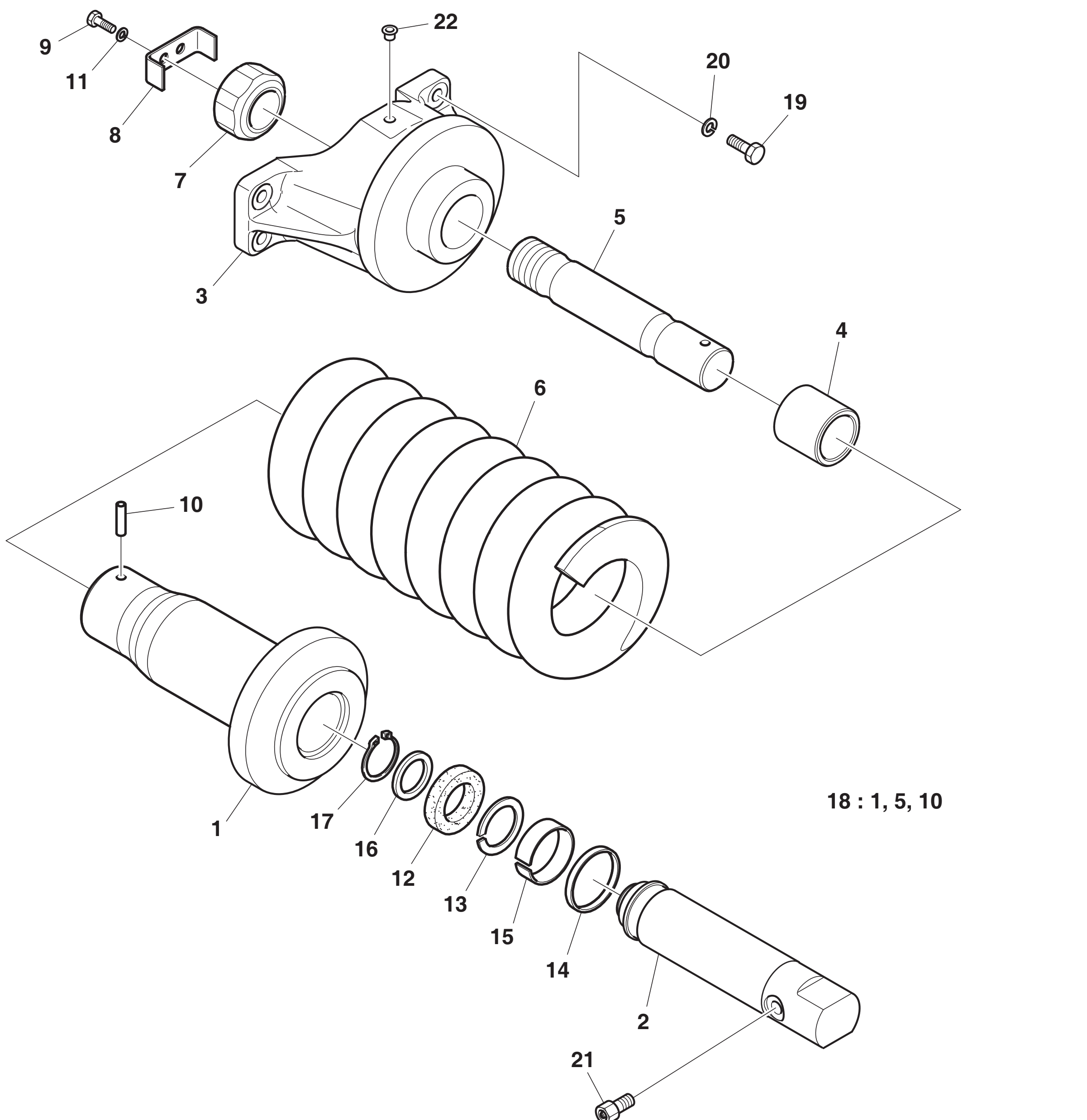


Figure 38

Reference Number	Description
1	Cylinder Body
2	Piston Rod
3	Bracket
4	Spacer
5	Shaft
6	Spring
7	Locknut
8	Lock Plate
9	Bolt
10	Spring Pin
11	Spring Washer

Reference Number	Description
12	U-ring Packing
13	Backup Ring
14	Dust Seal
15	Piston Ring
16	Stop Ring
17	Stop Ring
18	Cylinder Assembly
19	Bolt
20	Washer
21	Grease Valve
22	Cap

- Weight: 210 kg (463 lb)

Disassembly

1. Apply pressure on spring (6, Figure 39) with a press.

   NOTE: *The spring is under a large installed load. This is dangerous, so be sure to set properly.*

   - Spring set load: 19,100 kg (42,108 lb)

2. Remove bolt (9, Figure 39), spring washer (11) and lock plate (8).

   - Tool: 19 mm ( )

3. Remove lock nut (7, Figure 39).

   - Tool: 90 mm ( )

   NOTE: *Take enough notice so that the press which pushes down the spring, should not be slipped out in its operation.*

4. Tighten the press load slowly and remove bracket (3, Figure 39) and spring (6).

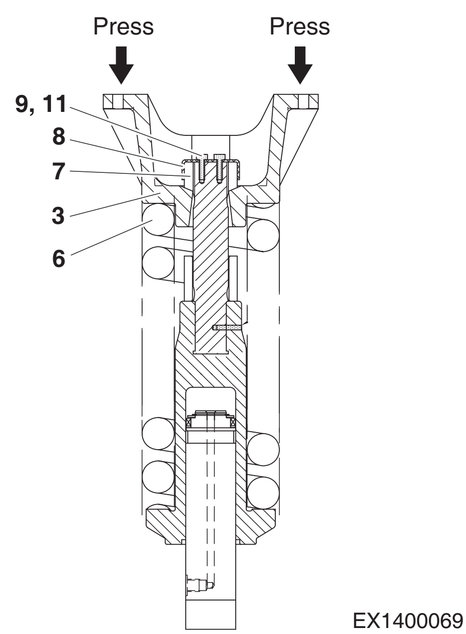


Figure 39

5. Remove piston rod (2, Figure 40) from body (1).
6. Remove grease valve (21, Figure 40) from piston rod (2).

   - Tool: 27 mm ( )

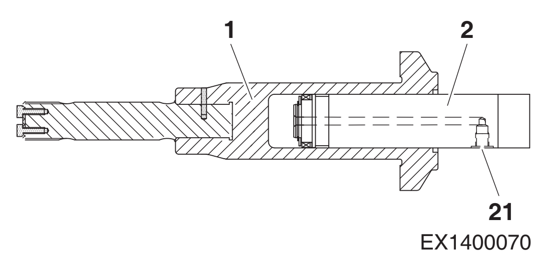


Figure 40

7. Remove dust seal (14, Figure 41) from body (1).

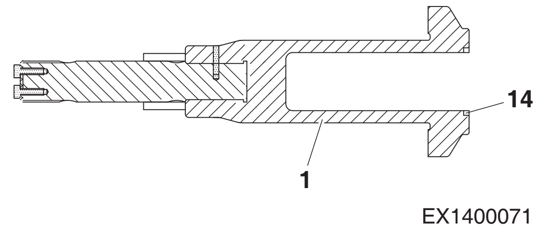


Figure 41

8. Remove stop ring (17, Figure 42), plate (16), backup ring (13), packing (12) and piston ring (15) from piston rod (2).

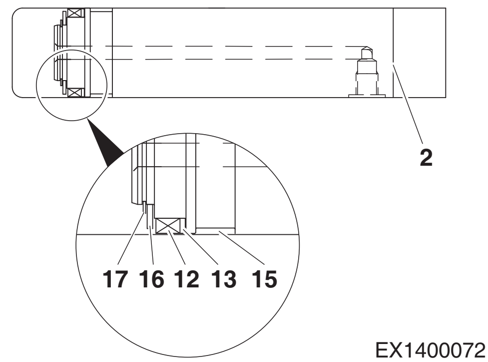


Figure 42

Assembly

1. Install piston ring (15, Figure 43), packing (12), backup ring (13), plate (16) and stop ring (17) to piston rod (2).

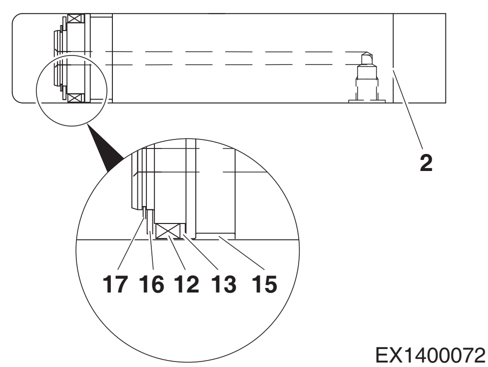


Figure 43

2. Install dust seal (14, Figure 44) to body (1).

   NOTE: *When installing piston ring (15), packing (12), dust seal (14) take full care as not to damage the lip.*

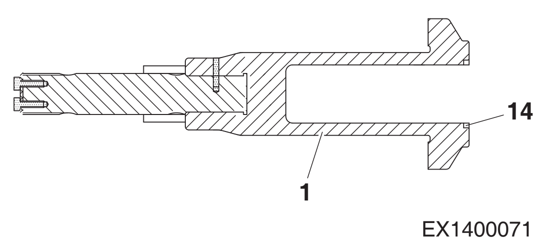


Figure 44

3. Grease into body (1, Figure 45), then push in piston rod (2) by hand.

   NOTE: *Fill up "B" part with grease. Press fit the piston rod (2, Figure 45) by maximum to *105 mm. Remove air in the "B" part and the piston rod and install the grease valve (21).*

   NOTE: *If air letting is not sufficient, it may be difficult to adjust the tension of crawler.*

   - Tool: 27 mm ( )
   - Grease valve torque: 137 N.m (14 kg.m, 101 ft lb)

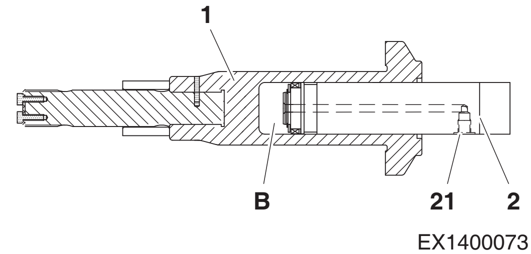


Figure 45

4. Install piston rod (2, Figure 46) to body, and assemble spacer (4) with the shaft (5) after assembling the shaft (5) with spring pin (10).
5. Install spring (6, Figure 46) and bracket (3) to body.
6. Apply pressure to spring (6, Figure 46) with a press and tighten lock nut (7).

   - Tool: 90 mm ( )

   NOTE: *Apply sealant before assembling.*

   NOTE: *During the operation, pay attention specially to prevent the press from slipping out.*

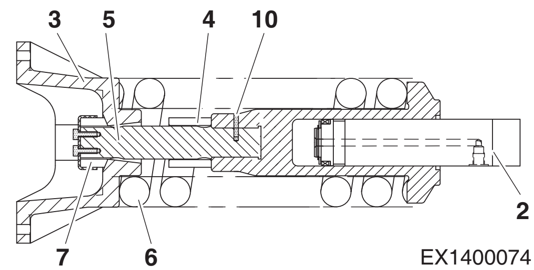


Figure 46

7. Tighten the press load and confirm the set length of spring (6, Figure 47).

   - Length A: 522 mm (20.6 in)

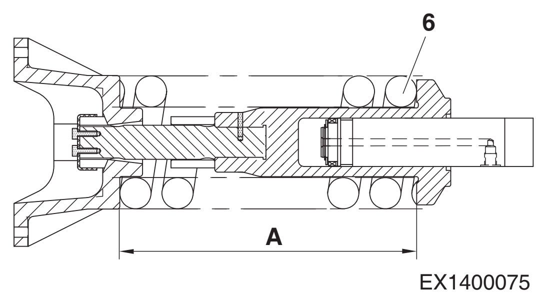


Figure 47

8. After the setting of spring (6, Figure 48), install lock plate (8), spring washer (11) and bolt (9).

   NOTE: *Apply loctite on bolt (9, Figure 48).*

   - Tool: 19 mm ( )
   - Toque: 107.9 N.m (11 kg.m, 79.6 ft lb)

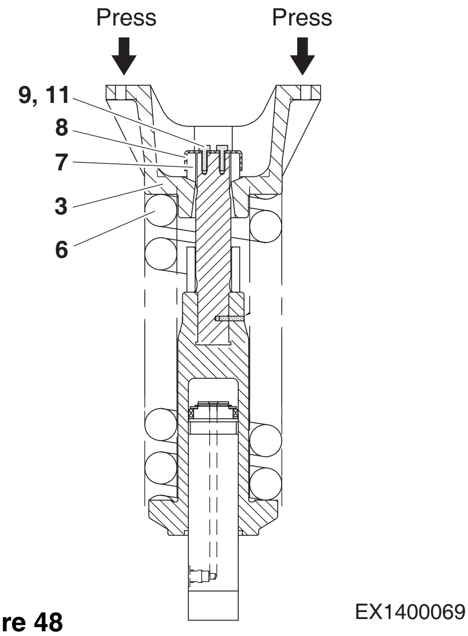


Figure 48

9. Install the bolt (3, Figure 49) and washer (4).

   - Tool: 24 mm ( )
   - Torque: 264 N.m (27 kg.m, 195 ft lb)

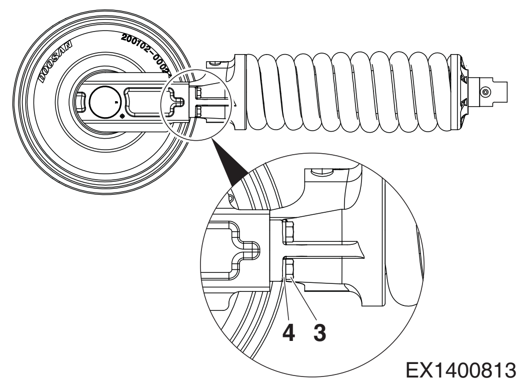


Figure 49

Front

Boom and Stick

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Boom and Stick

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.*

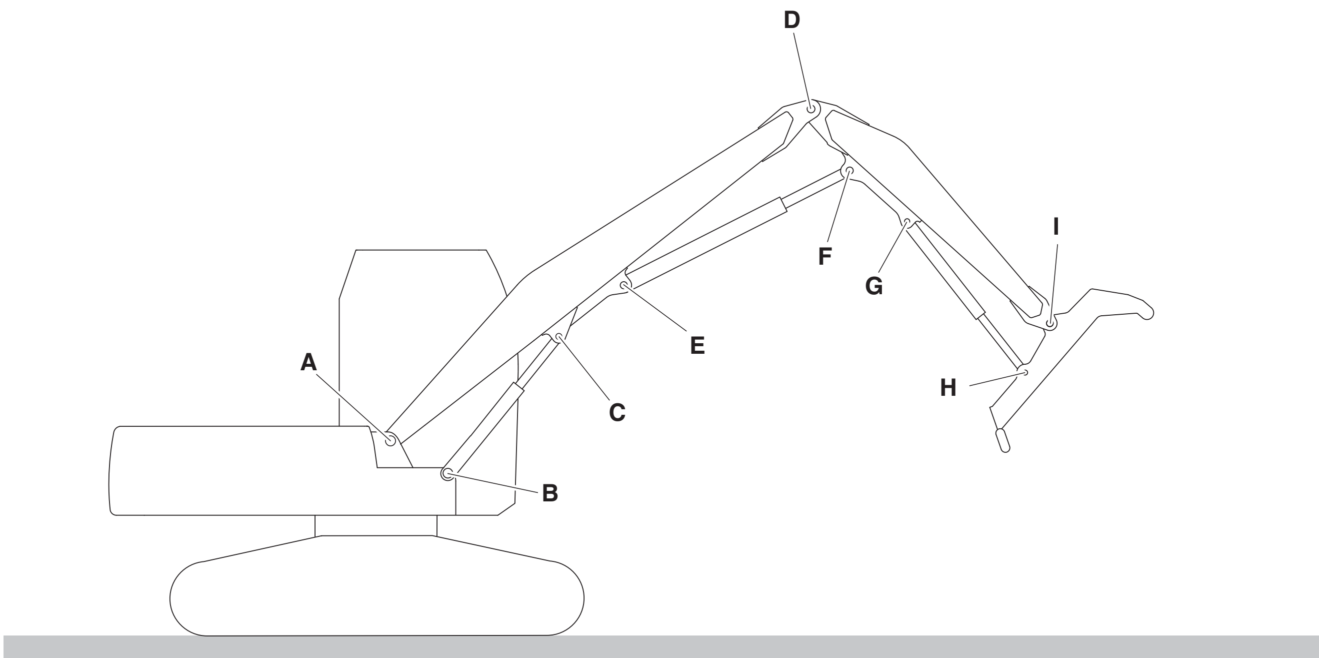


Figure 1

EX1300772

Mark	Measuring Part	Criteria					Remedy
		Standard Size	Tolerance		Standard Clearance	Clearance Limit	
			Pin	Hole			
A	Boom Foot	90 mm (3.54")	-0.10 -0.15	+0.054 0	0.1 ~ 0.204		
B	Boom Cylinder Head	80 mm (3.15")	-0.06 -0.11	+0.054 0	0.06 ~ 0.164		
C	Boom Cylinder Rod	80 mm (3.15")	-0.06 -0.11	+0.046 0	0.06 ~ 0.156		
D	Boom End	90 mm (3.54")	-0.10 -0.15	+0.054 0	0.1 ~ 0.204		
E	Arm Cylinder Head	90 mm (3.54")	-0.10 -0.15	+0.054 0	0.1 ~ 0.204	1.5	Replace
F	Arm Cylinder Rod	90 mm (3.54")	-0.10 -0.15	+0.054 0	0.1 ~ 0.204		
G	Heel Cylinder Head	65 mm (2.56")	-0.06 -0.11	+0.046 0	0.06 ~ 0.156		
H	Heel Cylinder Rod	65 mm (2.56")	-0.06 -0.11	+0.046 0	0.06 ~ 0.156		
I	Arm End	80 mm (3.15")	-0.06 -0.11	+0.046 0	0.06 ~ 0.156		

Size and Weight

Item	Length (A)	Weight
Boom	6,148 mm (242 in)	1,866 kg (4,113 lb)
Stick	3,657 mm (143 in)	887 kg (1,955 lb)
Heel	2,286 mm (90 in)	450 kg (992 lb)

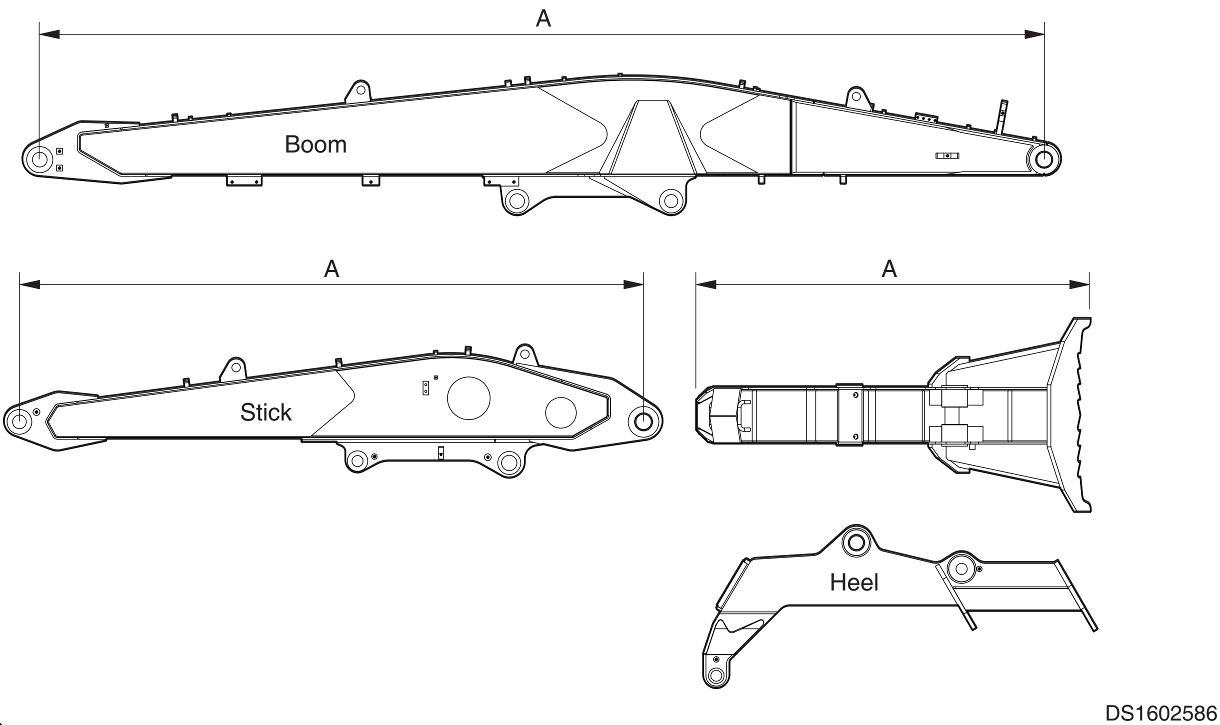


Figure 2

REMOVAL

DANGER

AVOID DEATH

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 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.

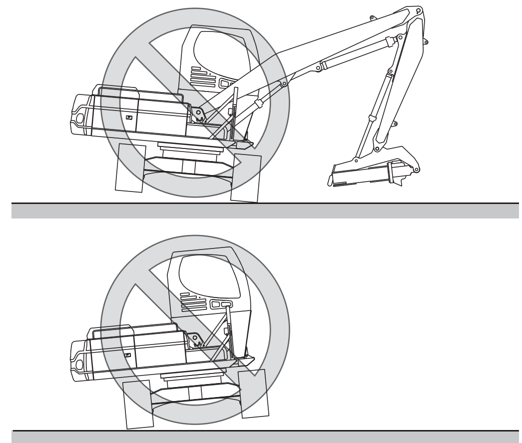


Figure 3

IMPORTANT

Always break down the front attachment by removing outermost sections first - the heel before the stick, the stick before the boom. Reinstallation of the attachment must begin with the boom and end with the heel.

Stick Removal

WARNING

AVOID DEATH OR SERIOUS INJURY

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.

Before beginning the disassembly of attachment mounting pins, disconnect the stick cylinder hydraulic hose couplings and put a clean plug in the end of each one. Use any 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.

Complete the heel end removal procedure by pulling out the two heel linkage pins and the heel cylinder mounting pin, on the stick. Use an assist crane or hoist to lift the cylinder and relieve weight on mounting pins.

Park the forestry machine away from obstructions and all traffic on clear, flat, level ground. Extend the stick cylinder and crowd the stick into the boom. Partially retract the boom cylinder so the boom is stretched out in front of the forestry machine, as low to the ground as possible, with the stick crowded under the boom.

The tip of the stick point must be lowered to secure blocking that will safely support the weight of the stick. Place the blocking directly in front of the forestry machine and make sure that it will not be unbalanced with an initial weight load that is all to one end, under the stick 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

AVOID DEATH OR SERIOUS INJURY

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 1,866 kg [4,113 lb], not including the weight of accessories or fixtures).

Place a sling under the stick cylinder (the cylinder used to extend and retract the attachment stick, pinned to the top of the boom). Lift the sling so that the weight load on the rod end of the stick cylinder (pinned to the ears on the inner end of the stick) is released. Prepare blocking under the stick that will securely support the weight of the stick and stick cylinder.

CAUTION

AVOID INJURY

To make sure that 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 the following disassembly and removal, cylinder rods should always be fully retracted. This eases handling problems and avoids possible damage.

Remove retainers on the end of the mounting pin for the stick cylinder rod end. Use the assist crane to relieve the weight load and withdraw the pin. Lower the stick down to the blocking support for any continued disassembly procedures.

Boom Removal

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 forestry machine.*

After the heel, stick and stick 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 Stick 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

AVOID DEATH OR SERIOUS INJURY

Traveling the forestry machine, 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 must be removed whenever the front attachment is taken off the machine.

INSTALLATION

Stick Installation

Reattach the base of the stick cylinder to the mounting point on top of the boom.

WARNING

AVOID DEATH OR SERIOUS INJURY

Before assembling the front attachment, make sure that individual boom, stick and heel 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 & 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 stick securely supported on blocking in front of the forestry machine. Pregrease the mounting pin for the rod end of the stick cylinder and push it through the ears on the end of the stick. Attach a sling around that mounting pin and lift the stick with an assist crane until it is in position for the boom-stick 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 stick cylinder.

Remove sling from around the rod end stick cylinder pin, withdraw the pin and lift the body of the stick cylinder to re-pin the mounting connection.

Boom Installation

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 must be lubricated as outlined in the initial start-up procedures of the operation manual. Refer to the appropriate Operation & Maintenance Manual for unit.

Cylinders

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

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Cylinders

GENERAL

General Description

Essentially types of hydraulic cylinders are used on the forest machine. The cylinder that is used to operate the forest machine boom or arm (stick) is equipped with a cushion ring, which acts as a cushion only when the cylinder rod is fully retracted (and the heel is pulled close to the arm).

Arm (stick) cylinder have a cushion or plunger for operation in both directions.

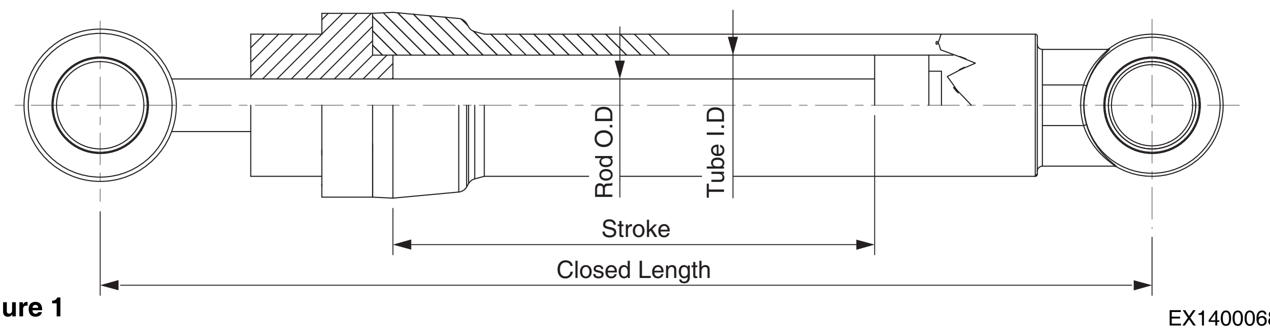


Figure 1

	Boom	**Arm (Stick)**	**Heel**
Quantity	2	1	1
Tube I.D	ø140	ø165	ø115
Rod O.D	ø95	ø115	ø75
Stroke (mm)	1,143	1,396	915
Closed Length (mm)	1,723	2,249	1,460
Head End Cushion	X	O	X
Rod End Cushion	O	O	X
Weight (kg/lb)	213/470	374/824	118/260

Parts List

The following parts list is a partial listing only; for complete parts list information, refer to the Hydraulic Equipment Component Parts List.

Boom Cylinder (LH)

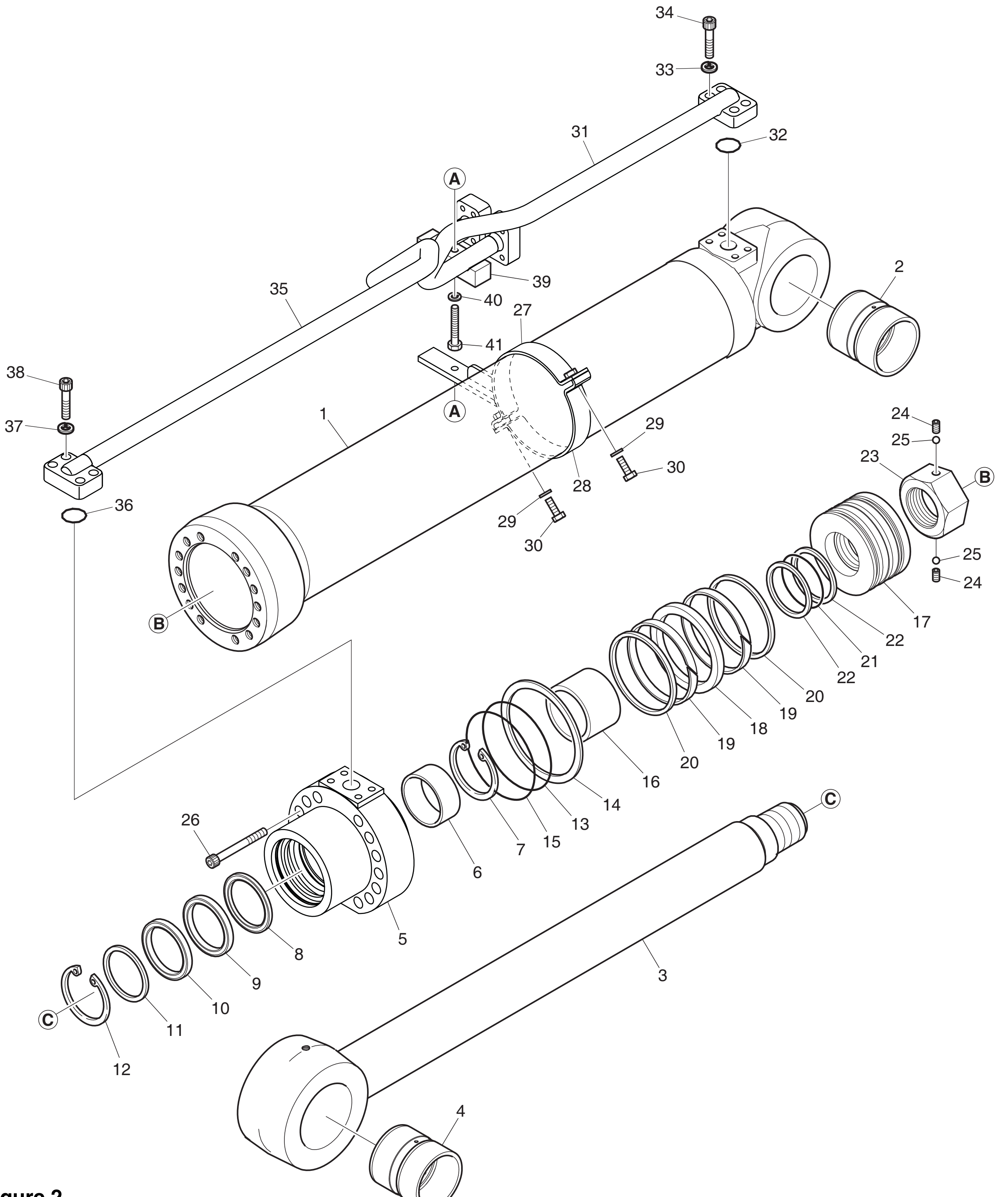


Figure 2

DS1602749

Reference Number	Description
1	Tube, Cylinder
2	Bush
3	Rod, Cylinder
4	Bush
5	Cover, Rod
6	DD-Bush
7	Ring; Retaining
8	Seal; Buffer
9	U-packing
10	Ring, Backup
11	Wiper; Dust
12	Ring; Retaining
13	O-ring
14	Ring; Backup
15	O-ring
16	Ring; Cushion
17	Piston
18	Seal; Slipper
19	Ring; Wear
20	Ring; Dust
21	O-ring

Reference Number	Description
22	Ring; Backup
23	Nut, Piston
24	Screw, Set
25	Ball, Steel
26	Bolt; Socket
27	Band Assembly, Pipe
28	Band, Pipe
29	Washer
30	Bolt
31	Pipe Assembly; H (LH)
32	O-ring
33	Washer
34	Bolt; Socket
35	Pipe Assembly; R (LH)
36	O-ring
37	Washer
38	Bolt
39	Clamp, Pipe
40	Washer
41	Bolt
*	Seal Kit; Boom Cylinder

*: 8, 9, 10, 11, 13, 14, 15, 18, 19, 20, 21, 22

Boom Cylinder (RH)

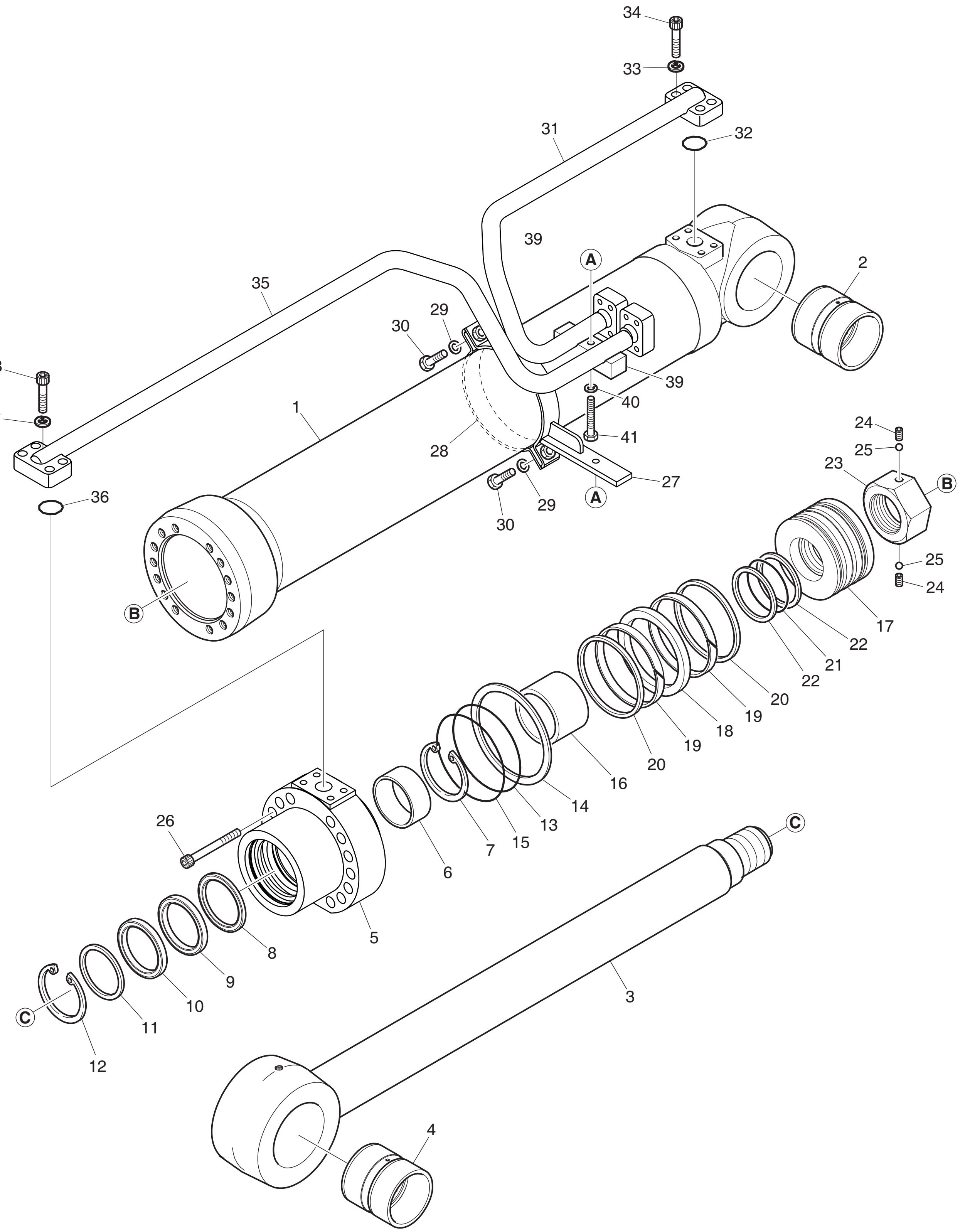


Figure 3

Reference Number	Description
1	Tube, Cylinder
2	Bush
3	Rod, Cylinder
4	Bush
5	Cover, Rod
6	DD-bush
7	Ring; Retaining
8	Seal; Buffer
9	U-packing
10	Ring, Backup
11	Wiper; Dust
12	Ring, Retaining
13	O-ring
14	Ring; Backup
15	O-ring
16	Ring; Cushion
17	Piston
18	Seal; Slipper
19	Ring; Wear
20	Ring; Dust
21	O-ring

Reference Number	Description
22	Ring; Backup
23	Nut, Piston
24	Screw, Set
25	Ball, Steel
26	Bolt; Socket
27	Band Assembly, Pipe
28	Band, Pipe
29	Washer
30	Bolt
31	Pipe Assembly; H (RH)
32	O-ring
33	Washer
34	Bolt; Socket
35	Pipe Assembly; R (RH)
36	O-ring
37	Washer
38	Bolt
39	Clamp, Pipe
40	Washer
41	Bolt
*	Seal Kit; Boom Cylinder

*: 8, 9, 10, 11, 13, 14, 15, 18, 19, 20, 21, 22

Arm (Stick) Cylinder

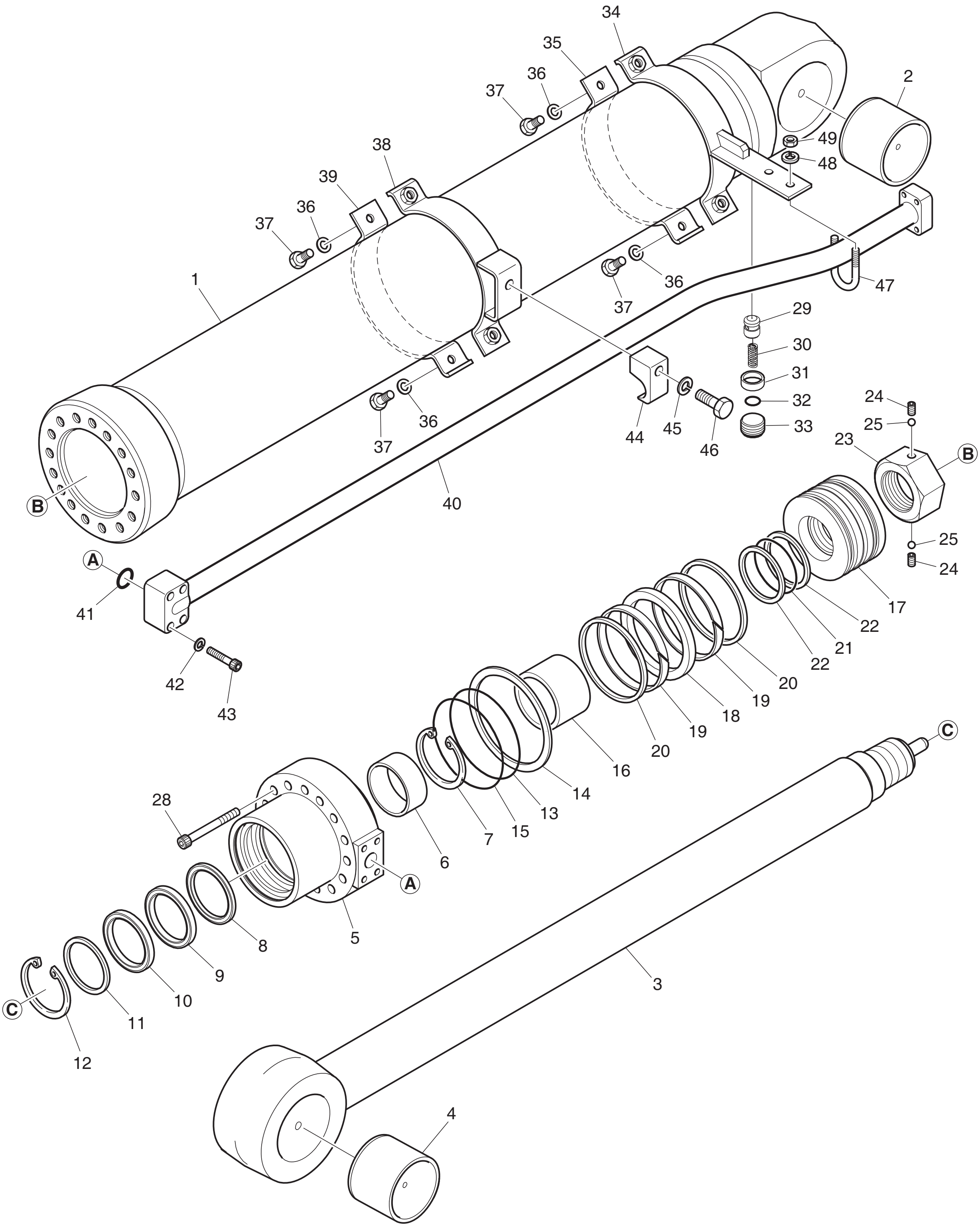


Figure 4

DS1602751

Reference Number	Description
1	Tube, Cylinder
2	Bushing
3	Rod, Cylinder
4	Bushing
5	Cover, Rod
6	Bush; DU
7	Ring, Retaining
8	Seal, Buffer
9	U-packing
10	Ring, Backup
11	Wiper, Dust
12	Ring, Retaining
13	O-ring
14	Ring; Backup
15	O-ring
16	Ring; Cushion
17	Piston
18	Seal; Slipper
19	Ring; Wear
20	Ring, Dust
21	O-ring
22	Ring, Backup
23	Nut, Piston
24	Screw, Set

Reference Number	Description
25	Ball, Steel
28	Bolt
29	Valve; Check
30	Spring
31	Support, Spring
32	O-ring
33	Plug
34	Band Assembly, Pipe
35	Band, Pipe
36	Washer
37	Bolt
38	Band Assembly, Pipe
39	Band, Pipe
40	Pipe Assembly
41	O-ring
42	Washer
43	Bolt
44	Clamp, Pipe
45	Washer
46	Bolt
47	U-bolt
48	Washer
49	Nut
*	Seal Kit

*: 8, 9, 10, 11, 13, 14, 15, 18, 19, 20, 21, 22

Heel Cylinder

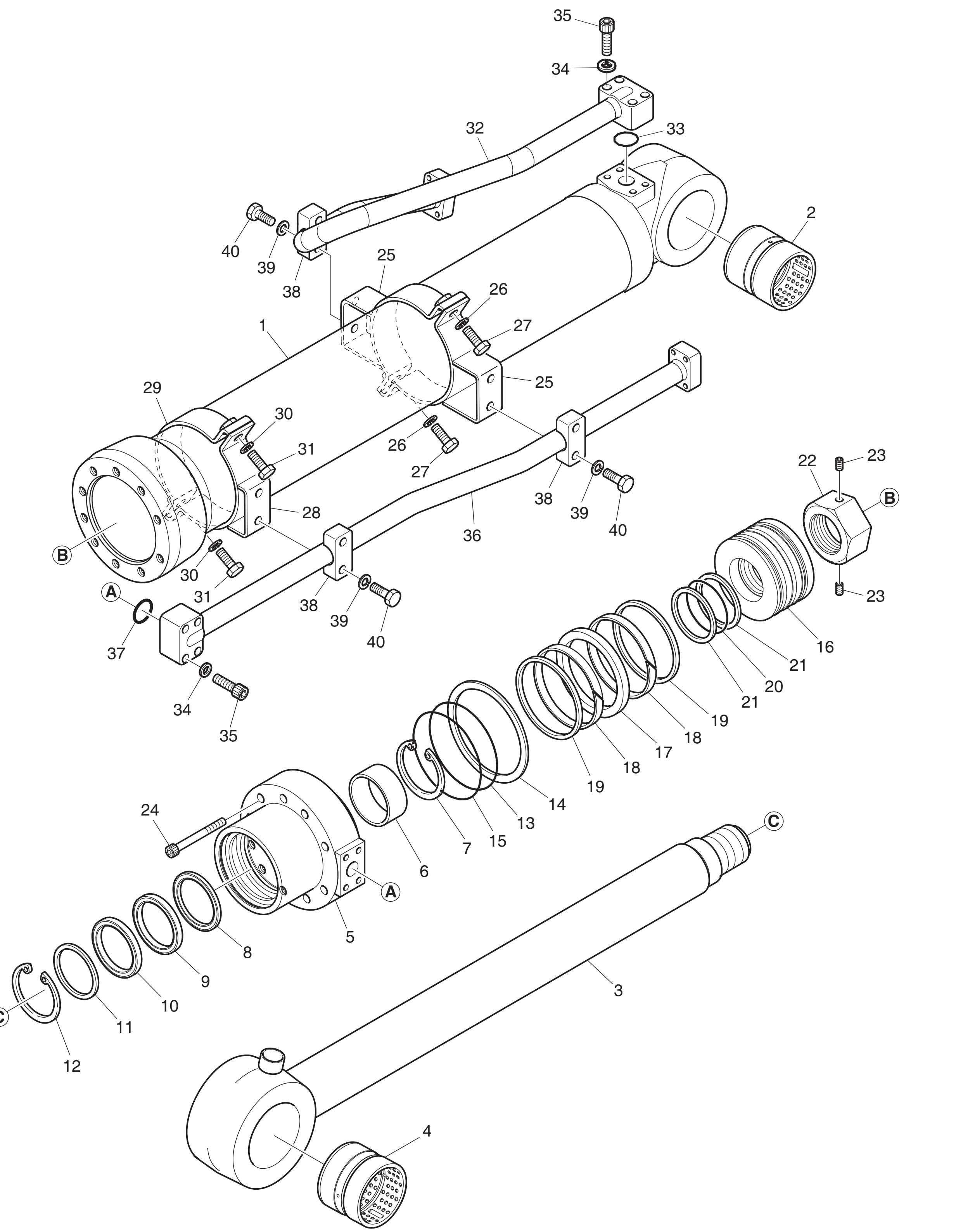


Figure 5

DS1602752

Reference Number	Description
1	Tube Assembly
2	Bushing
3	Rod Assembly, Cylinder
4	Bushing
5	Cover, Rod
6	DD-bush
7	Ring; Retaining
8	Seal; Buffer
9	U-packing
10	Ring; Backup
11	Wiper; Dust
12	Ring; Retaining
13	O-ring
14	Ring; Backup
15	O-ring
16	Piston; Cylinder
17	Seal; Slipper
18	Ring, Wear
19	Ring; Dust
20	O-ring
21	Ring; Backup

Reference Number	Description
22	Nut, Piston
23	Screw; Set
24	Bolt; Socket
25	Band Assembly, Pipe
26	Washer
27	Bolt
28	Band Assembly, Pipe
29	Band, Pipe
30	Washer
31	Bolt
32	Band, Pipe
33	O-ring
34	Washer
35	Bolt; Socket
36	Band, Pipe
37	O-ring
38	Clamp, Pipe
39	Washer
40	Bolt; Hex
*	Seal Kit

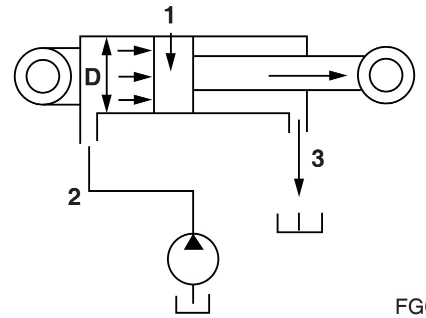
*: 8, 9, 10, 11, 13, 14, 15, 17, 18, 19, 20, 21

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 6).



FG001456

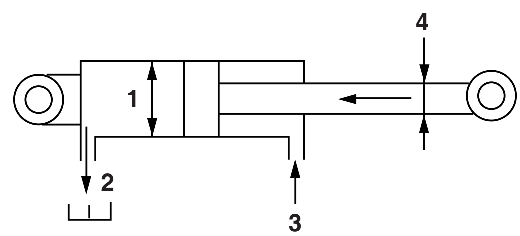
Figure 6

$$F_1 = P \times \frac{\pi D^2}{4}$$

(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.



FG001458

Figure 7

$$F_2 = P \times \frac{\pi(D^2 - R^2)}{4}$$

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.

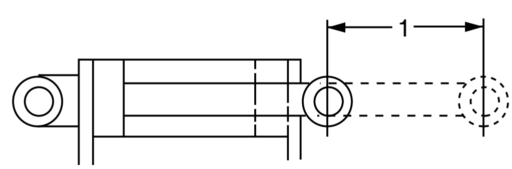


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Figure 8

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

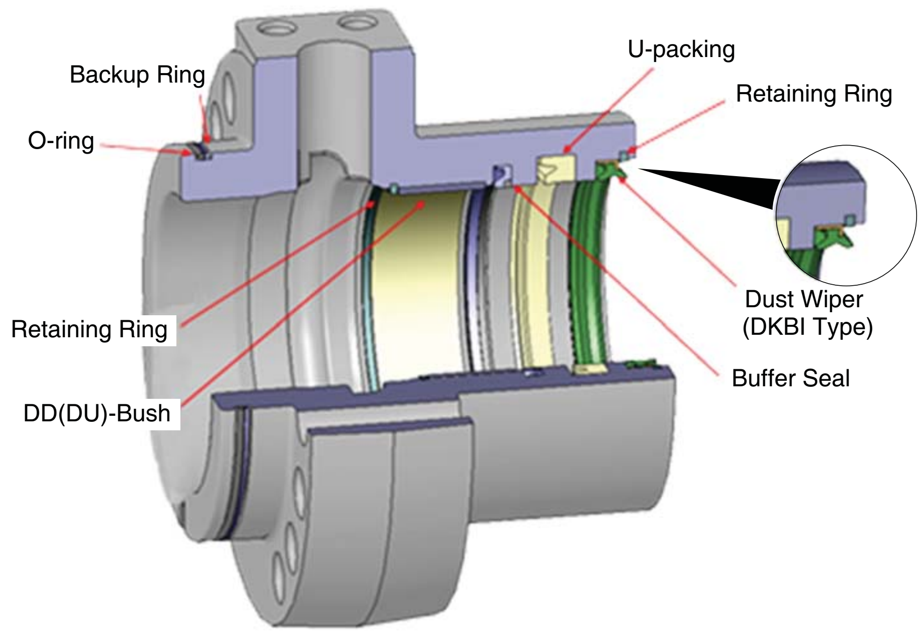
$$Q_2 = S \times \frac{\pi(D^2 - R^2)}{4}$$

$Q_1 > Q_2$

Seal of Cylinder

1. Assembly location and shape of seals

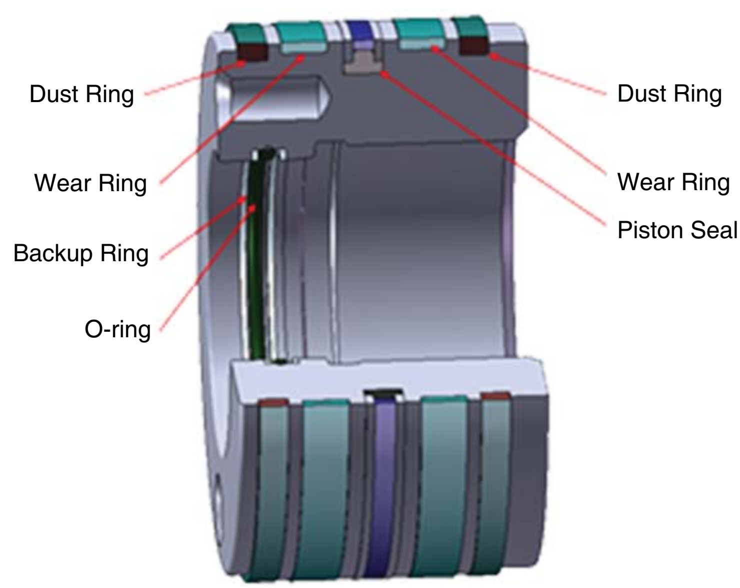
   A. Rod cover seal



EX1301741

Figure 9

   B. Piston seal



EX1301742

Figure 10

2. Seal function

No	Name	Function	Material
1	Piston Seal	Seal the hydraulic oil between the piston and the inner surface of the tube.	Slipper Seal, Glyd Ring, Compact Seal
2	Wear Ring (DU-bushing)	Prevents scratch on the inner surface of the tube and the rod surface caused by foreign materials, and eccentric center, and eccentric load, and plays role bearing keeping stable friction materials.	Phenol, Aramid
3	Contamination Seal	Protects the piston seal against the intrusion of foreign material to keep the functions of the seal intact.	Dust Ring, Slyd Ring
4	Rod Seal	Seals for preventing leak of hydraulic oil between the friction material and the cover of the rod.	U-packing, V-packing
5	Buffer Seal	Prevents surge/shock applied directly to the rod seal to extent lifecycle of the seal on the system for high-pressure.	Step Seal
6	Dust Seal (Dust Wiper)	Prevents intrusion of foreign materials into the cylinder from outside environment to protect the rod seal.	Single Lip, Double Lip
7	O-ring	Prevents intrusion of foreign materials (e.g., rain and snow), and makes sealing between the inner surface of the tube and the rod cover, and between the rod and the inner diameter of the piston.	NBR
8	Backup Ring	Prevents disengaging U-packing and O-ring because of pressure and gap.	PTFE, Nylon

SPECIAL TOOLS AND MATERIALS

Piston Nut

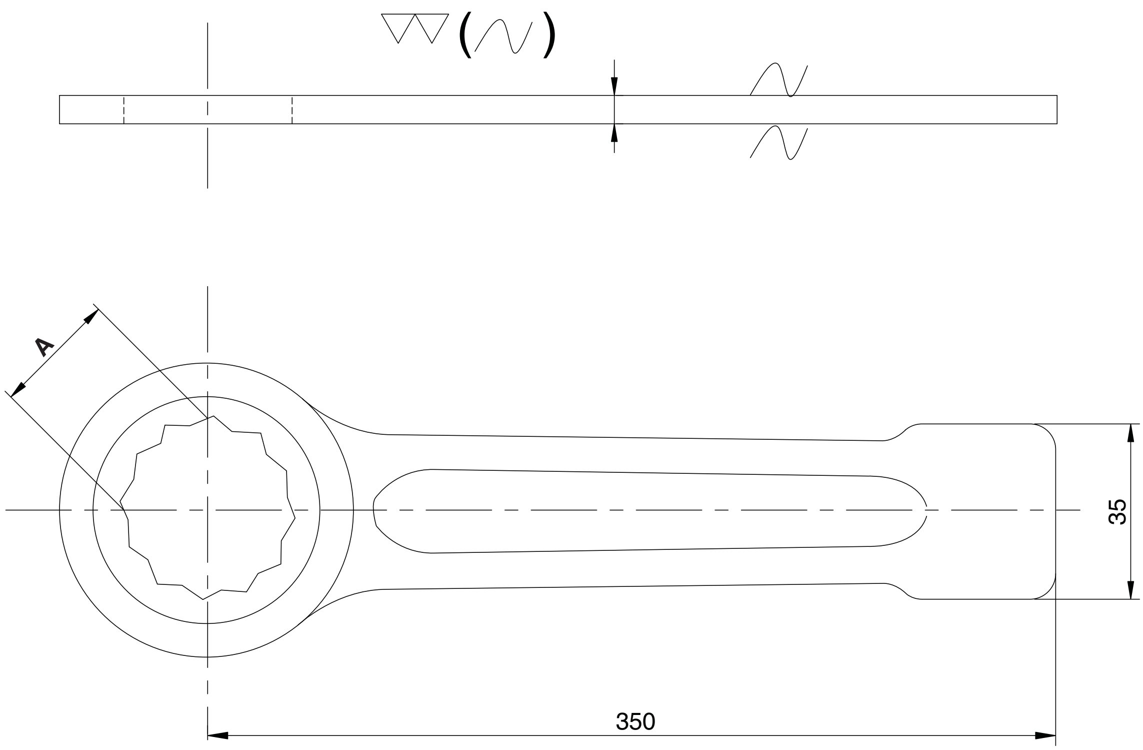


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Figure 11

Material SM45C (AISI 1045)

Rockwell Hardened from 22 ~ 27

Oil Quench

Cylinder	A
Boom	111 mm (4.37 in)
Arm (Stick)	131 mm (5.16 in)
Heel	81 mm (3.19 in)

Piston Jig

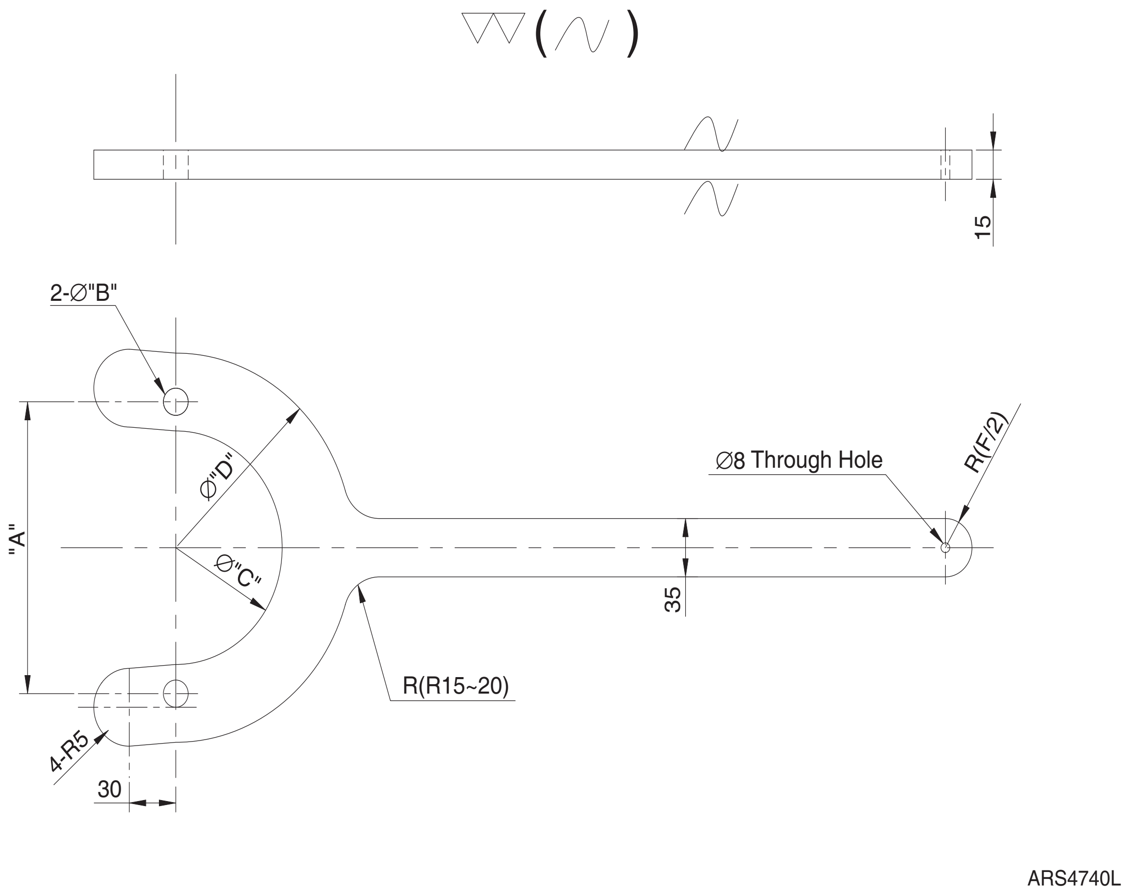


Figure 12

Material SM45C (AISI 1045)

Rockwell Hardened from 22 ~ 27

Oil Quench

Cylinder	A (±0.1)	øB	øC	øD
Boom	110.0 mm (4.33 in)	14.0 mm (0.55 in)	85.0 mm (3.35 in)	130.0 mm (5.12 in)
Arm (Stick)	130.0 mm (5.12 in)	14.0 mm (0.55 in)	105.0 mm (4.13 in)	160.0 mm (6.30 in)
Heel	85.0 mm (3.35 in)	12.0 mm (0.47 in)	65.0 mm (2.56 in)	110.0 mm (4.33 in)

Steel Bushing Jig

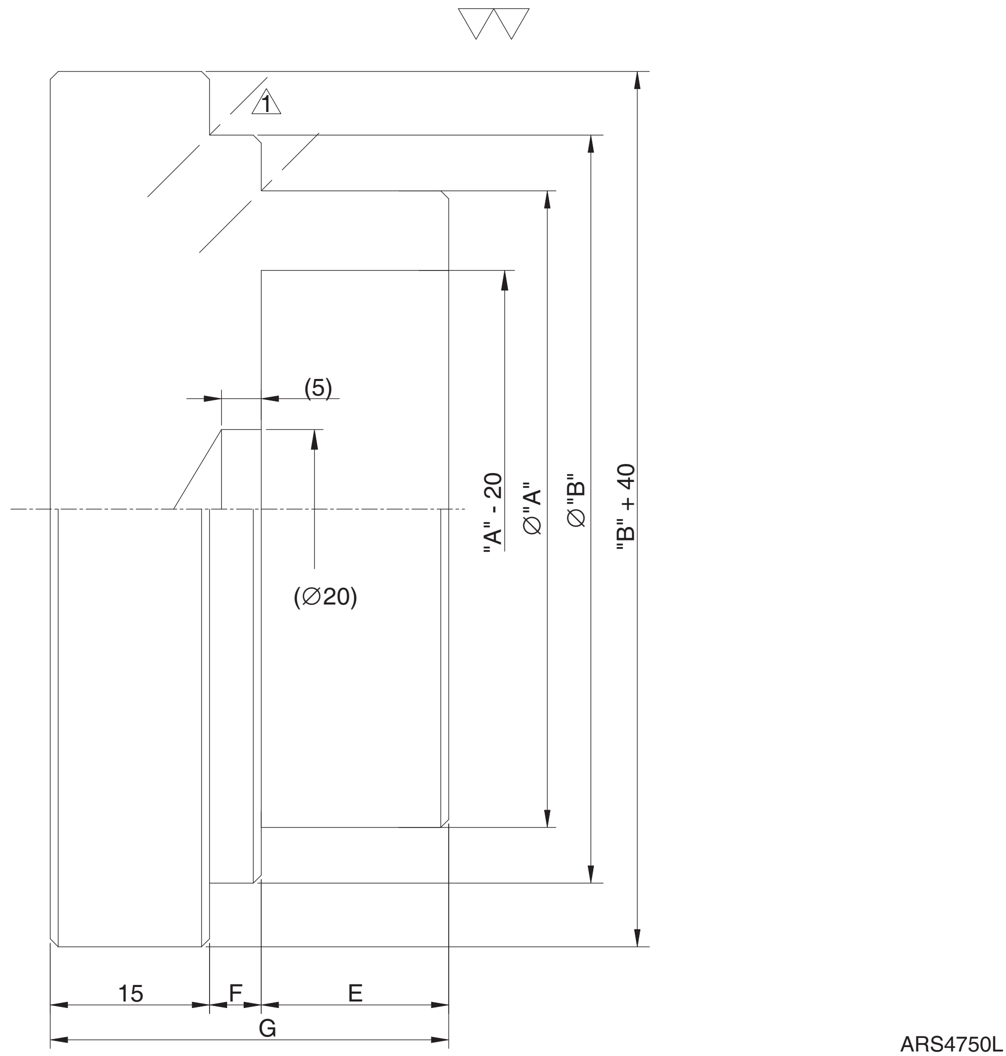


Figure 13

Material: SM45C which is done thermal refining <QT> HRC 22 ~ 28

Undefined Chamfer C/R = 0.5 Max.

1 Place: Final work to used DNMG Tip <Nose R0.4>

Cylinder	ØA $^{-0.05}_{-0.15}$	ØB (±0.1)	E	F $^{+0.05}_{0}$	G
Boom	79.5 mm (3.13 in)	94.5 mm (3.72 in)	30.0 mm (1.18 in)	6.5 mm (0.26 in)	51.5 mm (2.03 in)
Arm (Stick)	89.5 mm (3.52 in)	104.5 mm (4.11 in)	30.0 mm (1.18 in)	6.5 mm (0.30 in)	51.5 mm (2.03 in)
Heel	64.5 mm (2.54 in)	79.5 mm (3.13 in)	30.0 mm (1.18 in)	6.5 mm (0.26 in)	51.5 mm (2.03 in)

Dust Wiper Jig

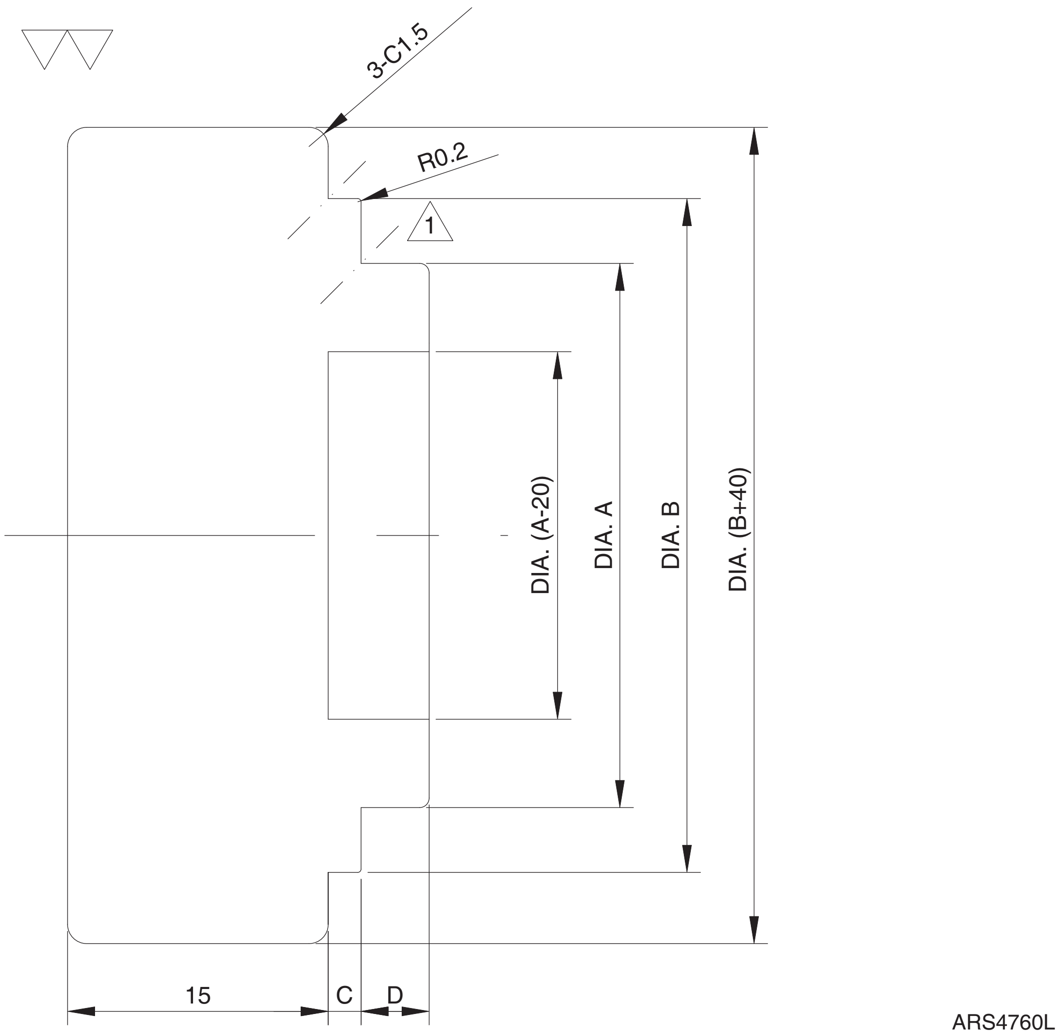


Figure 14

Material: SM45C which is done thermal refining <QT> HRC 22 ~ 28

Undefined Chamfer C/R = 0.5 Max.

1 Place: Final work to used DNMG Tip <Nose R0.4>

Cylinder	$øA^{-0.2}_{-0.3}$	$øB^{-0.2}_{-0.3}$	$C^{0}_{-0.1}$	D
Boom	94.0 mm (3.70 in)	109.0 mm (4.29 in)	5.0 mm (0.20 in)	8.5 mm (0.33 in)
Arm (Stick)	114.0 mm (4.49 in)	131.0 mm (5.16 in)	6.0 mm (0.24 in)	9.5 mm (0.37 in)
Heel	73.0 mm (2.87 in)	89.0 mm (3.50 in)	5.5 mm (0.22 in)	10.0 mm (0.39 in)

Slipper Seal Jig

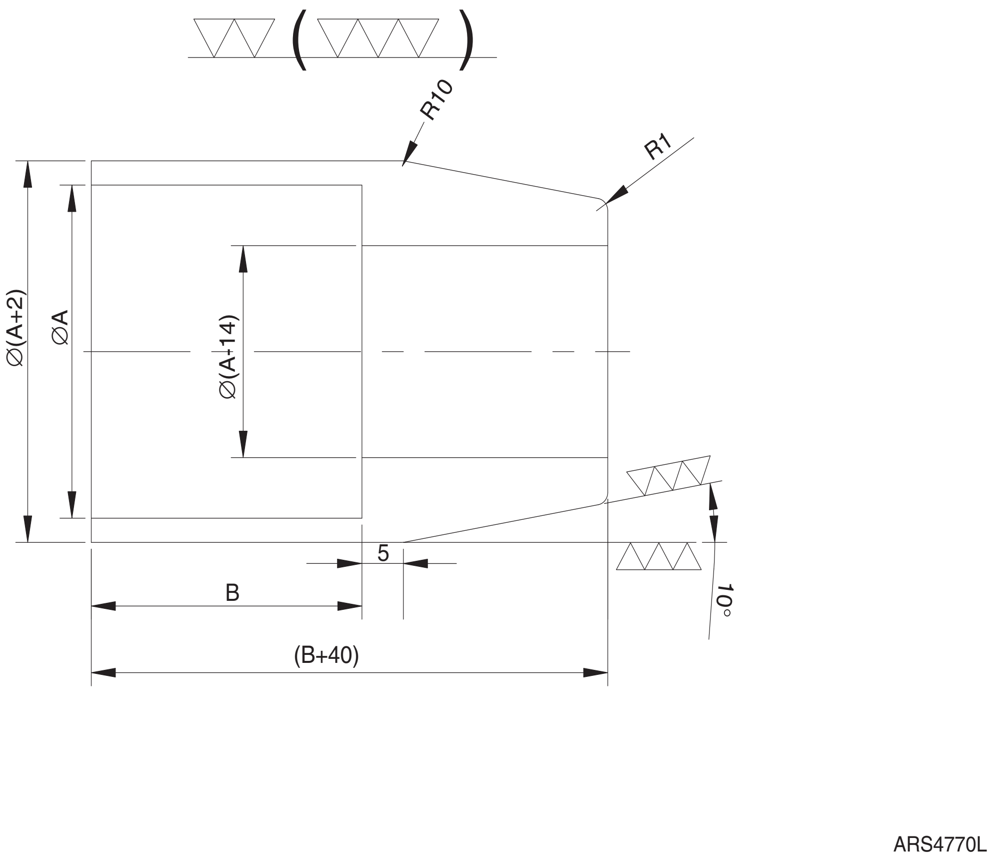


Figure 15

Cylinder	$øA^{+0.2}_{+0.1}$	$B^{+0.2}_{+0.1}$
Boom	140.0 mm (5.51 in)	27.0 mm (1.06 in)
Arm (Stick)	165.0 mm (6.50 in)	35.5 mm (1.40 in)
Heel	115.0 mm (4.53 in)	26.0 mm (1.02 in)

Slipper Seal Straightening Jig

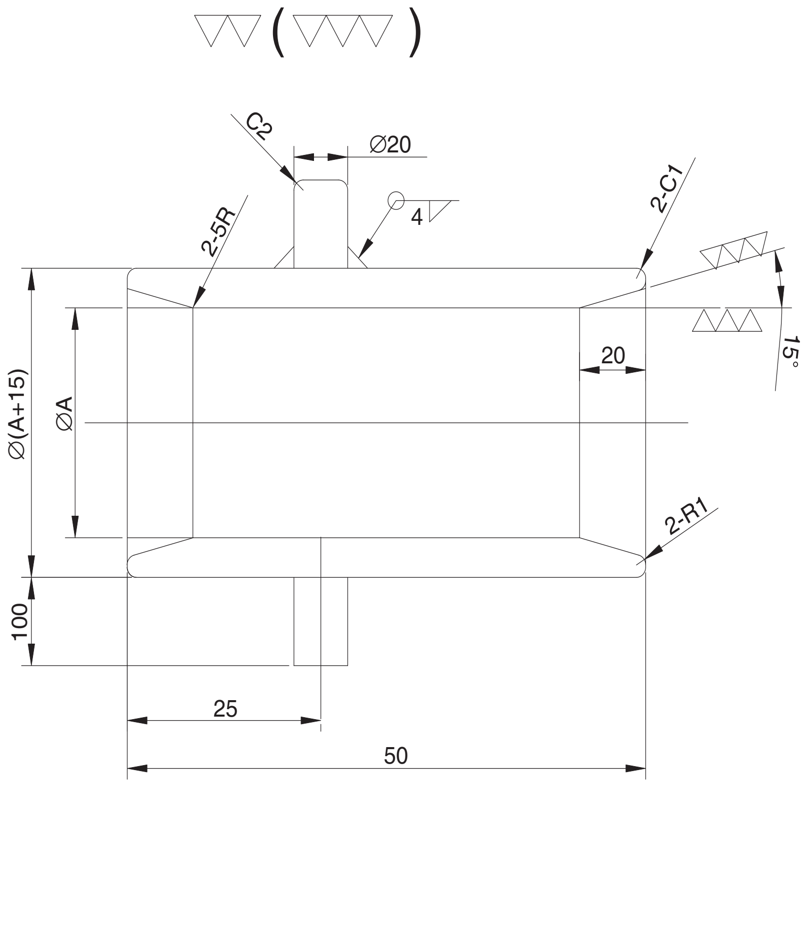


Figure 16

Cylinder	$\varnothing \mathbf{A}^{+0.2}_{+0.1}$
Boom	140.5 mm (5.53 in)
Arm (Stick)	165.5 mm (6.52 in)
Heel	115.5 mm (4.55 in)

Rod Bushing (DD-bushing) Pushing-in Jig

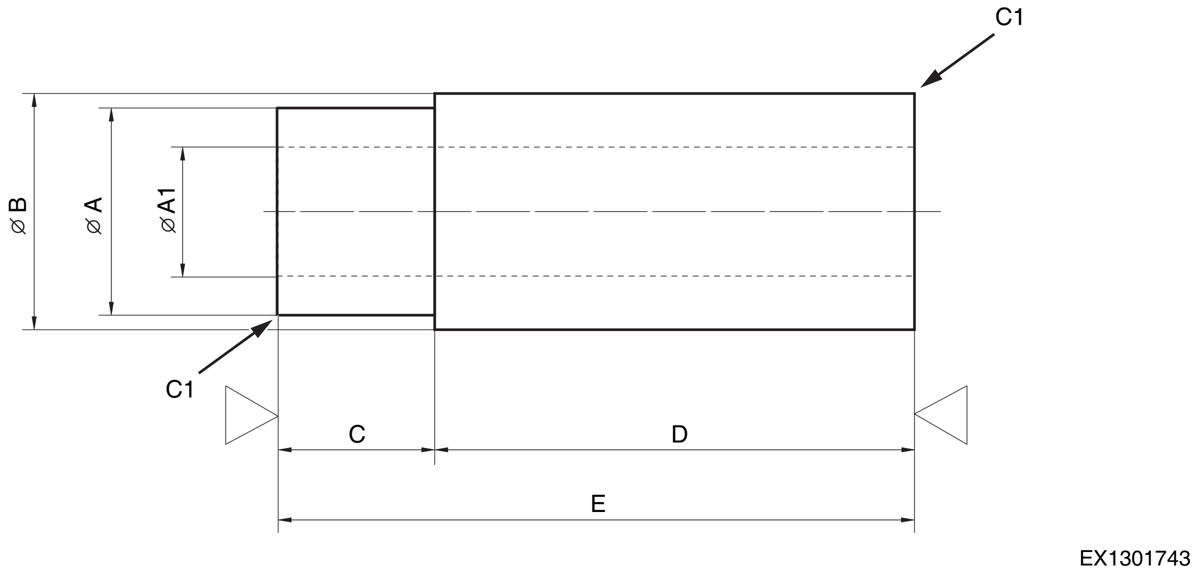


Figure 17

Inner diameter (A1): "A"-20 (no machining required on the inner diameter)

Cylinder	$øA^{+0.2}_{-0.1}$	øB (±0.1)	C	D	E
Boom	94 mm (3.70 in)	99.8 mm (3.93 in)	30 mm (1.18 in)	75 mm (2.95 in)	105 mm (4.13 in)
Arm (Stick)	114 mm (4.49 in)	119.8 mm (4.72 in)	45 mm (1.77 in)	80 mm (3.15 in)	125 mm (4.92 in)
Heel	74 mm (2.91 in)	79.8 mm (3.14 in)	30 mm (1.18 in)	65 mm (2.56 in)	95 mm (3.74 in)

1. Assemble the rod bushing with the exclusive jig (if disassembled).

   Push in the rod bushing in true vertical direction to prevent inclining of the bushing.

   Apply small volume of operating oil on inner surface of the rod cover for facilitating pushing in.

2. Remove all of pushing-in residues generated during the pushing-in process.
3. Mount the retaining ring on the rod cover groove at the end of the rod bushing after cleaning to prevent disengagement of the rod bushing.

   (Mount the retaining ring manually with pliers, and check if the ring is securely mounted.)

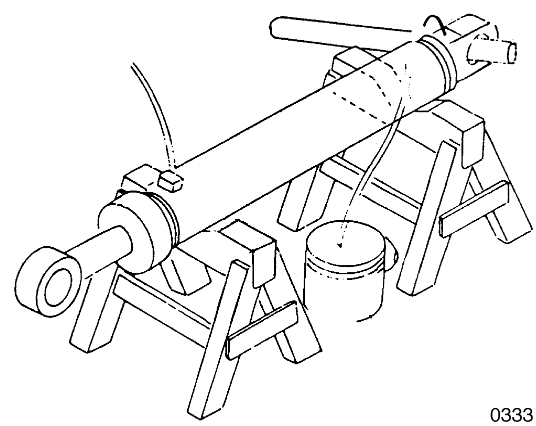
DISASSEMBLY

CAUTION

AVOID INJURY

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 hydraulic fluid into the system if excessive fluid is lost.

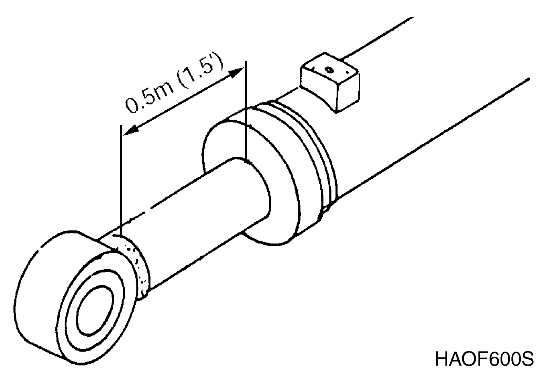
1. Following removal of cylinder from excavator attachment, support cylinder on some type of sturdy work platform and drain all oil. Rotate cylinder so piping ports are on top, to allow trapped air to vent.



0333

Figure 18

2. Position piston rod so it is extended approximately one half meter (20").

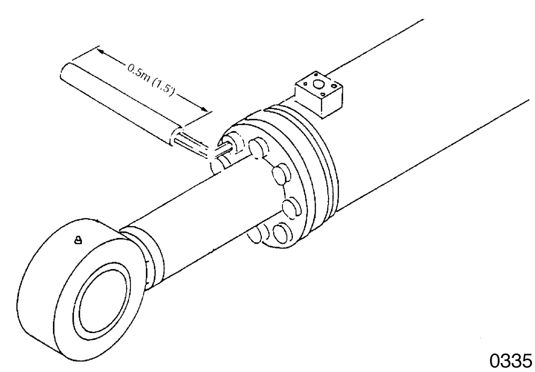


HAOF600S

Figure 19

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.*



0335

Figure 20

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.

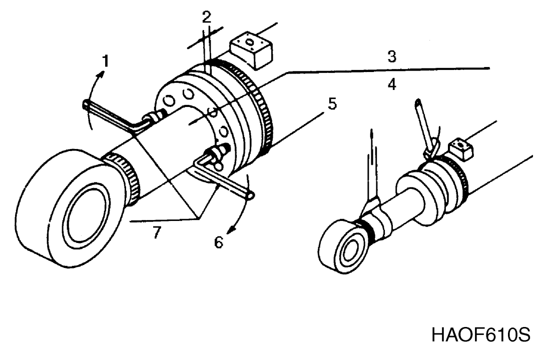


Figure 21

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.

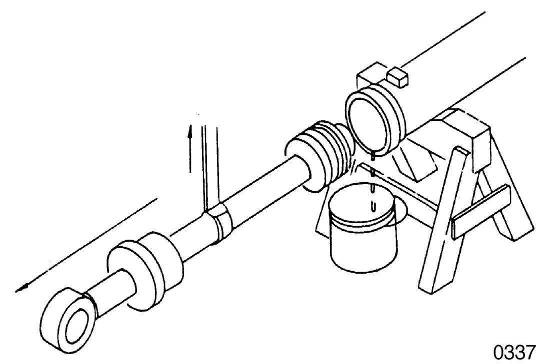


Figure 22

6. Lower piston rod to support blocks and detach wear ring (outer surface) (19) from end of rod.

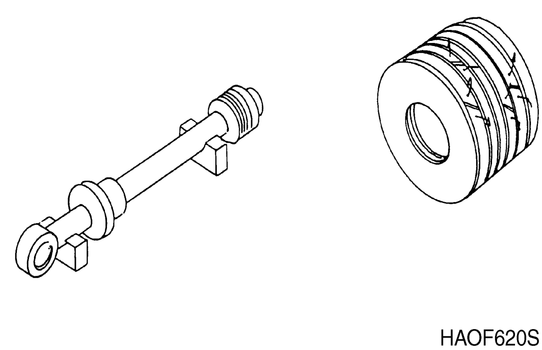


Figure 23

7. Immobilize piston rod by inserting a wooden or other nonscoring, nonmetallic support through end of rod.

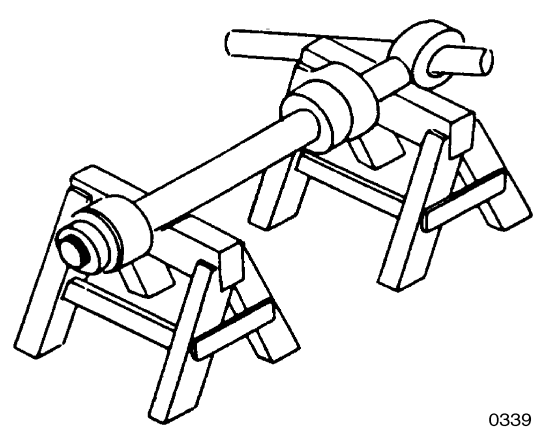


Figure 24

8. Remove set screw using socket wrench.

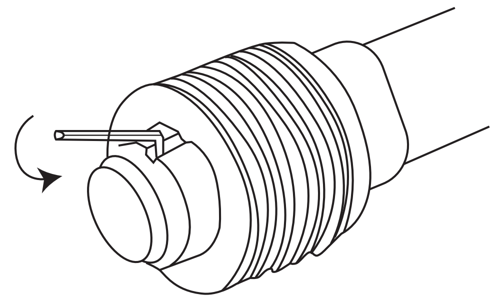


Figure 25

9. Fabricate or purchase a piston nut removal wrench. (Dimensions are called off at beginning of this procedure. This tool may also be ordered through your local DOOSAN Parts distributor). Remove nut from end of piston.

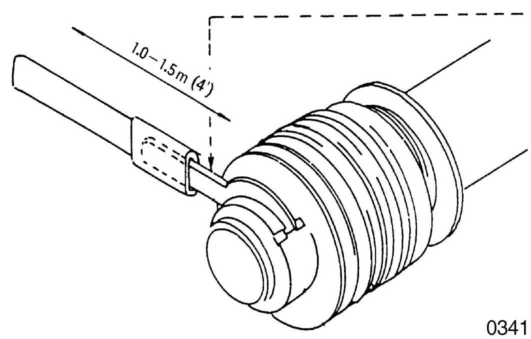


Figure 26

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.

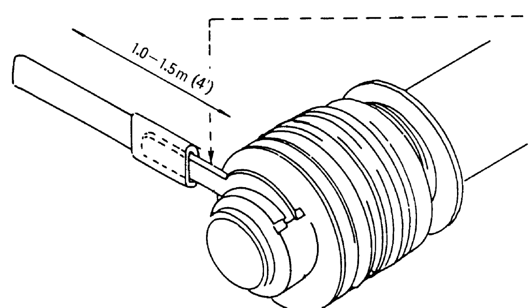


Figure 27

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.

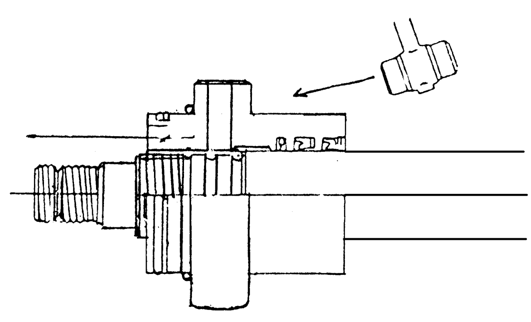


Figure 28

12. Use a dull, rounded tip tool to pry off O-ring (13) and backup ring (14).

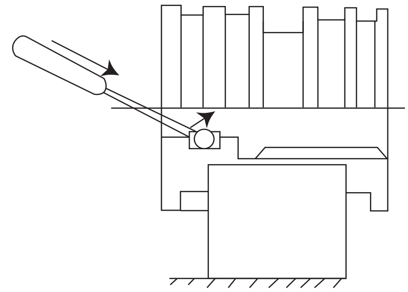


Figure 29

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).

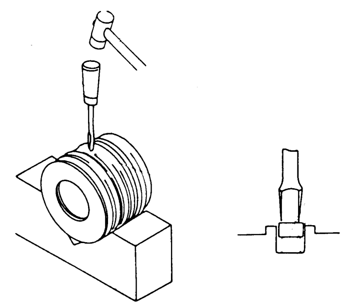


Figure 30

14. Remove O-ring (21) and backup ring (22) from cylinder head.

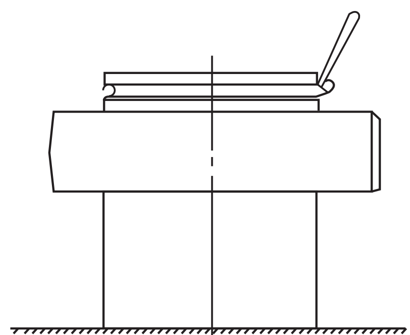


Figure 31

15. During disassembly of cylinder head, be careful not to damage buffer seal (8) and U-packing (9).

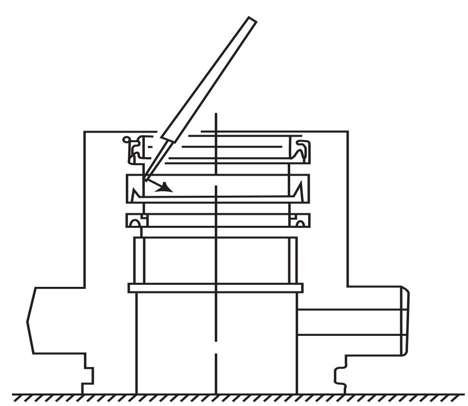


Figure 32

16. Disassemble retaining ring (12) and dust wiper (11). Separate retaining ring (7) and rod bushing (6).

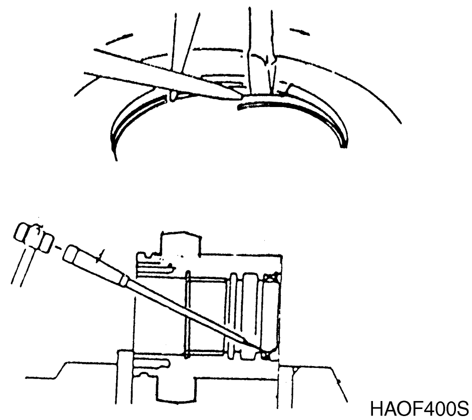


Figure 33

17. Force out pin bushing (2), (4) from body of cylinder.

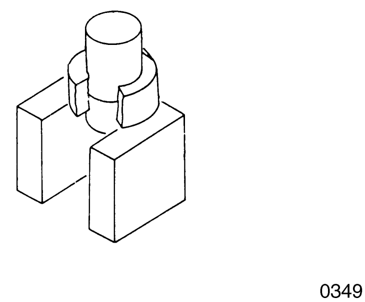


Figure 34

REASSEMBLY

IMPORTANT

Before reassembly:

- **Inspect and replace damaged or excessively worn parts.**
- **Clean parts and lubricate with clean hydraulic oil.**
- **Make sure work area is clean.**

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 must 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.

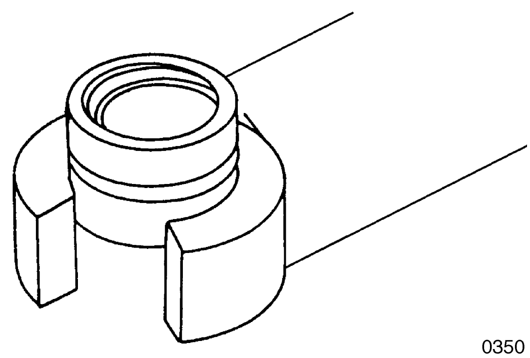

0350

Figure 35

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).

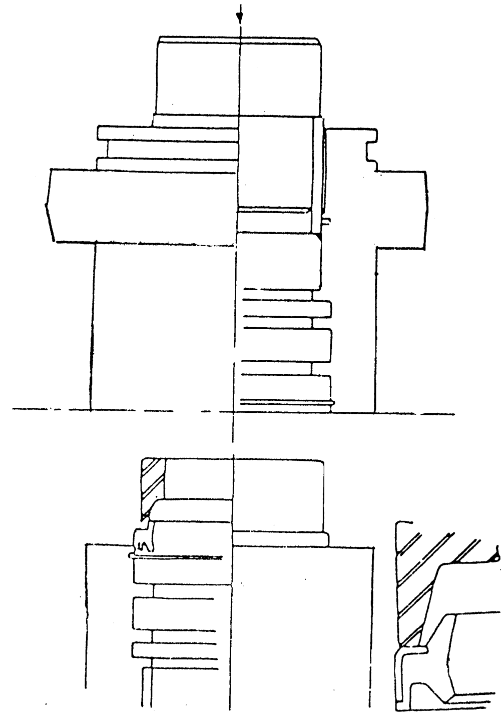


Figure 36

3. Prelubricate O-rings and seals before reassembly (Figure 37).

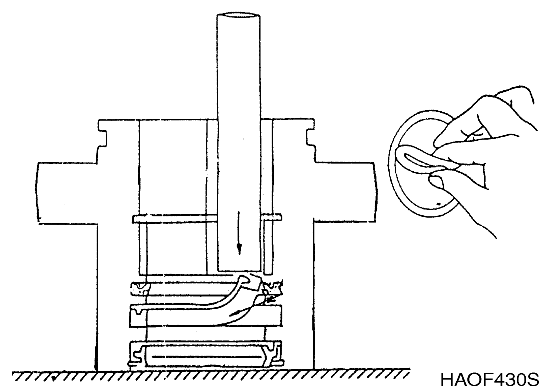


Figure 37

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.

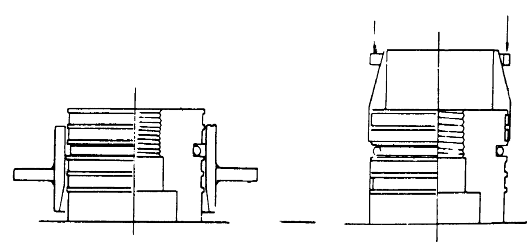


Figure 38

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).

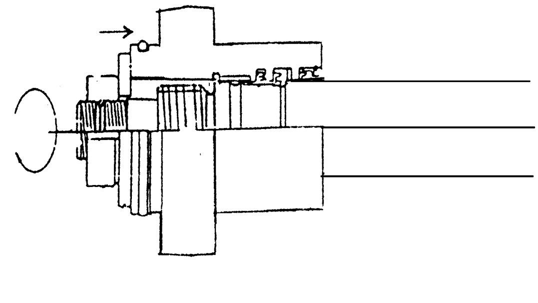


Figure 39

6. Assemble cushion ring (16) and attach piston assembly to piston rod.

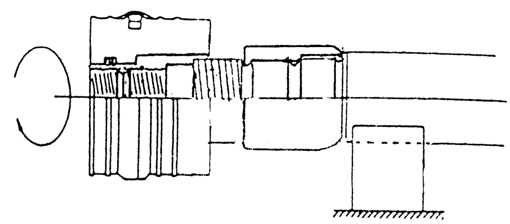


Figure 40

7. Use specially fabricate or factory sourced tool to tighten piston nut (23).

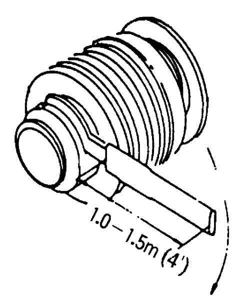


Figure 41

8. Assemble wear ring (19), slide ring (20) and set screw (24) to piston assembly.

Reference Number	Description
1	Set Screw

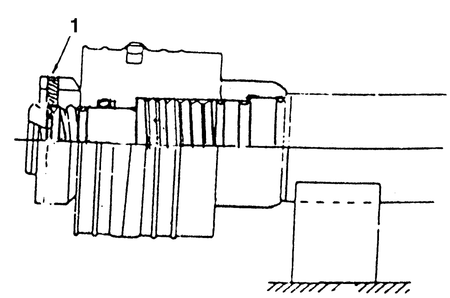


Figure 42

9. Immobilize body of cylinder before reassembly.

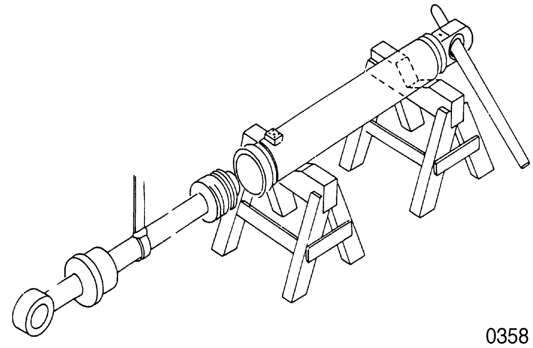


Figure 43

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.

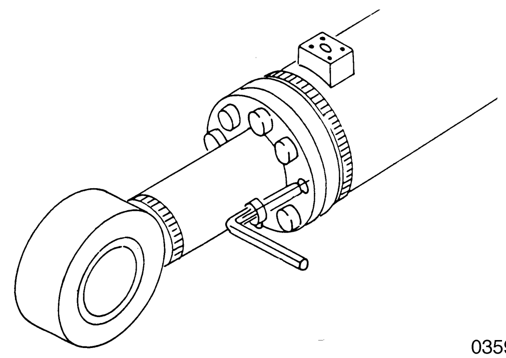


Figure 44

TROUBLESHOOTING

Problem	Possible Cause	Remedy
Oil leaking between cylinder head and piston rod.	Foreign material in U-packing.	Remove foreign material.
	Scratches in U-packing.	Replace U-packing.
	Damage to U-packing.	Replace U-packing.
	Foreign material in dust wiper.	Remove foreign material.
	Scratches to dust wiper.	Replace dust wiper.
	Damage to dust wiper.	Replace dust wiper.
	Foreign material in seal O-ring.	Remove foreign material.
	Scratches in O-ring.	Replace O-ring.
	Damage to O-ring.	Replace O-ring.
	Scratches on sealing surface of piston rod.	If scratches are not deep, hone with an oil stone and lubricate. If scratches are deep, replace piston rod.
	Deep scratches on inner surface of bushing.	Replace bushing.
Oil leaking between cylinder head and cylinder tube.	Damage to O-rings.	Replace O-rings.
Oil leaking from welded area of cylinder tube.	Damage to welded area.	Replace cylinder tube.
Oil leaking between cylinder head and piston rod.	Foreign material in U-packing.	Remove foreign material.
	Scratches in U-packing.	Replace U-packing.
	Damage to U-packing.	Replace U-packing.
	Foreign material in dust wiper.	Remove foreign material.
	Scratches in dust wiper.	Replace dust wiper.
	Damage to dust wiper.	Replace dust wiper.
	Foreign material in O-ring.	Remove foreign material.
	Scratches in O-ring.	Replace O-ring.
	Damage to O-ring.	Replace O-ring.
	Scratch on sealing surface of piston rod.	If scratches are not deep, hone with an oil stone and lubricate. If scratches are deep, replace piston rod.
	Deep scratches on inner surface of bushing.	Replace bushing
Oil leaking between cylinder head and cylinder tube.	Damage to O-rings.	Replace O-rings.
Oil leaking from welded area of cylinder tube.	Damage to welded area.	Replace cylinder tube.
Cylinder drops from pull of gravity.	Light scratches on sealing surface of cylinder tube.	Hone out scratches with oil stone.
	Deep scratches on sealing surface of cylinder tube.	Replace cylinder tube.
	Deep scratches on sealing surface of piston O-rings.	Replace O-rings.
	Foreign material in U-packing.	Remove foreign material.

Problem	Possible Cause	Remedy
Cylinder drops from pull of gravity.	Scratches in U-packing.	Replace U-packing.
	Damage to U-packing.	Replace U-packing.
	Wear rings twisted.	Replace wear rings.
	Wear rings scratched.	Replace wear rings.
	Wear rings have other damage.	Replace wear rings.
Slow bucket and boom movements.	Reduced oil flow due to dirty filter or dirty intake line.	Disassemble and clean parts.
	Air drawn into circuit through loose connections.	Tighten intake connections.
	Reservoir oil level too low.	Fill reservoir to correct level.
	Relief valve pressure setting incorrect.	Adjust relief valve pressure.
	Damaged pump shaft or pump drive sleeve.	Replace damaged parts.
	Pump worn or damaged internally.	Replace worn or damaged parts.
	Relief valve sticking.	Disassemble and inspect cartridge. Clean or replace cartridge.
	Air in pressure line.	Perform cylinder bleeding procedure to remove air. Tighten or replace pressure line.
	Damaged pipe or hose.	Replace pipe or hose.
	Worn cylinder seals.	Replace worn parts.
Low-pressure, shown by weak upward movement of boom and bucket.	Reduced oil flow due to dirty filter or dirty intake line.	Disassemble and clean parts.
	Reservoir oil level too low.	Fill reservoir to correct level.
	Relief valve pressure setting incorrect.	Adjust relief valve pressure.
	Pump worn or damaged internally.	Replace worn or damaged parts.
	Relief valve sticking.	Disassemble and inspect cartridge. Clean or replace cartridge.
	Worn cylinder seals.	Replace worn parts.
	Low pump output due to dirty discharge pipes.	Remove and clean pump discharge pipes.
	Relief valve spring is weak. Relief valve poppet worn.	Replace worn parts.
Cylinder drops when control valve is in neutral	Worn plunger in control valve.	Replace plunger.
	Stuck overload relief valve due to worn seat surface.	Replace worn parts.
	Loose pipes or joints.	Tighten parts.
	Worn piston seal on hydraulic cylinder.	Replace piston seal.
Vibration or excessive noise.	Excessive resistance in pump intake line.	Inspect intake line and clean or replace as necessary.
	Air being drawn into intake line.	Inspect pipe joints and tighten.
	Chattering relief valve.	Change oil, replace valve.
Air bubbles in oil.	Wrong type of operating oil.	Drain and fill with proper type of oil.
	Oil level too low.	Raise to proper level.
	Air trapped in system	Perform cylinder bleeding procedure to remove air.
Frequent rubber hose damage.	System pressure too high.	Adjust relief valve pressure.
	Hoses breaking due to contact with another machine parts.	Restrain hoses to prevent contact.

Hydraulic System

Hydraulic System

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Hydraulic System

GENERAL

General Description

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 Schematic Shop Manual".

General Description

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 drive pump and an idle pump) make up the main pump assembly.
- Hydraulic output from the drive pump is transmitted to the right side of the control valve. Output from the idle 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 drive pump in the pump assembly, operates valve spools for right travel, grapple, boom 1 and arm 2 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, supplied by the idle pump in the pump, has control spools for left travel, heel, swing, boom 2 and arm 1 operation.
- 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 (stick) "IN" and "OUT" 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 must 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).

- Boom, Arm, and Heel cylinder circuit are also protected by overload relief valves. Whenever high-pressure is generated because of a shock or overload, excess pressure is dumped to the reservoir return circuit through the relief valve.

HYDRAULIC COMPONENT AND OIL FLOW

Hydraulic Components

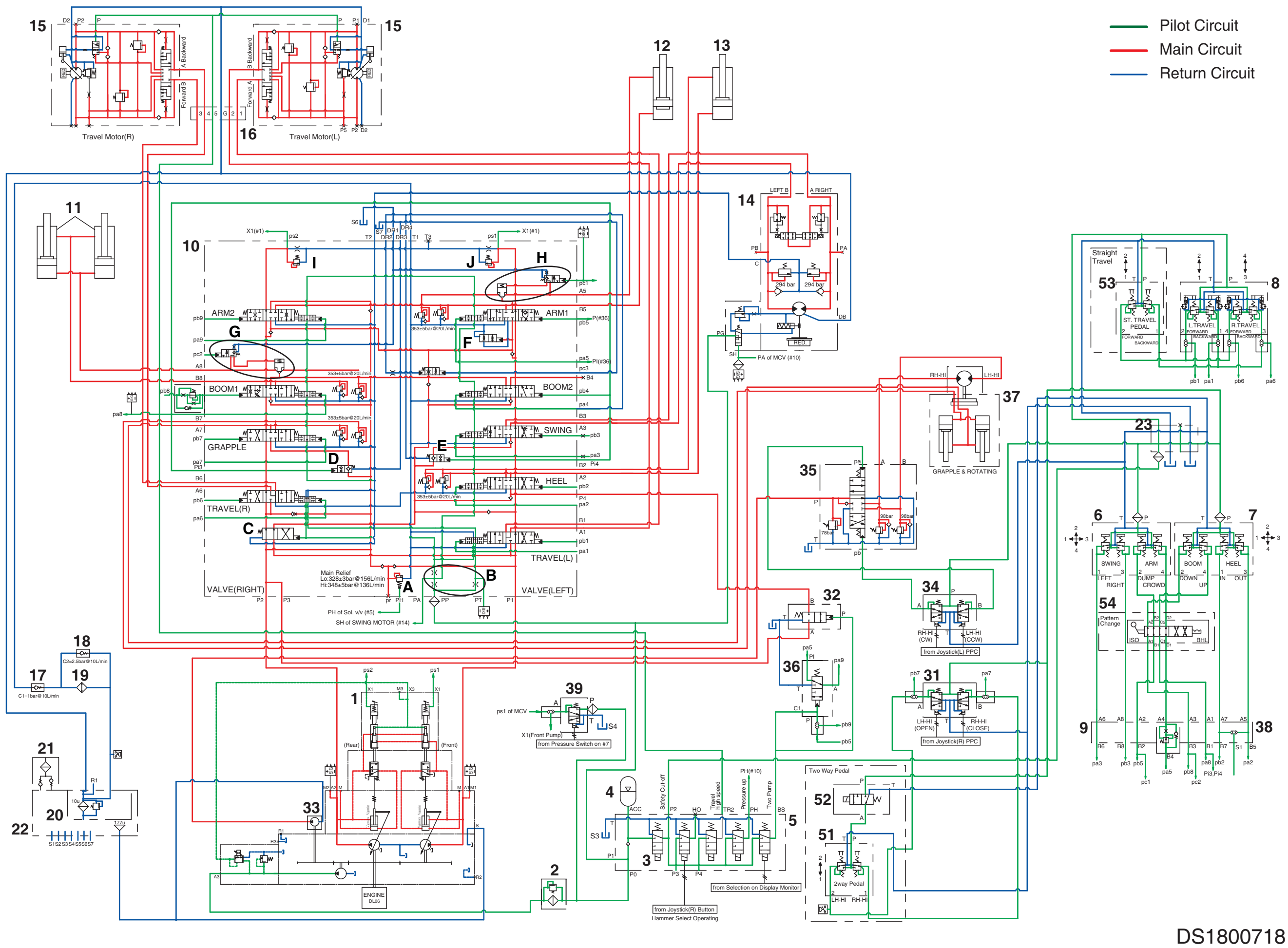


Figure 1

Reference Number	Description
1	Main Pump
2	Pilot Filter
3	Solenoid Valve (Cut OFF)
4	Accumulator
5	Solenoid Valve (Package)
6	Joystick Valve (L)
7	Joystick Valve (R)
8	Travel Pedal Valve
9	Pilot Joint Bracket
10	Main Control Valve
11	Hoist Cylinder (Boom)
12	Stick Cylinder (Arm)
13	Heel Cylinder
14	Swing Device
15	Travel Device
16	Center Joint
17	Restriction Valve
18	Restriction Valve
19	Oil Cooler
20	Return Filter
21	Air Breather
22	Hydraulic Tank
23	PT Block

Reference Number	Description
31	EPPR Valve for Grapple
32	Two Pump Flow Valve
33	Rotating Gear Pump
34	EPPR Valve for Rotating
35	Rotating Valve
36	Shift Valve for Two Pump (Heel)
37	Rotating System & Grapple
38	Shuttle Valve for Heel Alarm
39	EPPR Valve for 1 or 2 Way
51	Two Way Pedal Valve
52	Two Way Pedal Safety Valve
53	Straight Travel Pedal Valve
54	Pattern Change Valve
A	Main Relief Valve
B	Orifice
C	Travel Straight Valve
D	Boom Priority Valve
E	Boom Priority Valve
F	Arm Regeneration Valve
G	Boom Holding Valve
H	Arm Holding Valve
I	Foot Relief Valve
J	Foot Relief Valve

SAFETY CUTOFF VALVE OPERATION

Oil from the hydraulic tank (22) fills accumulator (4) first after passing through pilot pump and pilot filter (2) and is supplied to the solenoid package valve (5).

If an electric signal is inputted to safety cutoff valve (3) installed to the solenoid package valve (5), the oil sent to main control valve (10), pedal valve (8) and joystick valve (6, 7) is returned to hydraulic tank installed to inside of pilot pump through relief valve.

Once safety cutoff valve (3) is operated, any operation of machine is switched to safety mode and actuator will not operate even if joystick lever is moved.

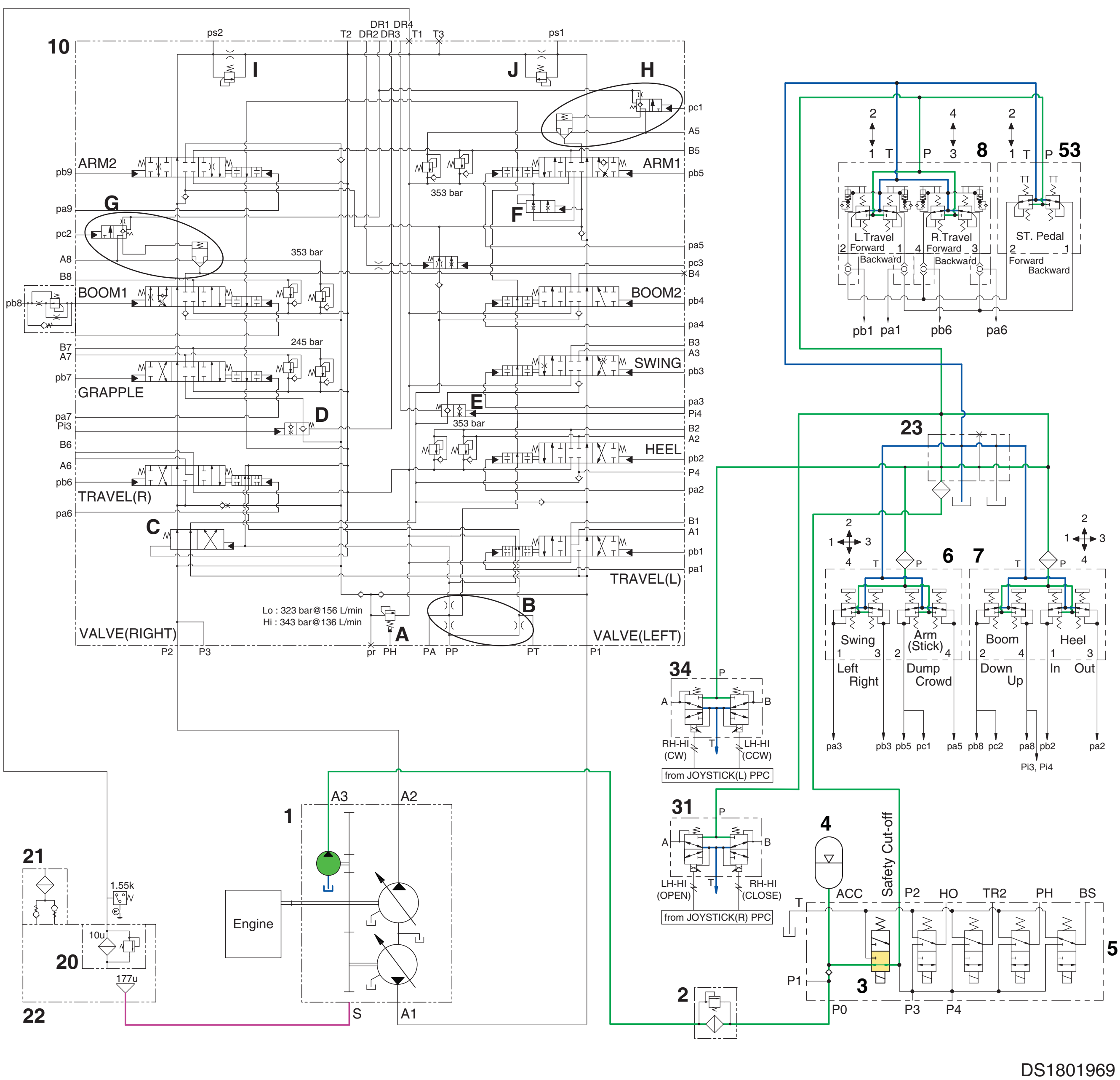


Figure 2

POWER UP VALVE OPERATION

Oil from the hydraulic tank (22) fills accumulator (4) first after passing through pilot pump and pilot filter (2) and is supplied to the solenoid package valve (5).

Pilot oil that passes through safety cutoff valve (3) of solenoid package valve (5) inside is supplied to main relief valve (A) "PH" port of main control valve (10) the following the signal of power up valve.

Once the oil is supplied to "PH" port of main control valve (10), the setting pressure of main relief valve is changed from 323 to 343 bar, increasing power of actuator.

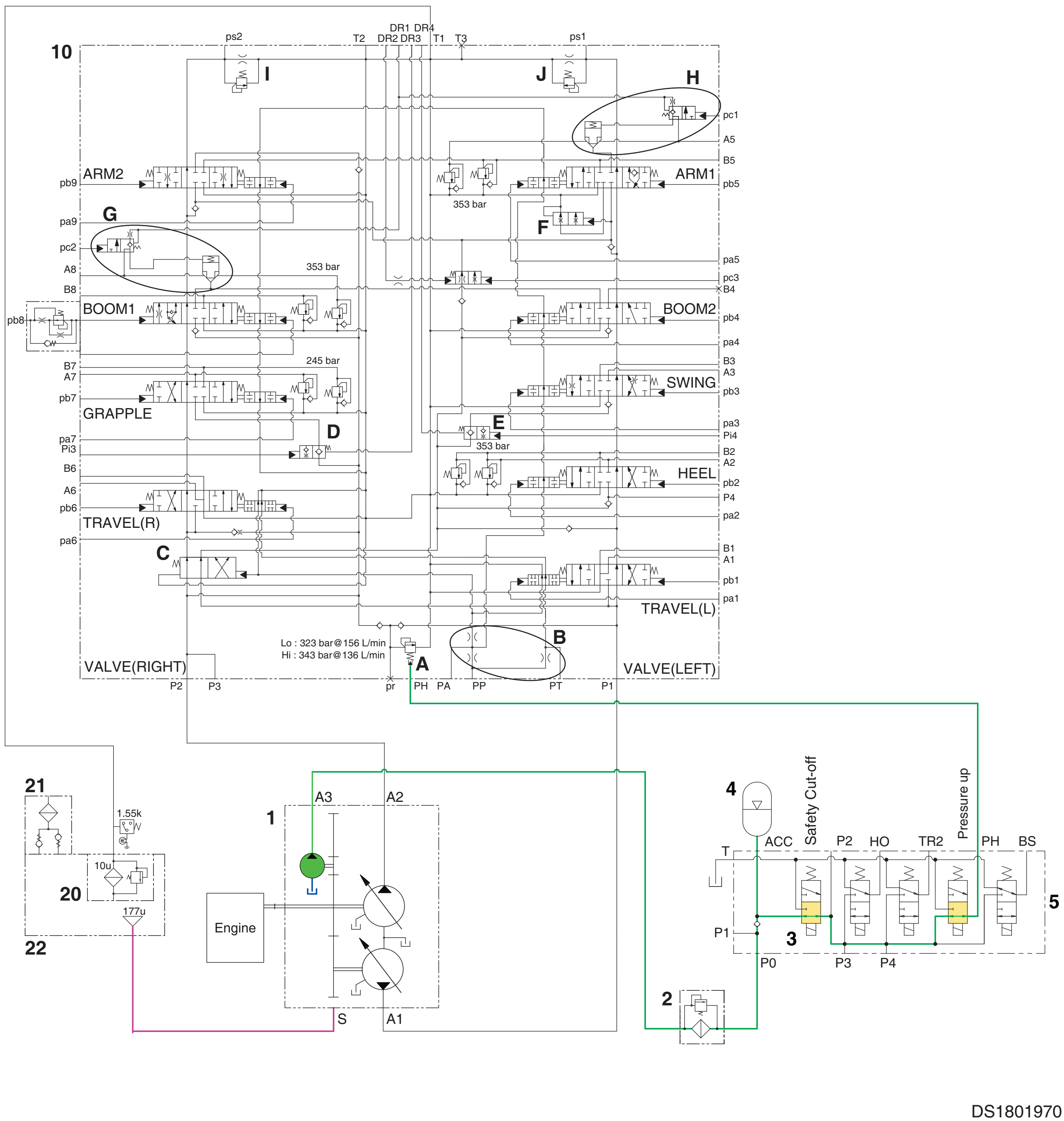


Figure 3

If pressure is applied to the pilot port "PH", piston "H" moves to pilot poppet.

As a result, spring force of pilot poppet will increase, causing setting pressure increase of "HP" (From 323 to 343 bar).

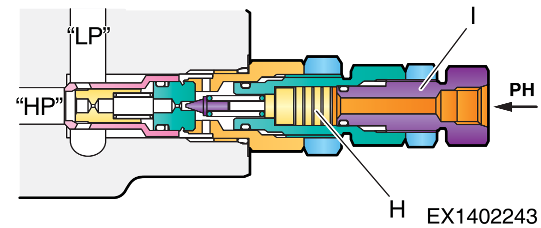


Figure 4

TRAVEL HIGH-SPEED VALVE OPERATION

Oil from the hydraulic tank (22) fills accumulator (4) first after passing through pilot pump and pilot filter (2) and is supplied to the solenoid package valve (5). Oil that passed through safety cutoff valve (3) of solenoid package valve (5) inside is supplied to travel motor's (15) "Pi" port the following the operation signal of travel high-speed valve, causing high-speed transfer spool (1501) to move. Oil from main pump (1) passes through oil passage of high-speed transfer spool (1501) and drives travel motor (15) while maintaining piston in high-speed position.

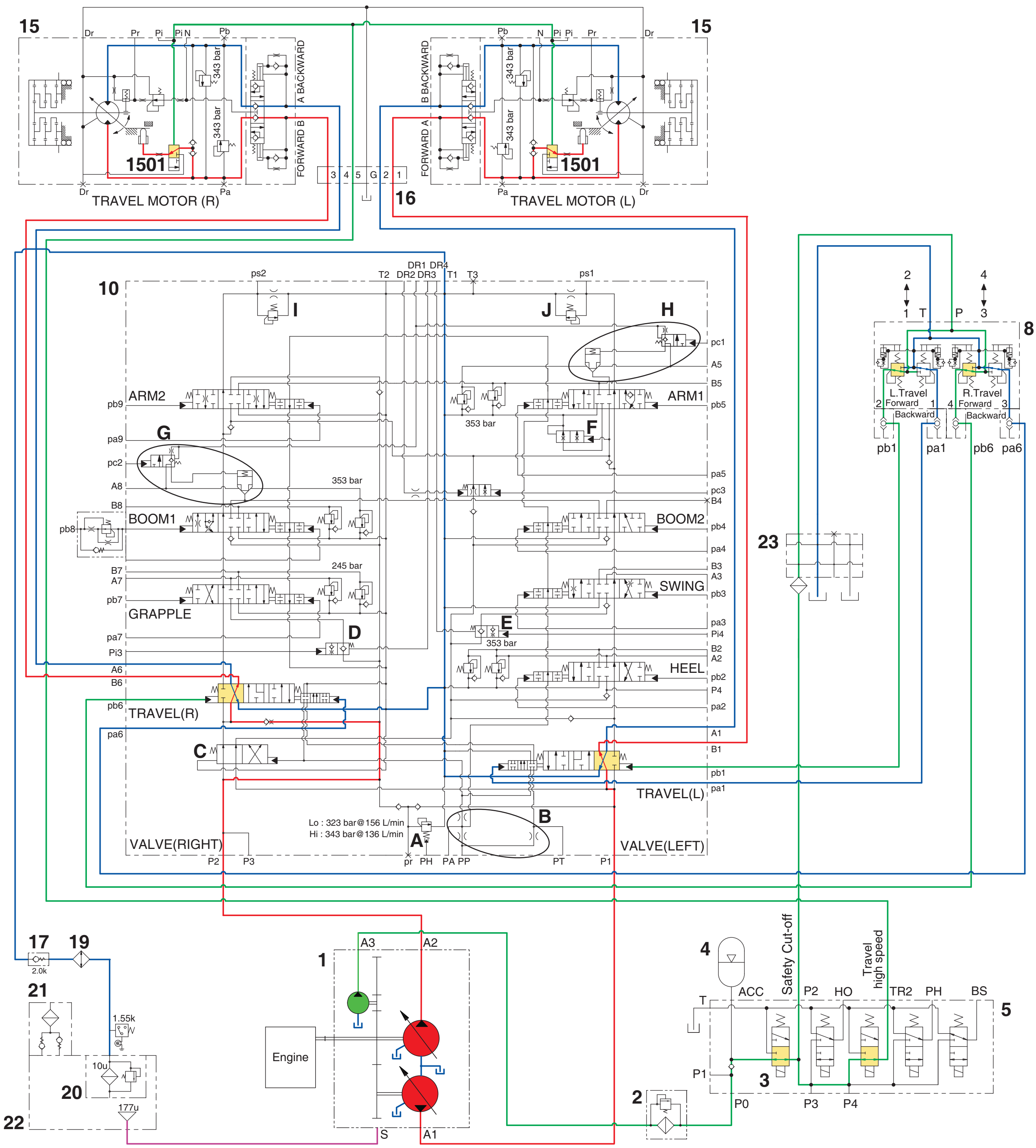


Figure 5

Operation of high-speed

This is a supporting device for swash plate (201) on which shoe slides. It has a hemispherical pivot ball (504) arranged along its both ends which bears load against swash stopper.

Changing in tilting angle of this swash plate changes capacity. This device has tilting pistons (502) arranged along swash stopper section and uses tilting control valve to control inflow/outflow of working oil from / to piston chamber, and thus it can determine tilting angle (large or small) of swash plate.

1. External pilot pressure Pi = 0 kg/cm^2 (0 bar) (Large tilting)
   High pressure acting to motor from high pressure select function assembled to valve casing (303) acts to P port of tilting spool (531). This pressure becomes save pressure.
   As spool (531) assembled into tilting switching section is in tight contact with plug (571) through spring (533), high-pressure in P port gets blocked.

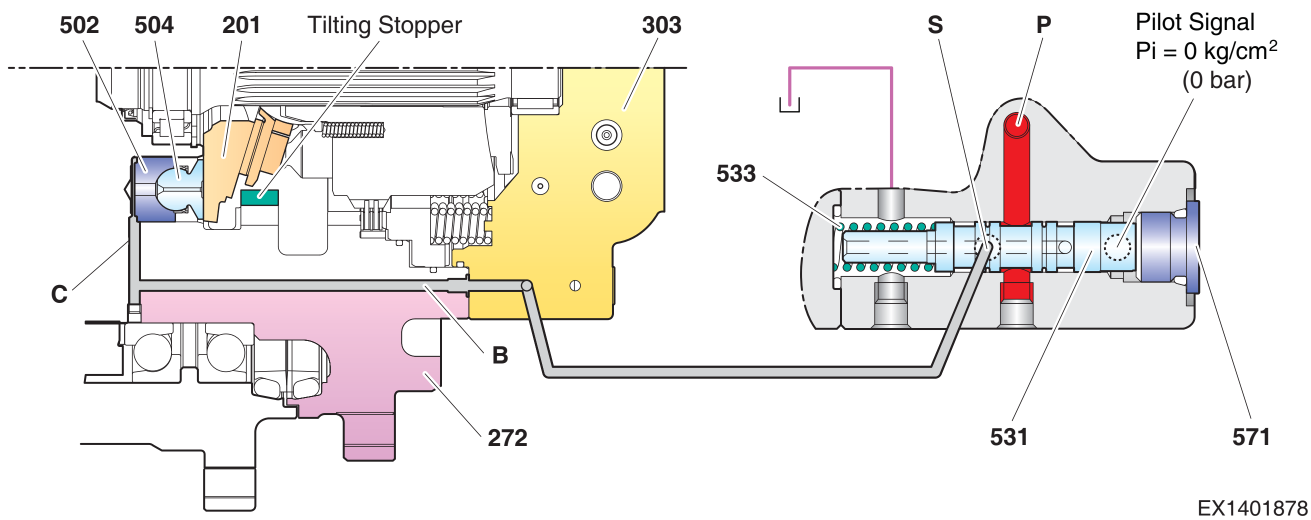


Figure 6

2. External pilot pressure Pi ≥ 20 kg/cm^2 (20 bar) (Small tilting)
   If force acting to tilting spool (531) overpowers spring (533) force, spool is switched to left direction. High pressure oil passes P port to S port of tilting spool, path B, then acting to C chamber. The tilting piston (502) moves right through this high-pressure oil and swash plate moves right. The swash plate moves all way to position of tilting stopper of shaft casing (272) until it becomes fixed in that position.

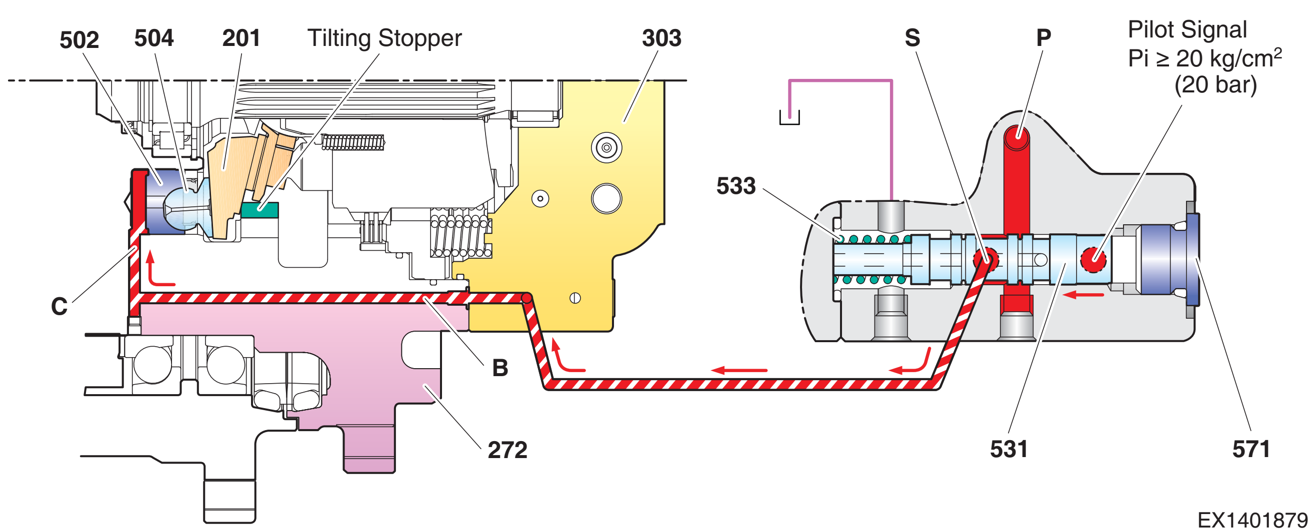


Figure 7

SWING BRAKE RELEASE OPERATION

Oil from the hydraulic tank (22) fills accumulator (4) first after passing through pilot pump and pilot filter (2) and is supplied to the solenoid package valve (5).
Oil that passed through safety cutoff valve (3) of solenoid package valve (5) inside moves swing spool of main control valve (10) the following the operation of joystick valve (6).
Once swing spool moves, pressure of oil supplied from solenoid package valve (5) to main control valve's (10) "PA" port increases and the oil is supplied to swing device's (14) "SH" port causing brake release spool to move. Then oil is supplied to swing device's (14) "PG" port connected to pilot pump and swing parking brake is released.

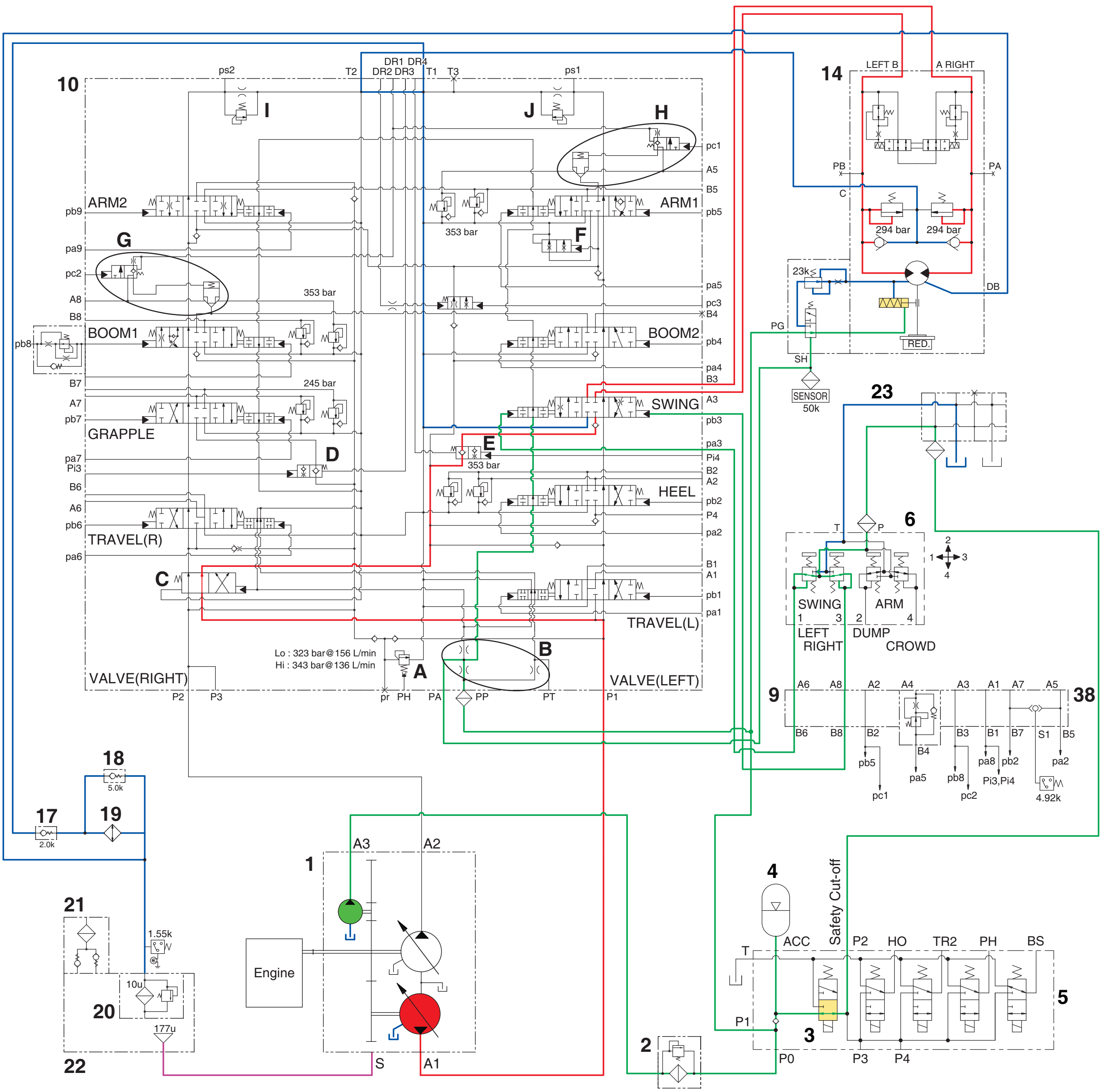


Figure 8

DS1801972

1. Parking brake operating

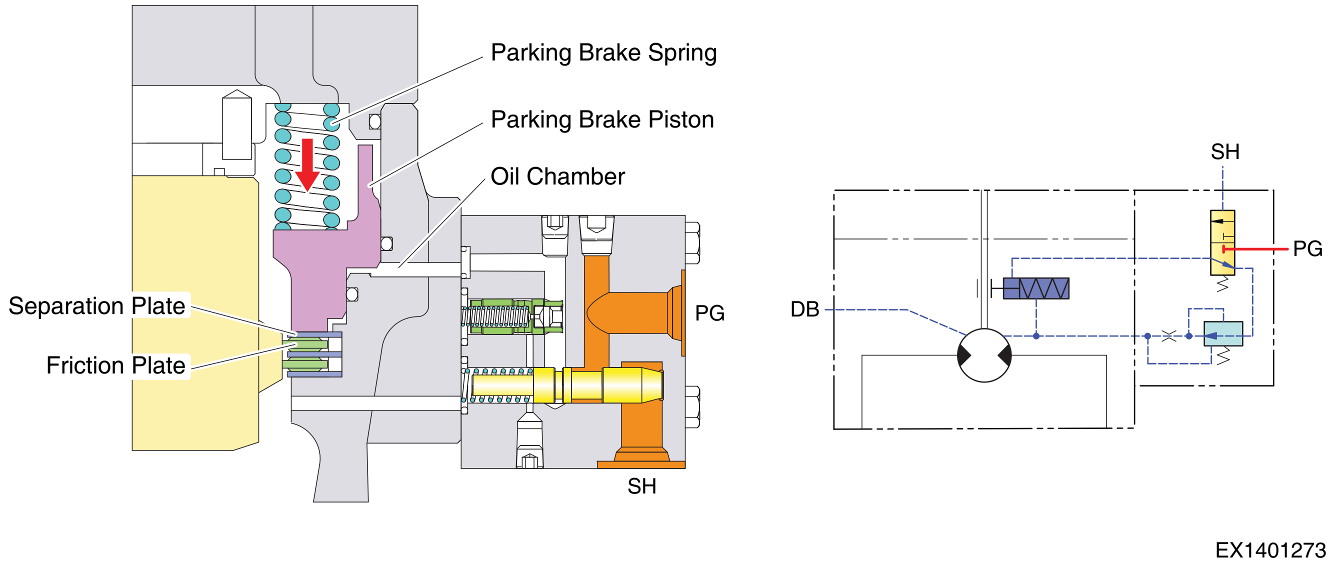


Figure 9

2. Parking brake release

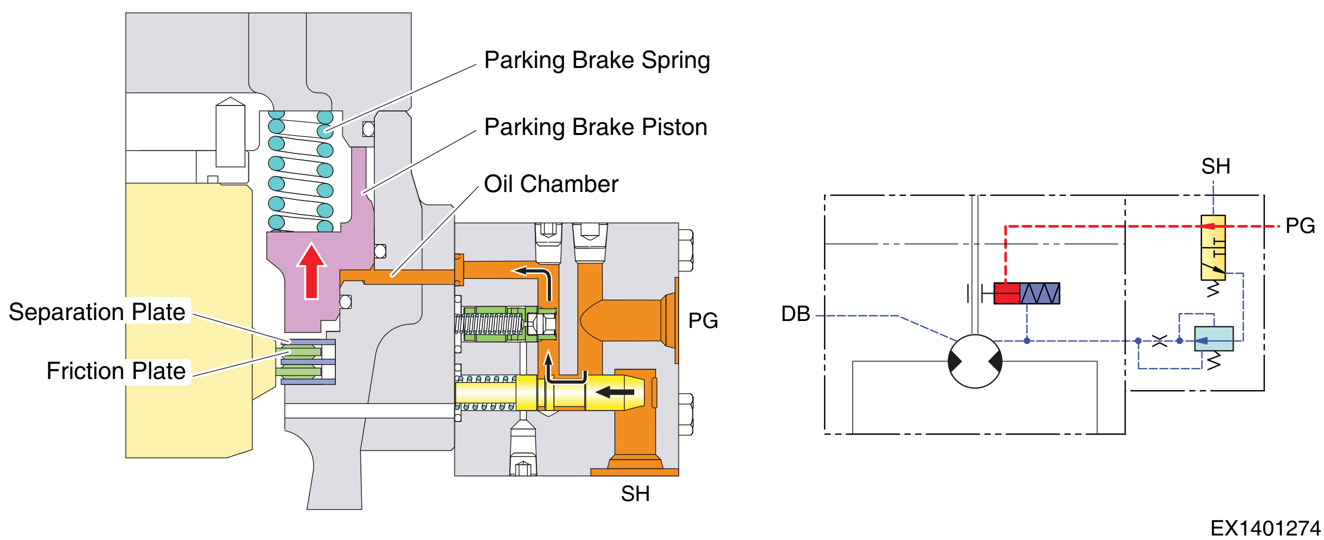


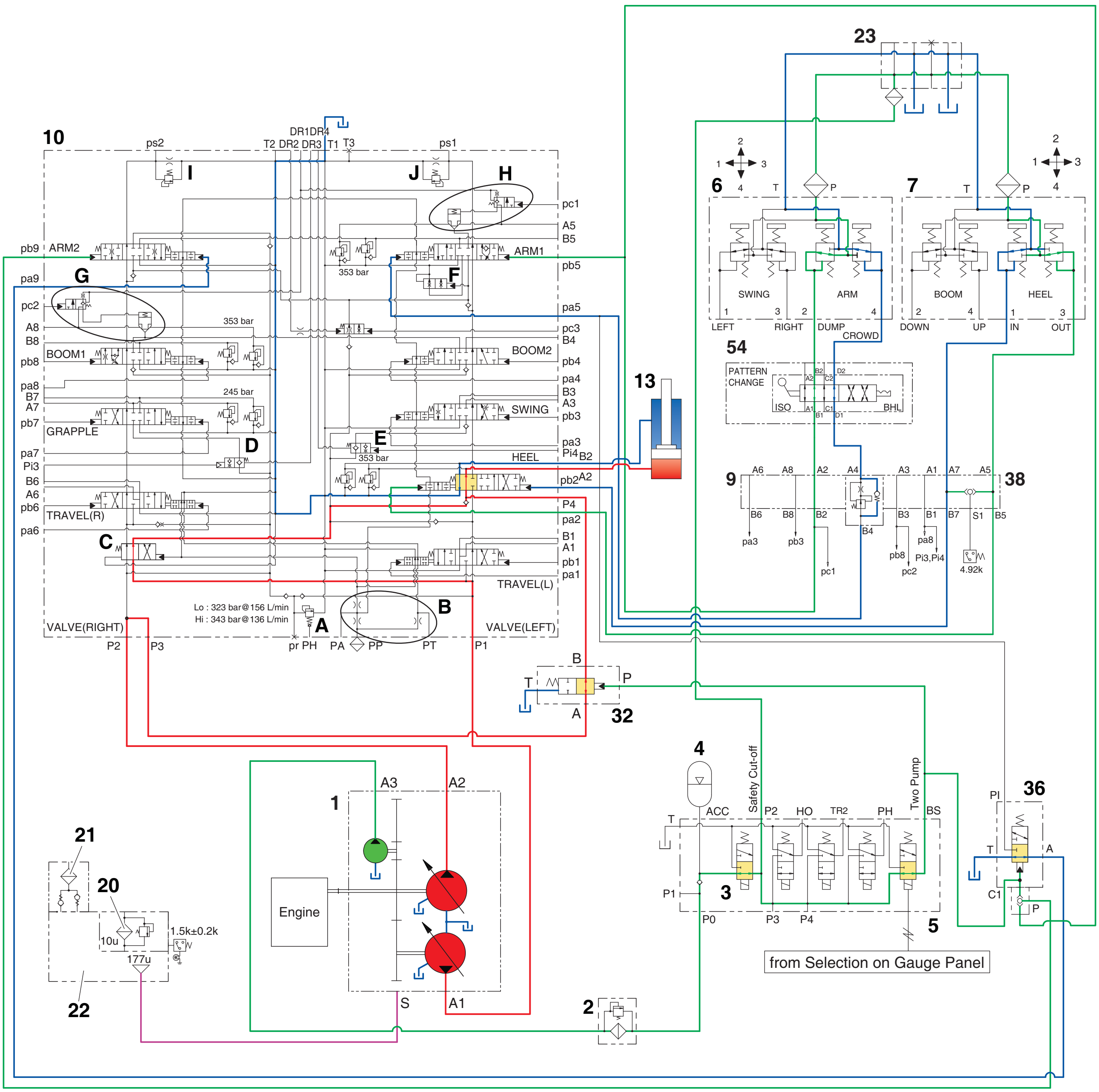
Figure 10

TWO PUMP OPERATION

When select the two pump mode on gauge panel, the two pump solenoid of the solenoid valve (5) is energized, switching its internal spool to open the port "BS".

Then, the pilot oil is applied to the two pump flow valve (32) through the port "BS" to move the internal spool.

As a result, the main pump (1) "A2" oil at the port "P3" of the main control valve (10) passes through the two pump flow valve (32) to be delivered to the port "P4" of the main control valve (10). Then, it joins the main pump (1) "A1" oil to be supplied for heel rack "IN/OUT" operation.



DS1801973

Figure 11

TRAVEL FORWARD AND BACKWARD OPERATION

When the travel levers are pushed forward or backward position, the travel spools in the main control valve (10) are moved to the forward or backward travel position by the pilot oil pressure from the pedal valve (8).
The oil from the each pump flows into the main control valve (10) and then goes to the each travel motor (15) through the center joint (16). The return oil from both travel motors (15) returns to the hydraulic oil tank (22) through the center joint (16) and the travel spools in the main control valve (10).
When this happens, the machine moves to the forward or backward.

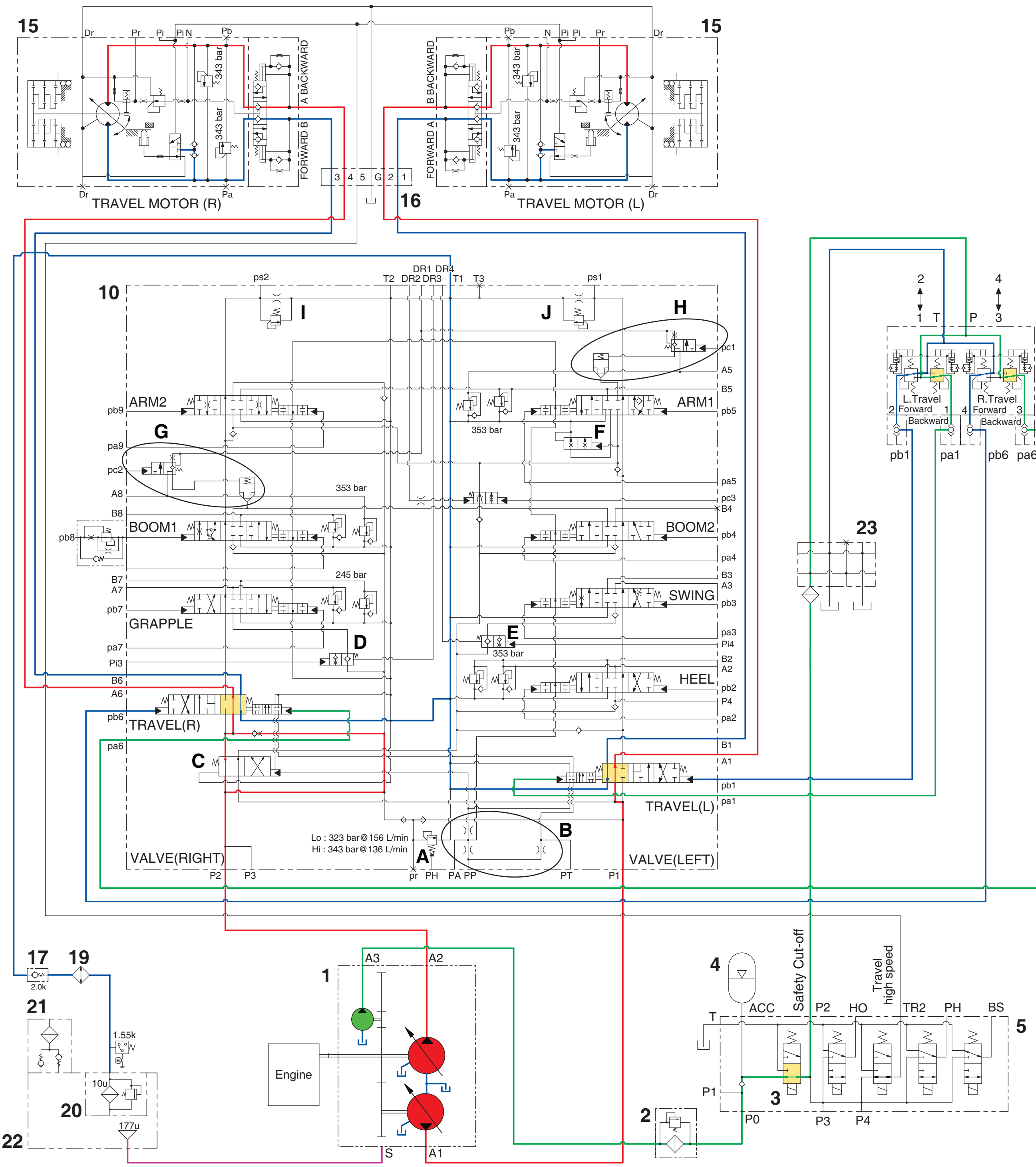


Figure 12

BOOM UP OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.
If the pilot oil is supplied to boom spool of main control valve (10) by the operation of joystick valve (7), the spool is moved and oil passage of main pump (1) and the one on the boom cylinder (11) head side open.
Oil supplied from main pump (1) is supplied to boom cylinder (11) head through boom holding valve (G), causing the moving to take place.
If boom up operation is stopped, the oil in boom cylinder is obstructed by check of boom holding valve (G) and the moving of boom is blocked.

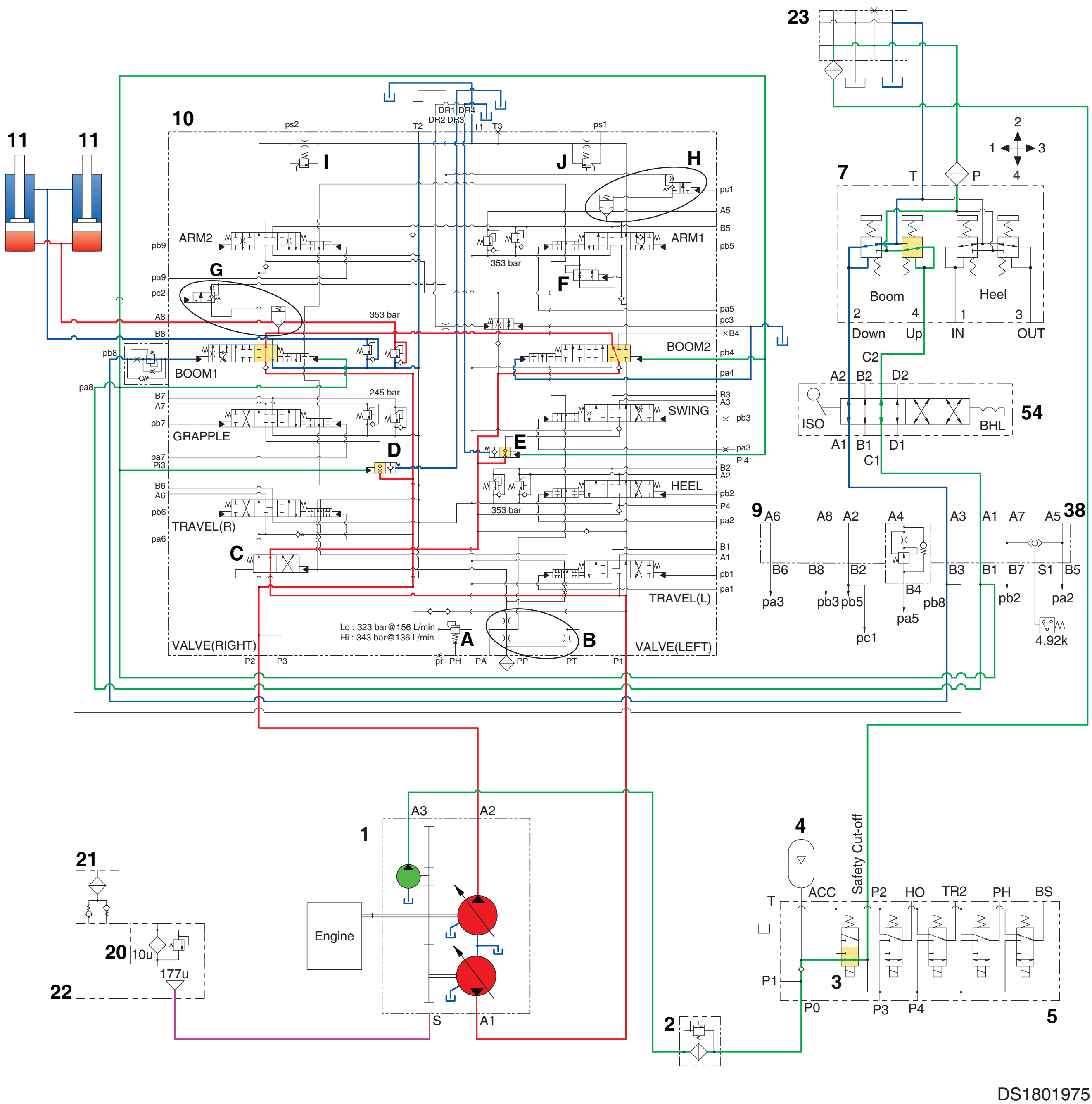


Figure 13

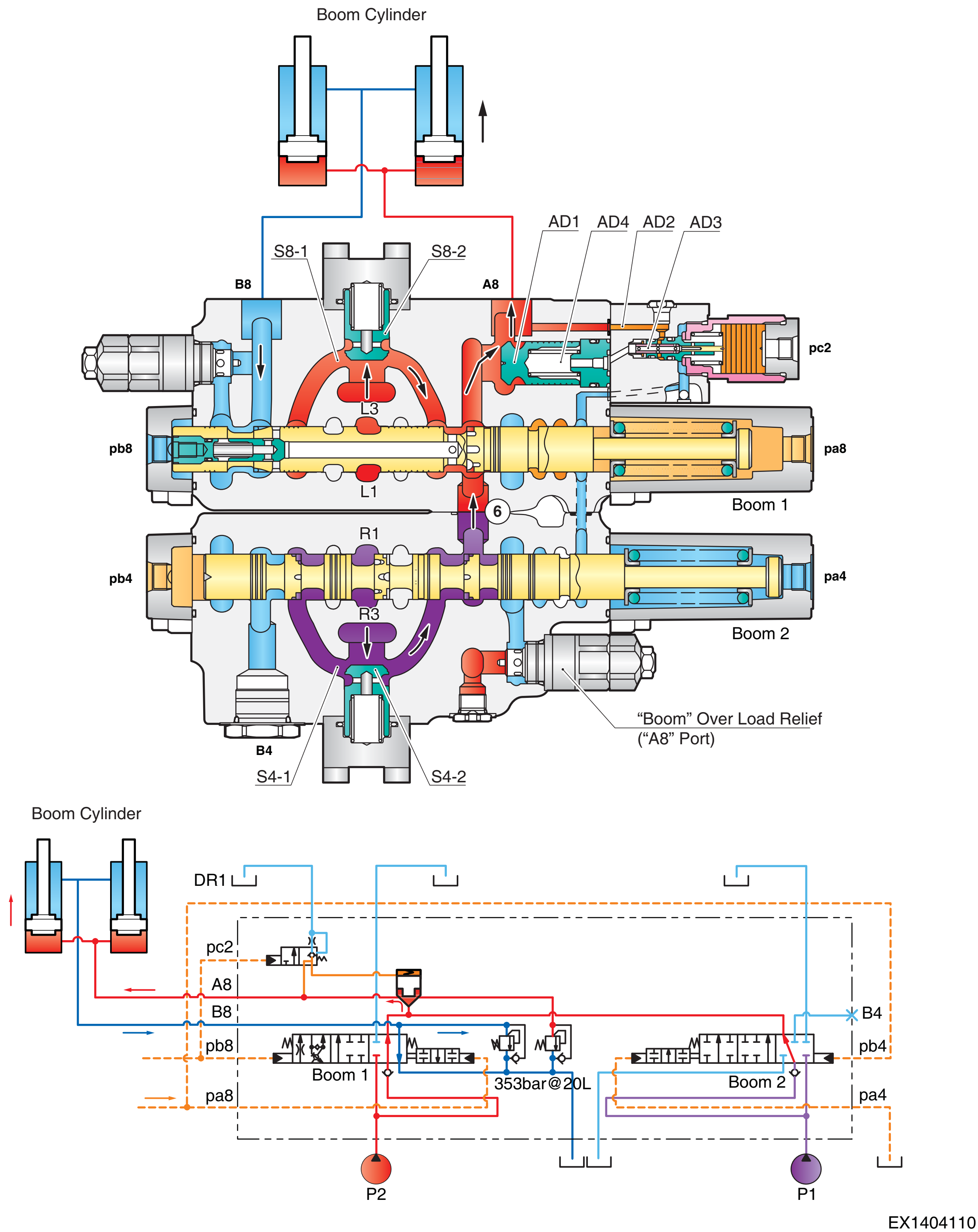

Boom Cylinder
S8-1
S8-2
AD1
AD4
AD2
AD3
B8
A8
pc2
pb8
pa8
L3
L1
6
Boom 1
R1
pb4
pa4
R3
Boom 2
"Boom" Over Load Relief
("A8" Port)
B4
S4-1
S4-2
Boom Cylinder
DR1
pc2
A8
B8
pb8
pa8
Boom 1
353bar@20L
Boom 2
B4
pb4
pa4
P2
P1
EX1404110

Figure 14

BOOM DOWN OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.

If the pilot oil is supplied to boom spool of main control valve (10) by the operation of joystick valve (7), the spool is moved and oil passage of main pump and the one on the boom cylinder (11) rod side open.

Oil passage supplied from main pump (1) is supplied to boom cylinder (11) rod side after passing through boom holding valve (G), causing the moving to take place.

Rapidly occurring boom down causes short supply of oil in the cylinder rod side, in which case the oil in cylinder head side is supplied to rod side so oil cavitation may be prevented.

If boom down operation is stopped, the oil in boom cylinder is obstructed by check of boom holding valve (G) and the moving of boom is blocked.

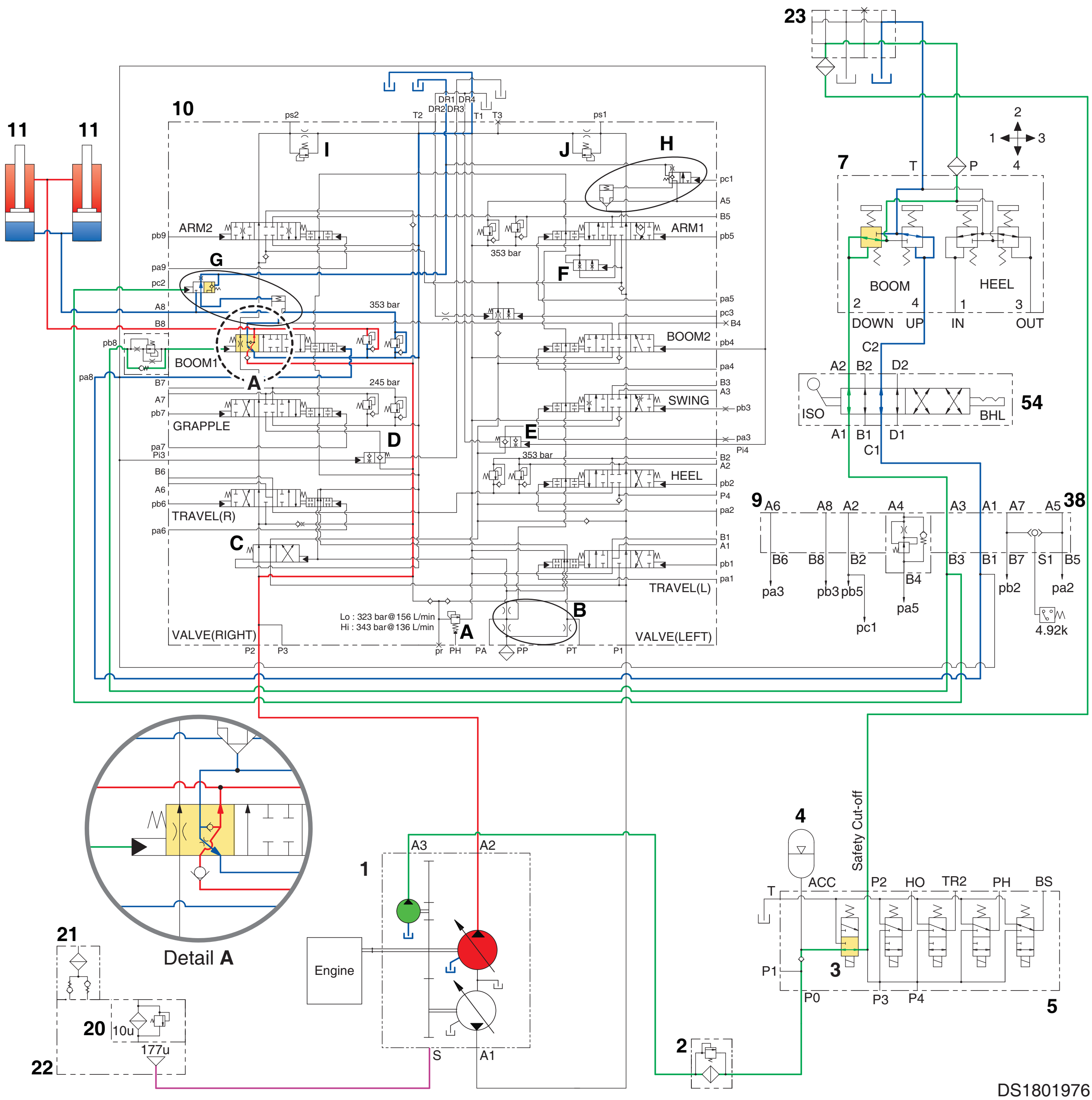


Figure 15

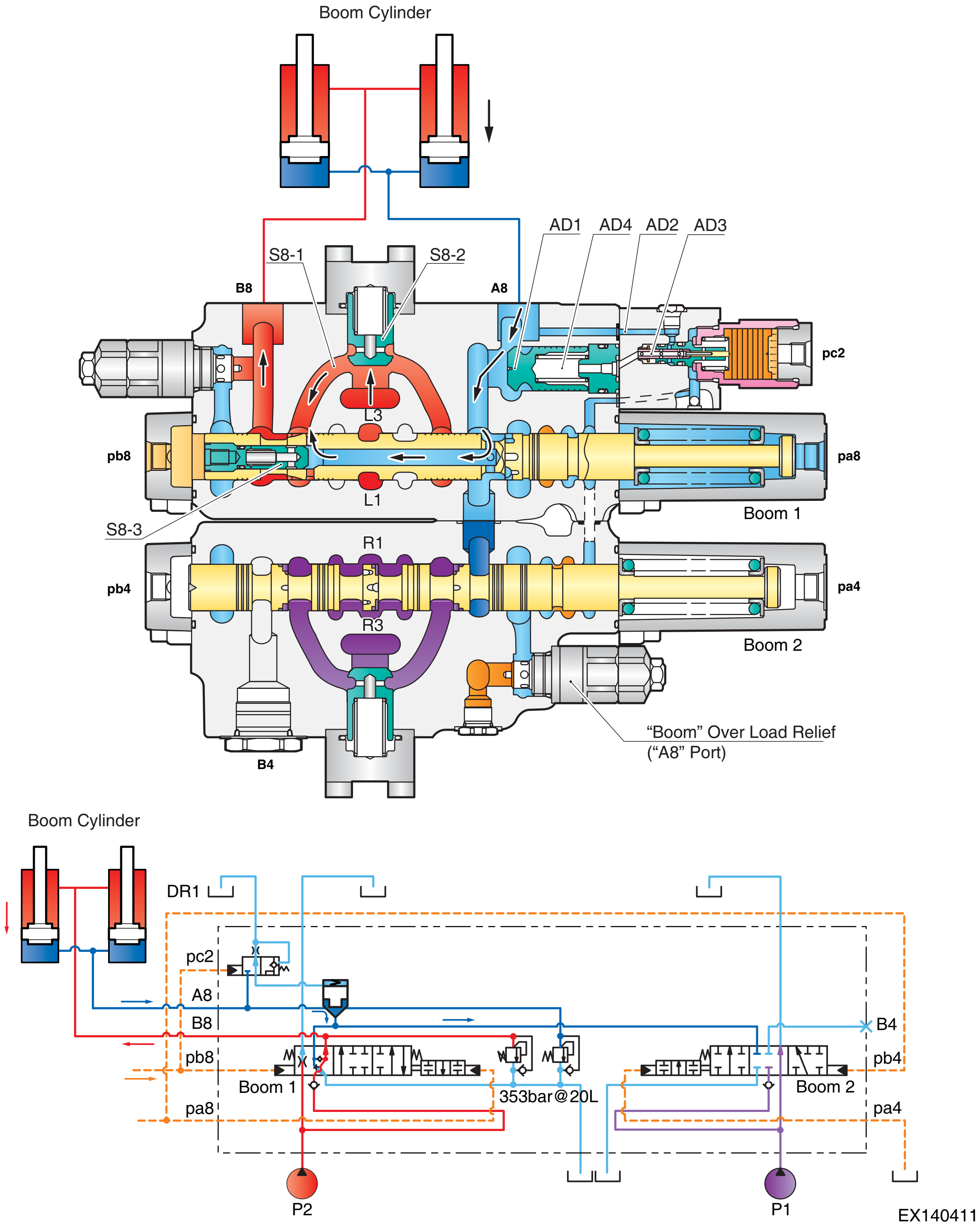

Boom Cylinder
AD1
AD4
AD2
AD3
S8-1
S8-2
B8
A8
pc2
L3
pb8
pa8
L1
S8-3
Boom 1
R1
pb4
pa4
R3
Boom 2
"Boom" Over Load Relief
("A8" Port)
B4
Boom Cylinder
DR1
pc2
A8
B8
B4
pb8
pb4
Boom 1
Boom 2
353bar@20L
pa8
pa4
P2
P1
EX1404111

Figure 16

ARM (STICK) IN OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.

If pilot oil is supplied to arm 1 and arm 2 dump spool of main control valve (10) by the operation of joystick valve (6), then spool is moved and main pump oil passage and arm cylinder rod oil passage open.

Oil supplied from drive pump and idle pump of main pump is put together and is supplied to arm cylinder (12) rod direction after passing through arm holding valve (H), causing arm moving to take place.

If arm in action is stopped, the oil in arm cylinder is obstructed by check of arm holding valve (H) and the arm moving is blocked.

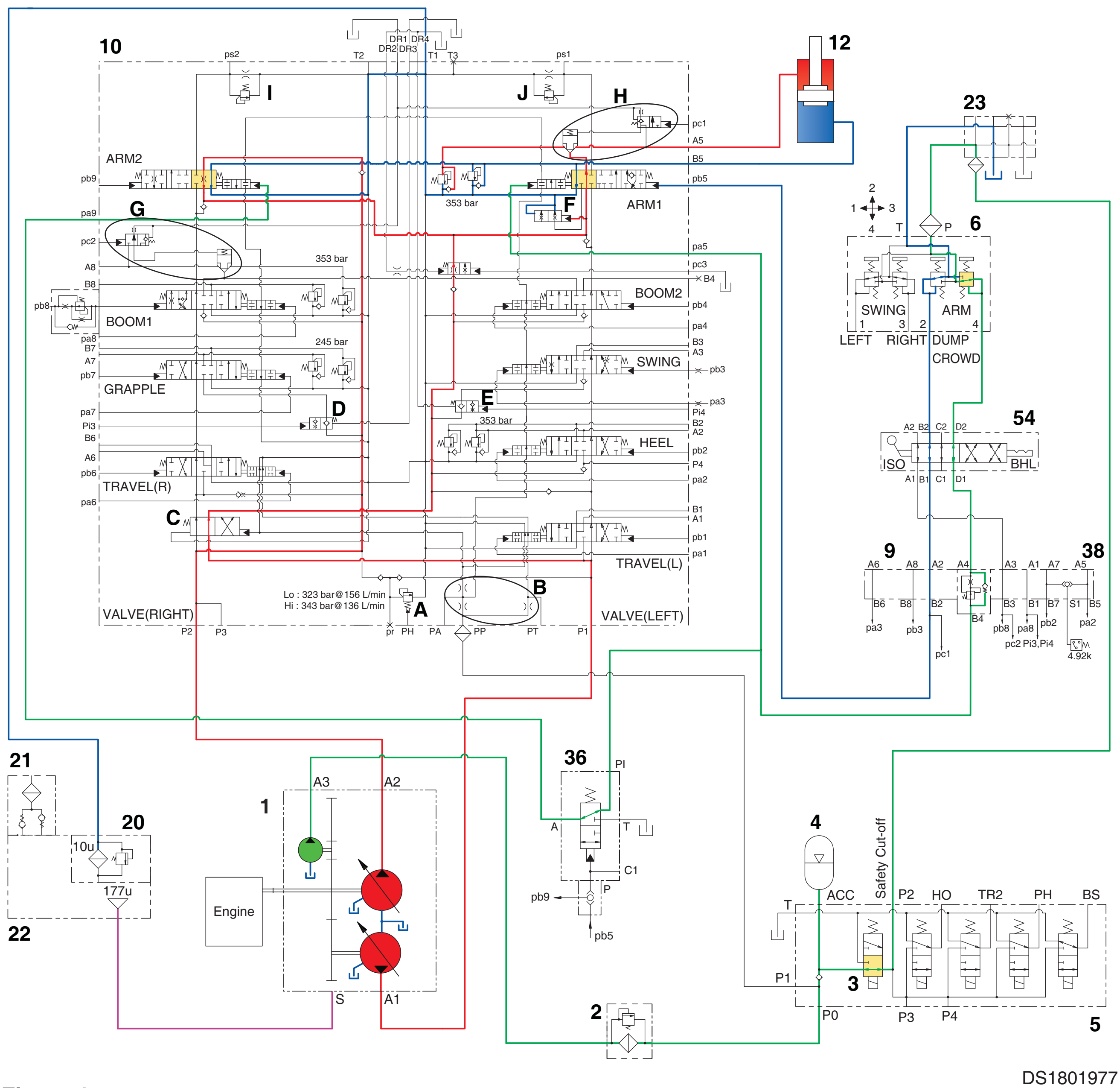


Figure 17

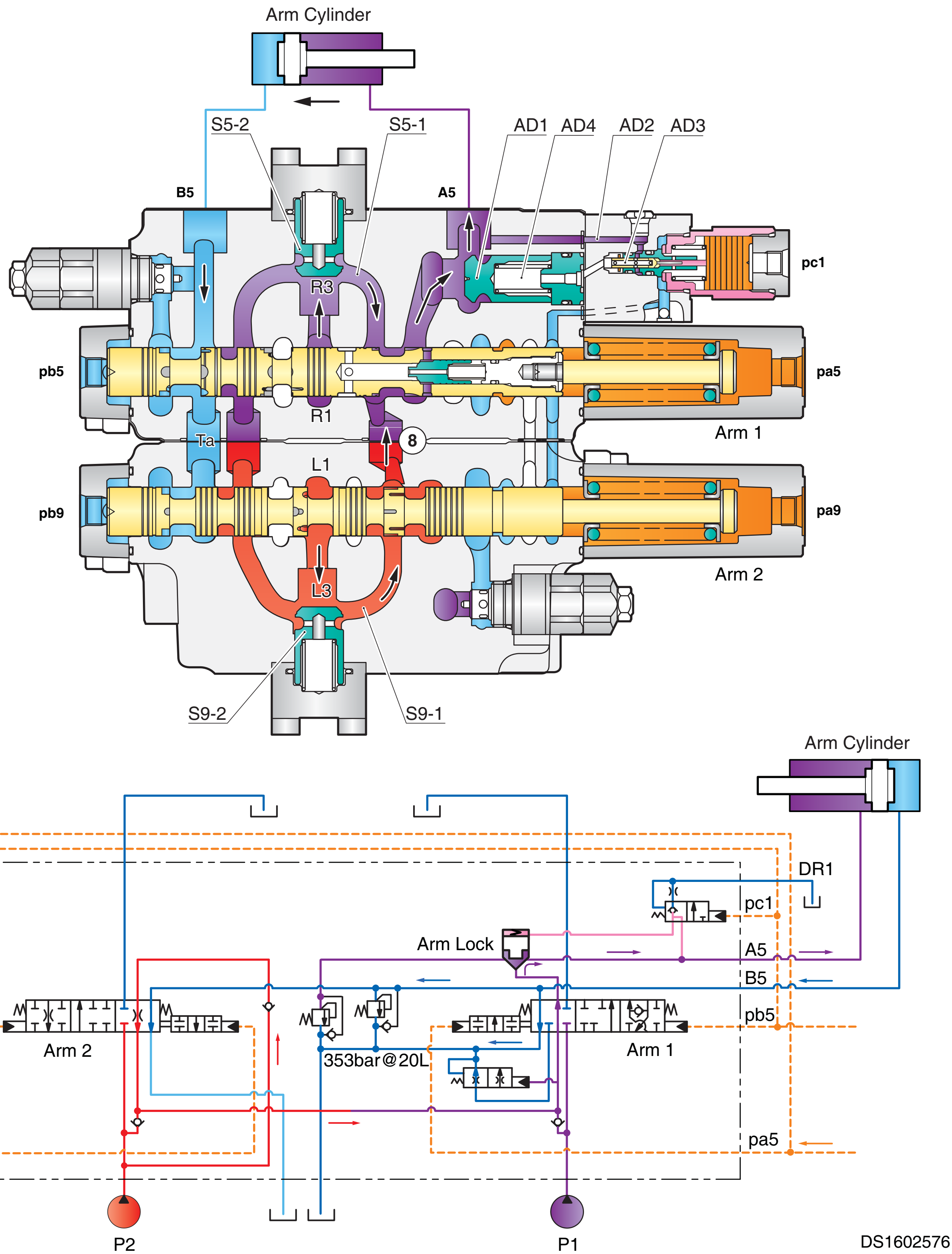
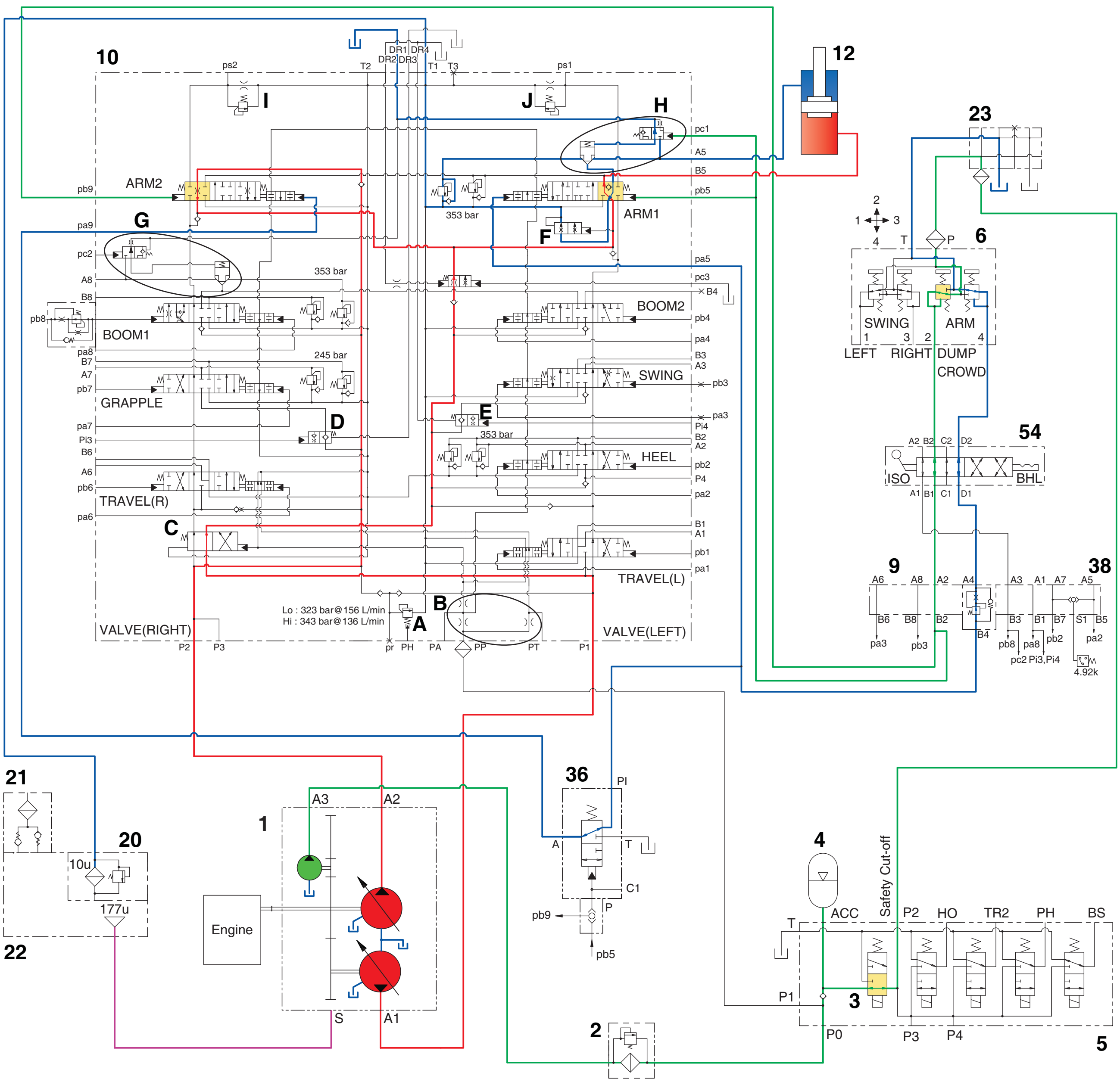

Arm Cylinder
S5-2
S5-1
AD1
AD4
AD2
AD3
B5
A5
pc1
R3
pb5
pa5
R1
Ta
8
L1
Arm 1
pb9
pa9
L3
Arm 2
S9-2
S9-1
Arm Cylinder
DR1
pc1
Arm Lock
A5
B5
pb9
pb5
Arm 2
Arm 1
353bar@20L
pa9
pa5
P2
P1
DS1602576

Figure 18

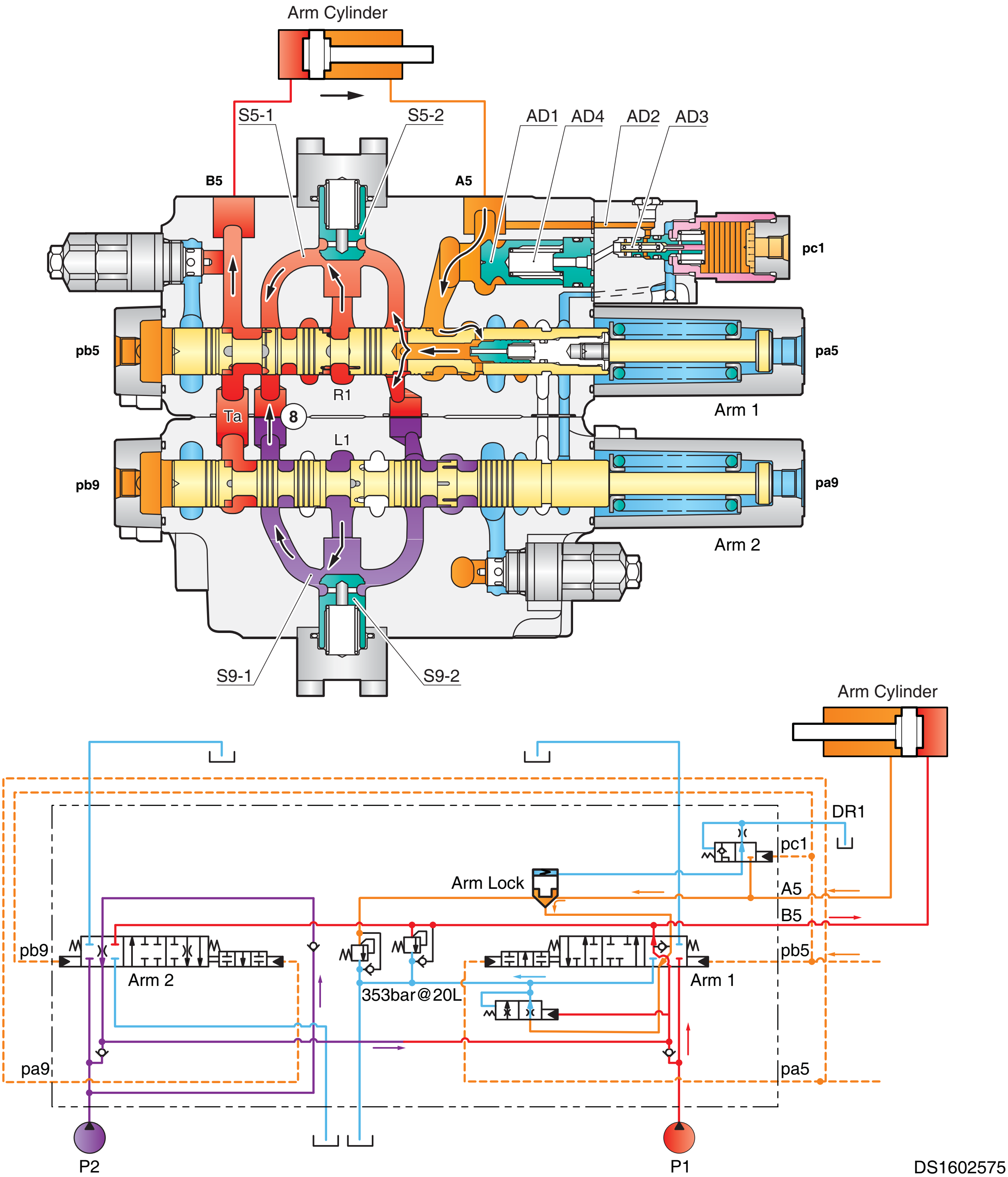
ARM (STICK) OUT OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.
If pilot oil is supplied to arm 1 and arm 2 spool of main control valve (10) by the operation of joystick valve (6), then spool is moved and main pump (1) oil passage and arm cylinder (12) head oil passage open.
Oil passage supplied from main pump (1) is supplied to arm cylinder (12) head after passing through arm holding valve (H), causing the arm moving to take place.
Rapidly occurring arm dump causes short supply of oil in the arm cylinder head, in which case the oil in arm cylinder rod is supplied to arm cylinder head so oil cavitation may be prevented.
If arm out action is stopped, oil in arm cylinder is obstructed by check of arm holding valve (H), and the moving of arm is blocked.



DS1801978

Figure 19



Arm Cylinder
S5-1
S5-2
AD1
AD4
AD2
AD3
B5
A5
pc1
pb5
pa5
R1
Arm 1
Ta
8
L1
pb9
pa9
Arm 2
S9-1
S9-2
Arm Cylinder
DR1
pc1
Arm Lock
A5
B5
pb9
pb5
Arm 2
Arm 1
353bar@20L
pa9
pa5
P2
P1
DS1602575

Figure 20

HEEL RACK IN OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.

If pilot oil is supplied to heel spool of main control valve (10) by the operation of joystick valve (7), then spool is moved and main pump oil passage and heel cylinder rod oil passage open.

Oil supplied from idle pump of main pump (1) is supplied to heel cylinder (13) rod direction causing heel moving to take place.

If boom operation takes place during heel rack in operation, oil flowing to heel spool of main control valve (10) is preferably supplied to boom spool, and, as a result, composite action in which boom operation has a priority takes place.

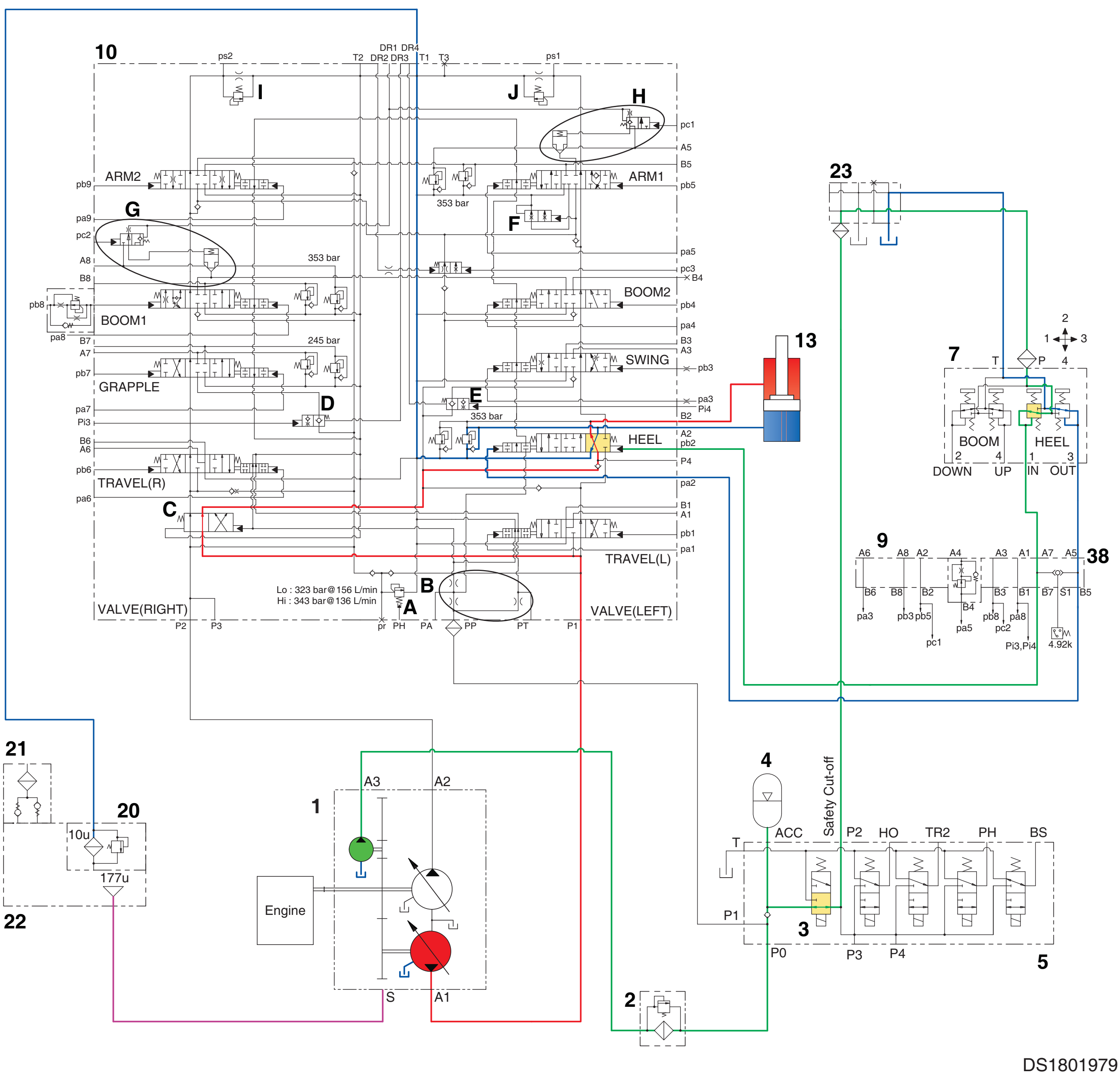


Figure 21

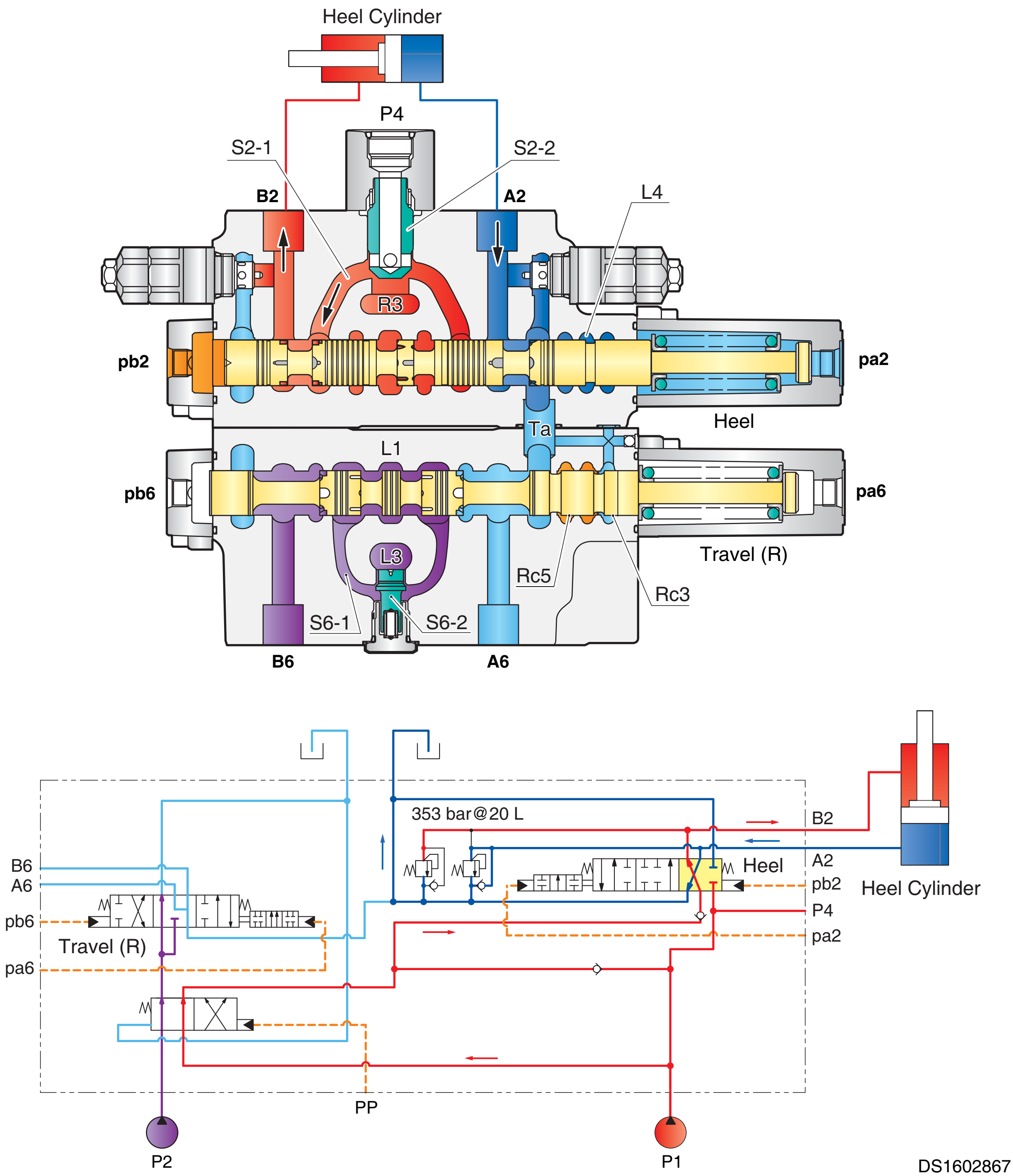

Heel Cylinder
P4
S2-1
S2-2
B2
A2
L4
R3
pb2
pa2
Heel
Ta
L1
pb6
pa6
L3
Rc5
Rc3
Travel (R)
S6-1
S6-2
B6
A6
353 bar@20 L
B2
A2
pb2
P4
pa2
Heel
Heel Cylinder
B6
A6
pb6
pa6
Travel (R)
PP
P2
P1
DS1602867

Figure 22

HEEL RACK OUT OPERATION

Oil supplied from hydraulic tank (22) passes through pilot pump connected to main pump (1) and pilot filter (2) and is supplied to solenoid package valve (5) after accumulator (4) is first filled with the oil.

If pilot oil is supplied to heel spool of main control valve (10) by the operation of joystick valve (7), then spool is moved and main pump oil passage and heel cylinder head oil passage open.

Oil supplied from idle pump of main pump (1) is supplied to heel cylinder (13) head direction causing heel moving to take place.

If boom operation takes place during heel rack out operation, oil flowing to heel spool of main control valve (10) is preferably supplied to boom spool, and, as a result, composite action in which boom operation has a priority takes place.

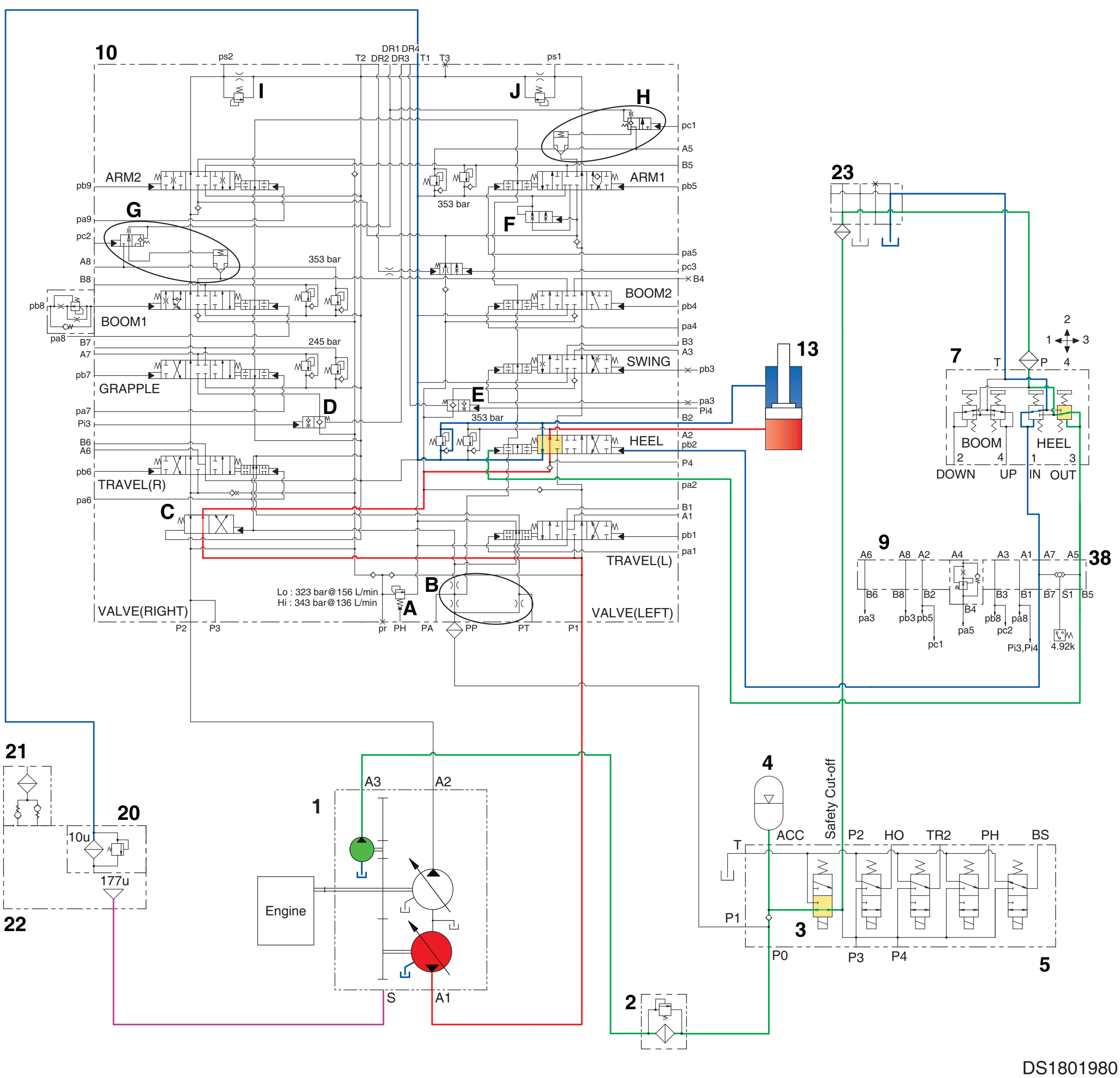


Figure 23

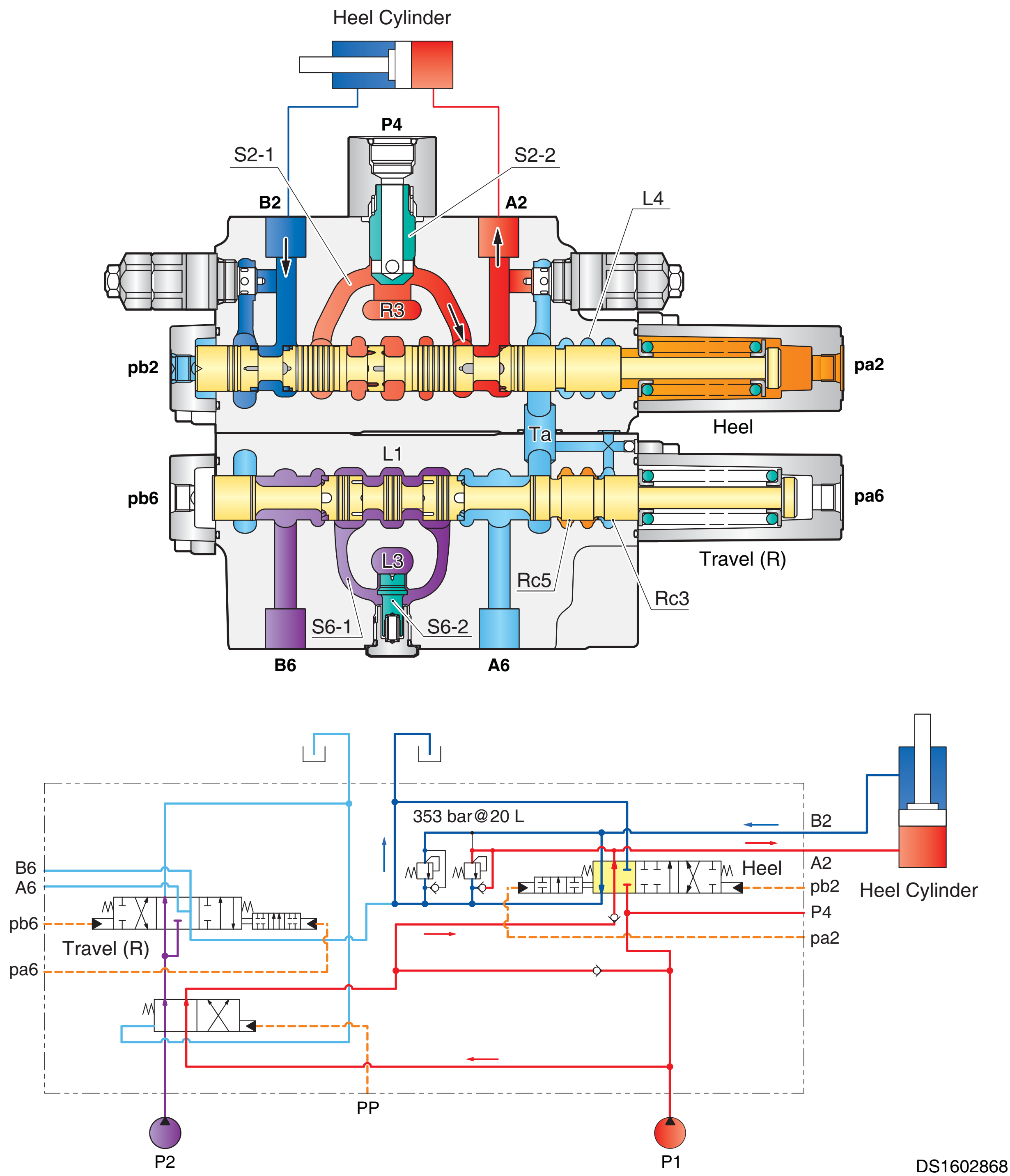

Heel Cylinder
P4
S2-1
S2-2
B2
A2
L4
R3
pb2
pa2
Heel
Ta
L1
pb6
pa6
Travel (R)
L3
Rc5
Rc3
S6-1
S6-2
B6
A6
353 bar@20 L
B2
A2
Heel
pb2
P4
pa2
Heel Cylinder
B6
A6
pb6
Travel (R)
pa6
PP
P2
P1
DS1602868

Figure 24

Hydraulic System Testing and Adjustment

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Hydraulic System Testing and Adjustment

PROCEDURAL TROUBLESHOOTING BASELINE RECOMMENDATIONS

Initial Checks and Tests to Establish Operating Condition of the Excavator

Troubleshooting Recommendations

An excavator that fails to deliver designed performance must be checked for the following:

- First hydraulic flow.
- Then hydraulic pressure 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 (1,900 rpm), performance problems may be because of inadequate hydraulic flow caused by lagging rotational speed.

NOTE: *Verify actual flow on the excavator against rated performance, with a flow meter.*

If engine tests meet specifications and adequate torque and horsepower are available at the pump drive flex coupling, pull out the electrical tray under the operator's seat to inspect the self-diagnostic display.

If the EPOS trouble code display is clear, check hydraulic functions in the following sequence:

- Pilot pressure.
- Negacon, negative control pressure.
- Main relief pressure (P1 and P2 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 component is worn beyond tolerance limits, while all other hydraulic functions are adequate.*

IMPORTANT

It is suggested that 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

AVOID DEATH OR SERIOUS INJURY

This procedure must be done with two people. To reduce the chance of accidental movement of the excavator, one person should properly seated 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 safety lever is in the up (UNLOCK) 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 locknut 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

Refill 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 (40 ±5 kg/cm^{2,} 569 ±71 psi)	23 ±1.5 bar (23 ±1.5 kg/cm^2, 334 ±21 psi)

POWER MODE VALVE

Current Signal and Hydraulic Pressure Adjustments

WARNING

AVOID DEATH OR SERIOUS INJURY

This procedure must be done with two people. To reduce the chance of accidental movement of the excavator, one person should properly seated 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 pumps (not visible in the harness connections drawing, because it is underneath the assembly), near the engine/pump flexible coupling, adjacent to the pump return line. 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 a VOM meter can be connected to the circuit. To set up the testing equipment, stop 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 locknut 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 locknut.*

Mode	Engine rpm	Current	Pressure
Power Plus	High Idle: 1,900 (Auto Idle OFF) 1,800 (Auto Idle ON)	300 mA ±30 Midrange value corresponding to engine rpm for both current and hydraulic pressure readings.	8 bar (116 psi)
Power	High Idle: 1,700	325 mA ±30	9.8 bar (142 psi)
Standard	High Idle: 1,650	355 mA ±30	11.7 bar (170 psi)
Economic	High Idle: 1,600	395 mA ±30	14.2 bar (206 psi)

PRESSURE UP VALVE

Checks and Adjustments

WARNING

AVOID DEATH OR SERIOUS INJURY

This procedure must be done with two people. To reduce the chance of accidental movement of the excavator, one person should properly seated 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) locknut on the relief valve. Turn the adjusting screw clockwise to increase pressure, or counterclockwise to decrease it. Pressure must be 323 bar (330 kg/cm^2, 4,694 psi), or up to 10 bar (10 kg/cm^2, 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 must be at least 323 bar (330 kg/cm^2, 4,694 psi), but less than 343 bar (350 kg/cm^2, 4,978 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.

<table>
<tr><th>Mode</th><th>Operation</th><th>Main Pressure and Tolerance</th><th>Pilot Pressure and Tolerance</th></tr>
<tr><td>Power Mode</td><td>Neutral, No Operation</td><td>20 ~ 40 bar
(20 ~ 40 kg/cm^2, 290 ~ 580 psi)</td><td rowspan="3">40 ±10 bar
(40 ±10 kg/cm^2, 290 ±145 psi)</td></tr>
<tr><td>Power Mode</td><td>Cylinder Stall</td><td>323 ±5 bar
(330 ±5 kg/cm^2, 4,694 ±73 psi)</td></tr>
<tr><td>Power Mode W/ Pressure Up</td><td>Cylinder Stall</td><td>343 ±10 bar
(350 ±10 kg/cm^2, 4,978 ±145 psi)</td></tr>
</table>

NOTE: *The electrical pressure up (power boost) solenoid valve alongside the 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

AVOID DEATH OR SERIOUS INJURY

This procedure must be done with two people. To reduce the chance of accidental movement of the excavator, one person should properly seated 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 "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 – 1,900 ±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.

Refer to the illustration of the pump regulator control valve (Figure 1) for the location of adjustment screws. There are two different adjustments, with the Negacon, negative control, adjustment screw. 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.*

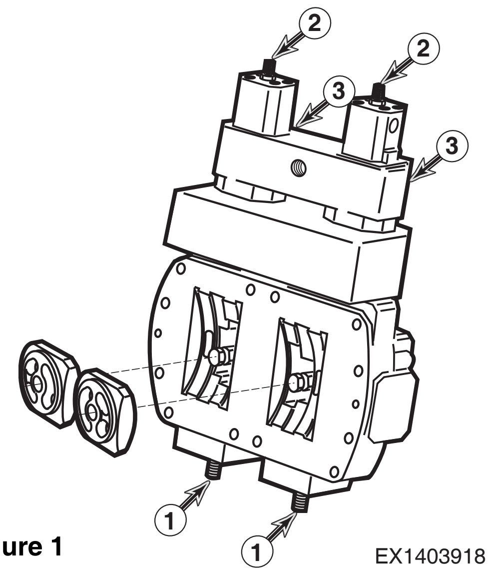


Figure 1

Start the engine and turn the engine speed dial to maximum. When normal operating temperature is reached, loosen the largest diameter locknut around the adjustment screw 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 out will decrease pump input horsepower. 1/4 turn on the adjusting screw is equal to approximately 17 horsepower.

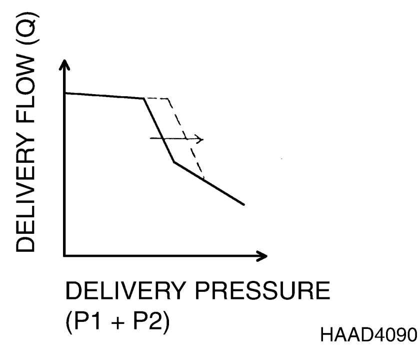


Figure 2

IMPORTANT

Because changing the position of adjusting screw also affects the setting of the adjustment for the inner spring, the smaller diameter adjusting screw, turn in the inner screw 198° (slightly more than 1/2 turn, 180°) before screw is backed out 1/4 turn (90°).

NOTE: *For each full turn of adjustment on the larger diameter screw, the square-tipped adjusting screw must 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 clockwise moves the flow curve up, increasing flow and then input horsepower.

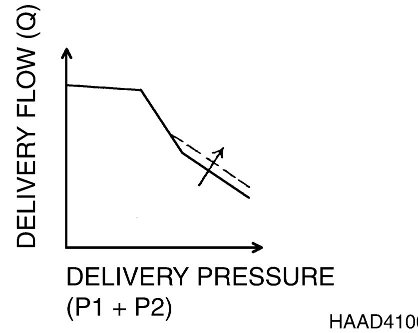


Figure 3

The adjusting screw (Figure 1) affects the delivery rate (Q) of the pump. Tightening the adjusting screw decreases the maximum cut flow (as shown in Figure 4) while backing out the screw increases cut flow delivery rate.

Balance both pumps for equal output.

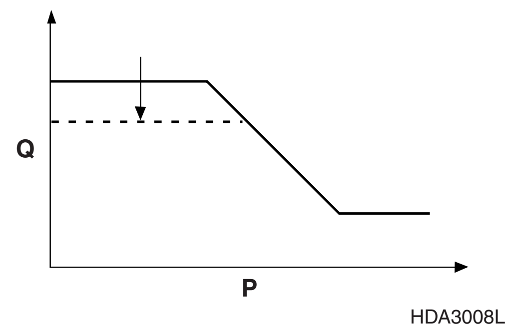


Figure 4

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 performing your own testing, they must 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

- Stop 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 always – should restart the engine and run it long enough (at minimum rpm) to deaerate 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
	98 bar (100 ±5 kg/cm^2 (1,422 psi)	
	147 bar (150 ±5 kg/cm^2 , 2,133 psi)	
	196 bar (200 ±5 kg/cm^2 (2,844 psi)	
	294 bar (300 ±5 kg/cm^2 (4,267 psi)	
	343 bar (350 ±5 kg/cm^2 (4,975 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 meet 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.

SWING SYSTEM TROUBLESHOOTING

Precautions/Initial Checks

1. Stop work. Release all weight or any load safely before proceeding. Avoid risking injury or adding to damage.
2. Stop engine and disengage control functions until initial tests are ready to be made.

WARNING

AVOID DEATH OR SERIOUS INJURY

Stop operation and park excavator whenever these problems are noticed:

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 in compliance with all applicable environmental laws and 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 500 bar (510 kg/cm^2, 7,252 psi) pressure gauges to the inlet and outlet measuring ports on top of the swing motor.

   Pressure must be between 290 and 300 bar (4,206 psi and 4,351 psi), with both swing locks engaged. With swing locks released, during full acceleration and deceleration, pressure should approach 294 bar (300 kg/cm^2 (4,267 psi) in each direction.

   B. Connect a 100 bar (102 kg/cm^2, 1,450 psi) pressure gauge at the "SH" port of the hydraulic brake.

   Pressure should always stay at or above 13 bar (189 psi) when operating swing, boom or arm.

   C. Connect a 10 bar (10 kg/cm^2, 145 psi) gauge at the motor makeup valve.

   Pressure should stay consistently above 2.5 bar (2.5 kg/cm^2, 36 psi). If pressure drops 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, drivetrain 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 (13 kg/cm^2, 189 psi) level, check the shuttle valve in the rear compartment behind cabin. When pressure through the port is at the recommended level, the brake release valve should disengage the swing brake, allowing the swing motor to rotate the excavator. If pressure adjustment to the valve has been restored but the brake still fails to release, the brake piston or friction plate may be frozen, requiring disassembly of the motor and parts repair/replacement.

4. If pressure tested at the motor makeup valve drops 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 drivetrain 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 EPOS circuit is causing diminished swing performance. Pull out the EPOS indicator panel from underneath the operator's seat and perform the self-diagnostic test. Refer to the Electrical section of this book for more information.*

Hydraulic System Troubleshooting

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Hydraulic System Troubleshooting

Unusual Noise Comes Out from Pump Connection

Remove dust plug under engine flywheel and check if rubber pieces or particles are not present?

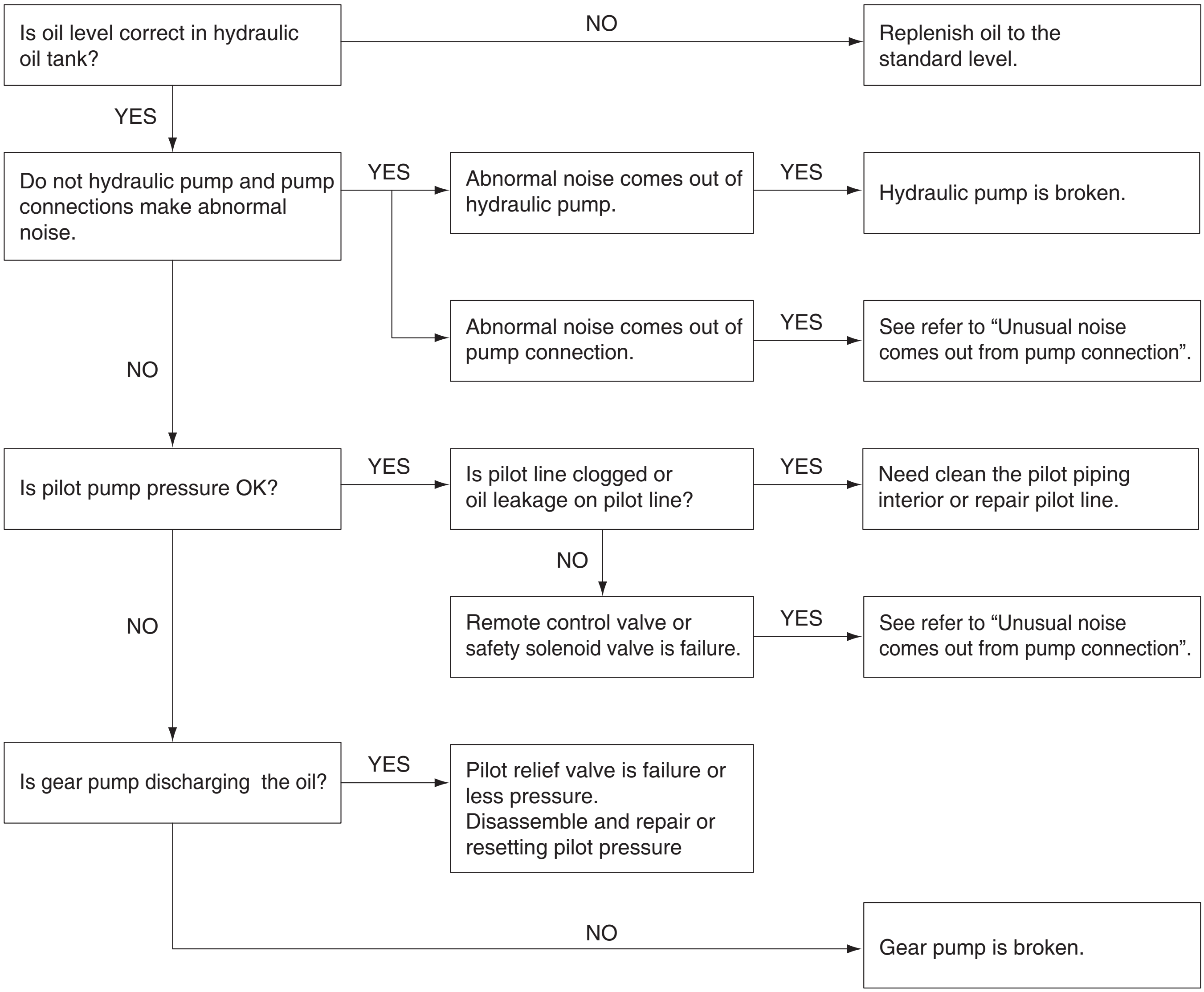
- YES → Coupling element is broken.
- NO ↓

Coupling hub spline is worn or hub fastening screw is loose.

- YES → Replace the coupling or retighten the screw.
- NO ↓

If hydraulic pump or engine is suspected, Refer to the service manual on hydraulic pump and engine.

Engine Starts but Machine Does Not Operate



Hydraulic Oil is Cloudy

Has been the oil change interval maintenance?
- NO → Need observance of oil change interval.
- YES ↓

Drop hydraulic oil sample on a hot plate and check if it foams come up.
- YES → Water is mixed. Replace the oil.
- NO ↓

Is the hydraulic oil with another oil brand?
- YES → Must be used one kind brand oil. Replace with Doosan genuine oil.
- NO ↓

The hydraulic system has overheated.
- YES → Clean the cooler and check of the hydraulic system.
- NO → Oil is aerated. Check suction line and return line and eliminate the air intruding source.

Hydraulic Oil Overheated

Is hydraulic oil level correct?
- NO → Replenish specified oil to the corrected level.
- YES ↓

Is not oil cooler clogged and is anything blocking air circulation?
- YES → Clean oil cooler. Secure air circulation route.
- NO ↓

Check the EPOS controller or electric wire.

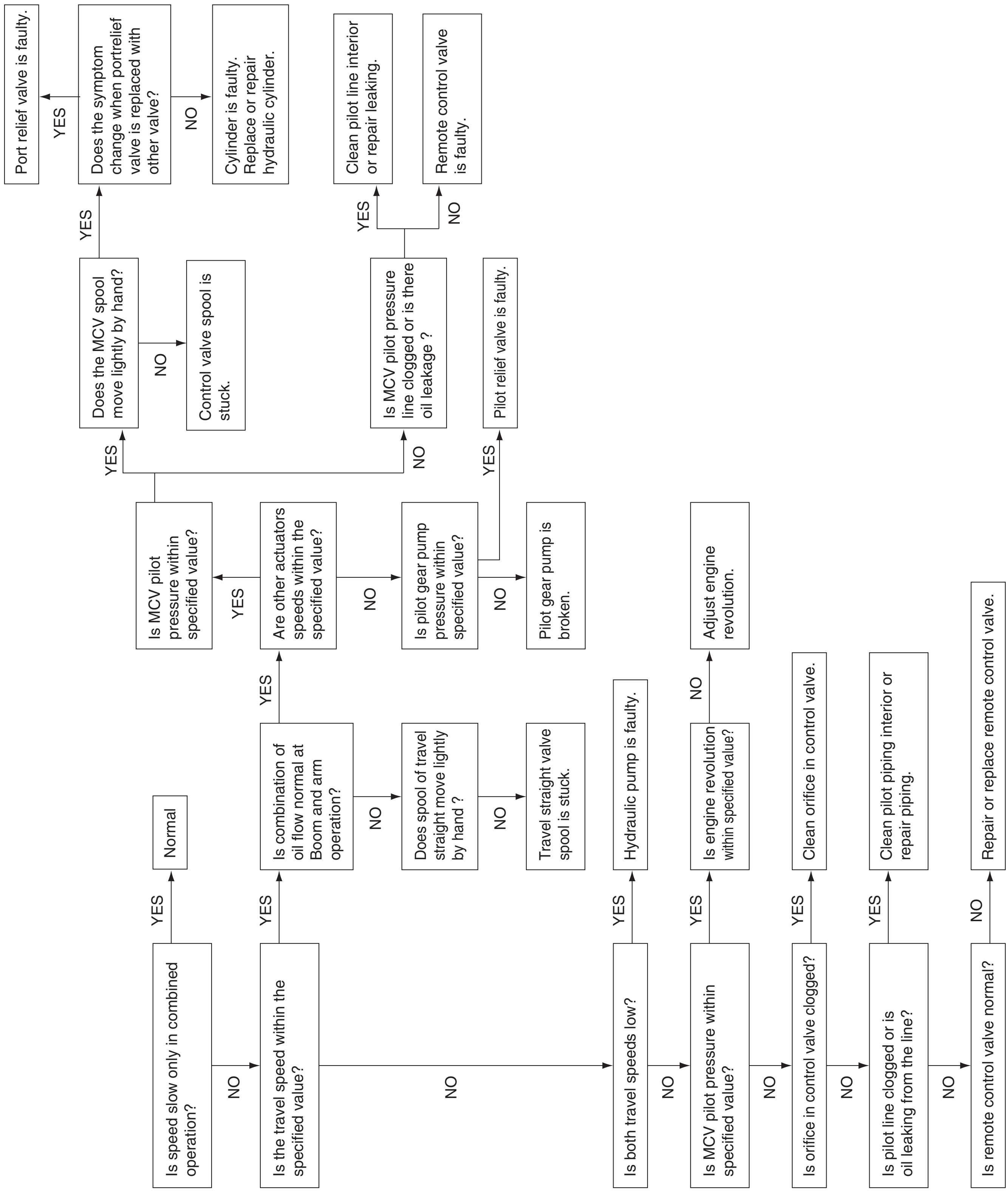
Hydraulic Pump Cavitation

- Is hydraulic oil level correct?
  - NO → Replenish specified oil to the correct level.
  - YES ↓
- Is not viscosity of hydraulic oil too high?
  - YES → Replace oil with proper viscosity.
  - NO ↓
- Is the suction strainer clogged?
  - YES → Replace suction strainer.
  - NO ↓
- Is air intrusion at pump suction line?
  - YES → Check for air intrusion in suction line and retighten or replace parts.

Hydraulic Oil is Contaminated

- Has the hydraulic oil passed specified replacement hours?
  - YES → Replace hydraulic oil and filter. Clean the hydraulic system.
  - NO ↓
- Has return filter been replaced at proper intervals?
  - NO → Replace hydraulic oil and replace return filter.

Boom, Arm, Heel Speed is Slow



Boom, Arm or Heel Power is Weak

Is main relief pressure within specified value?

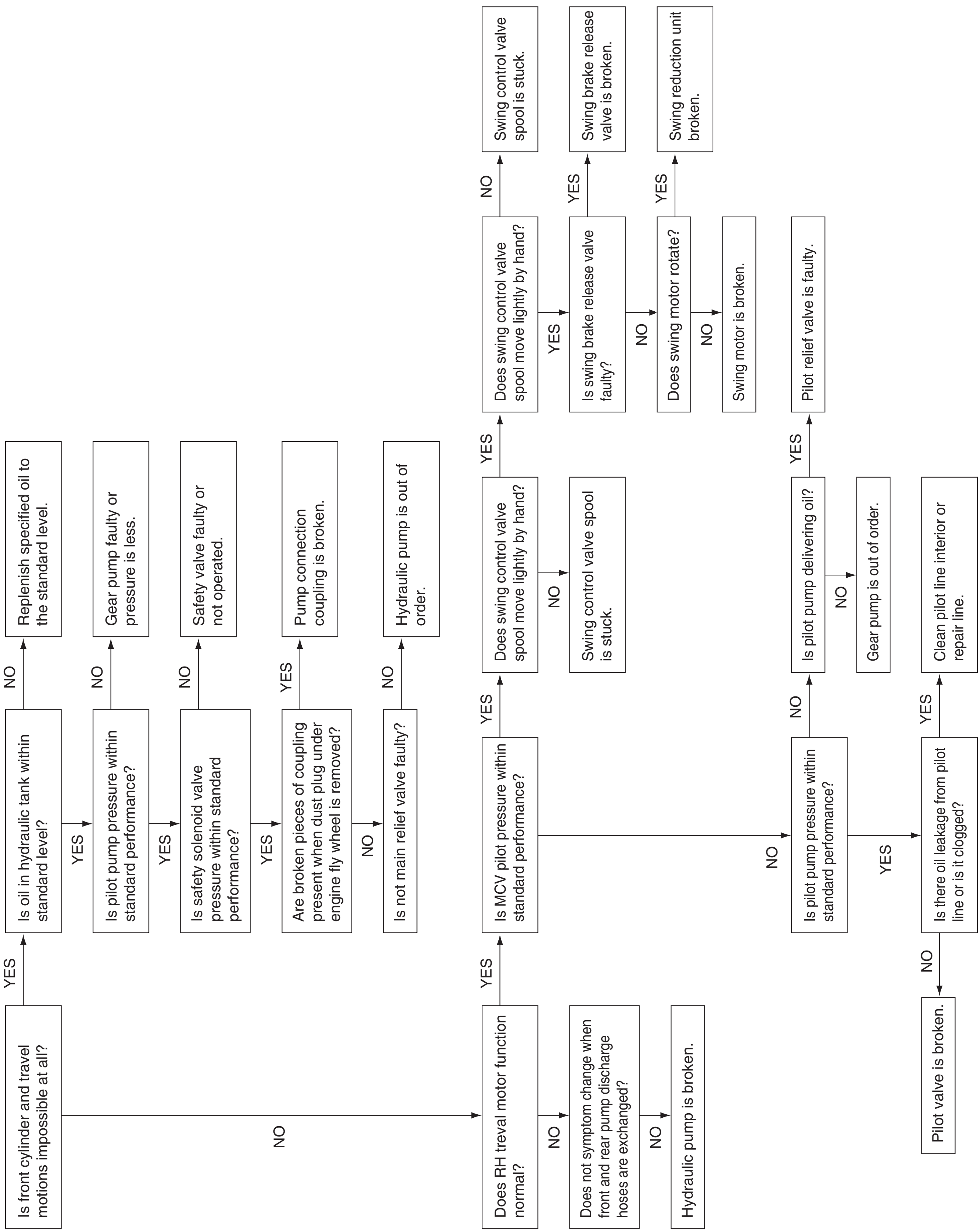
- YES → Is cylinder internal leakage within standard performance?
  - YES → Check according to the procesure in item "Speed is Slow".
  - NO → Cylinder is faulty. Disassemble and repair.
- NO → Main relief valve is defective. Adjust pressure or replace.

Cylinder Moves When Remote Control Valve is in the Neutral Position

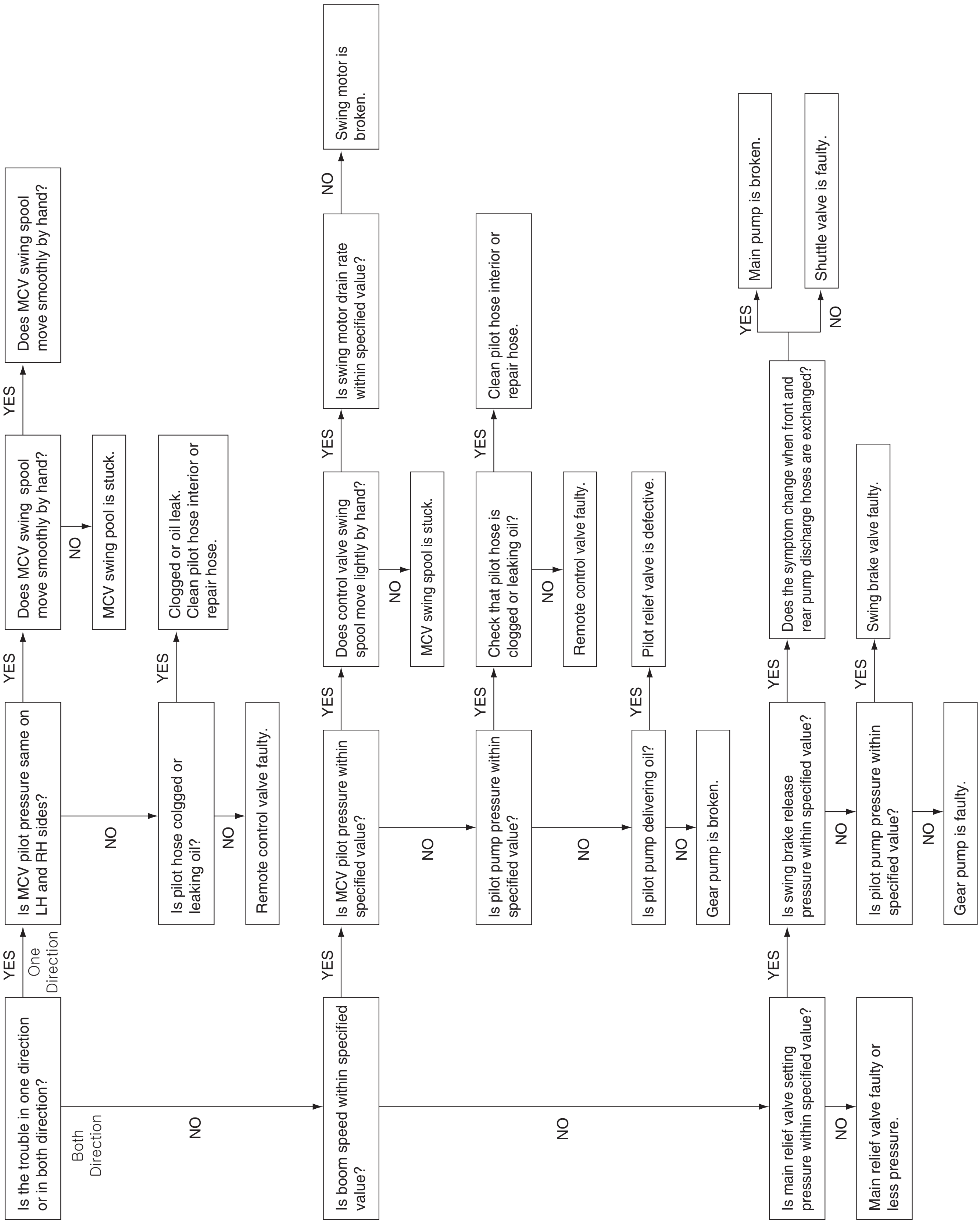
Joystick valve operation is normal.

- YES → Is overload valve pressure within standard value?
  - YES → Cylinder is faulty. Disassemble and repair.
  - NO → Repair or replace overload valve.
- NO → Replace or repair Joystick valve.

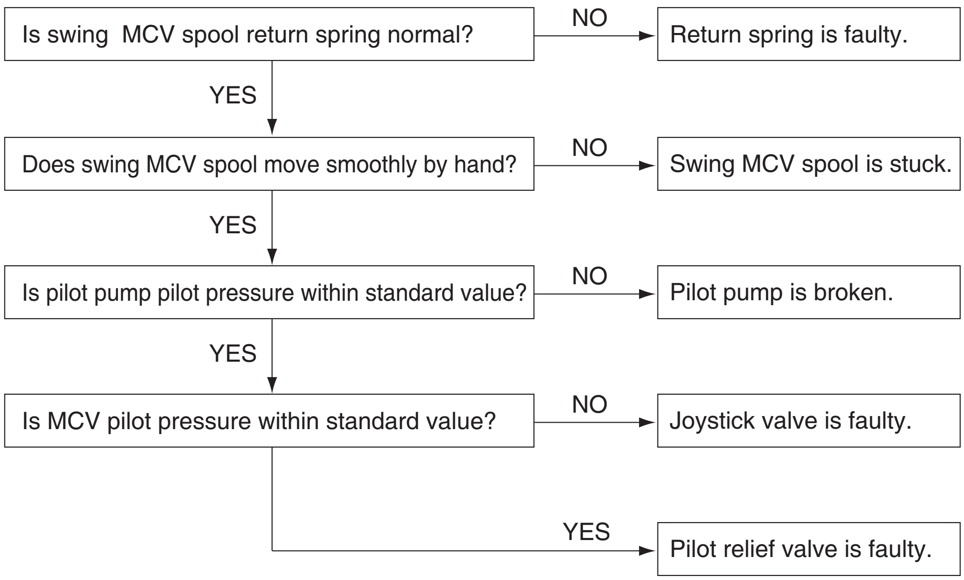
TR (L), TR (R) Swing Does Not Operate When Remote Control Valve Operated



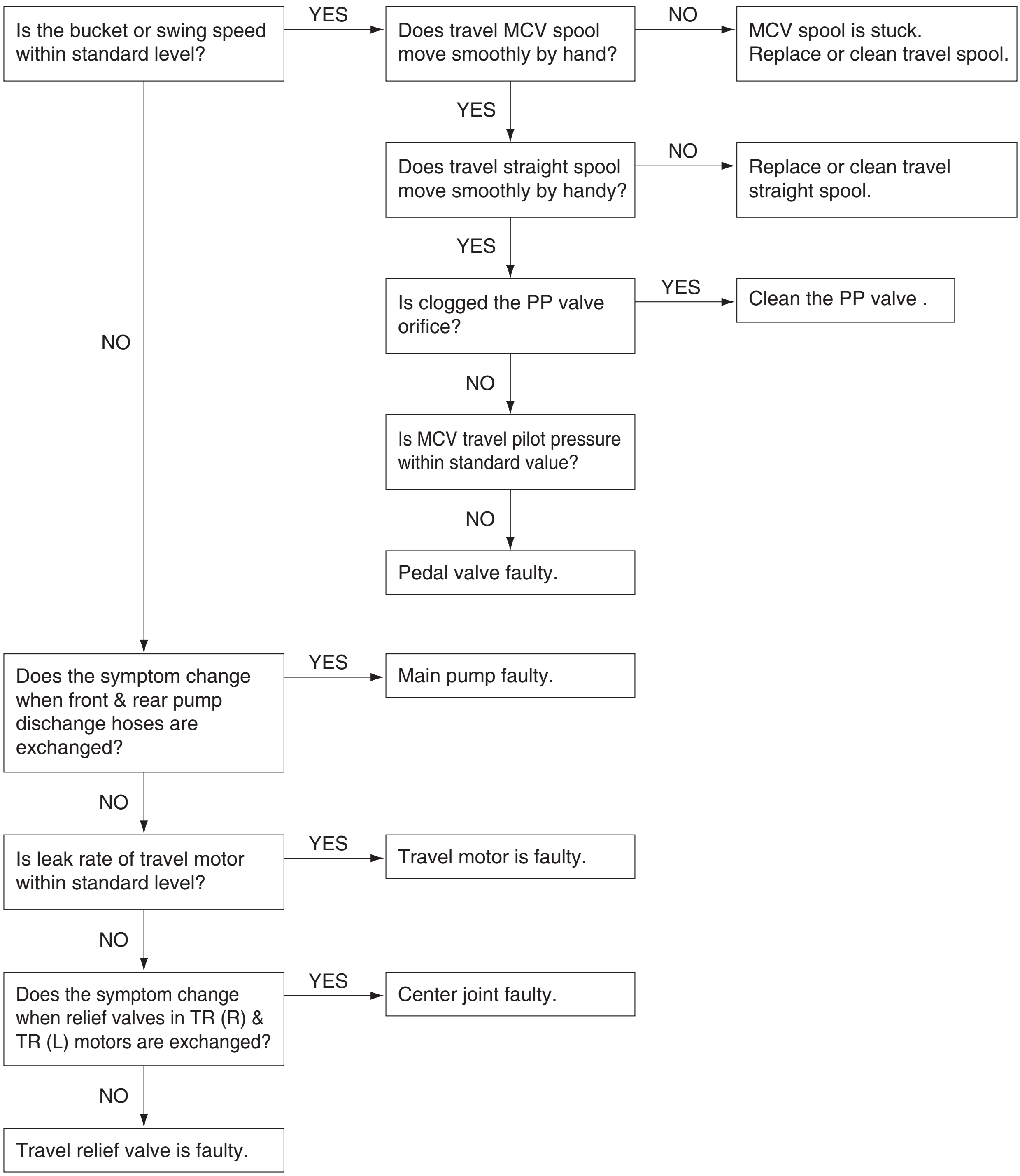
Swing Speed is Slow



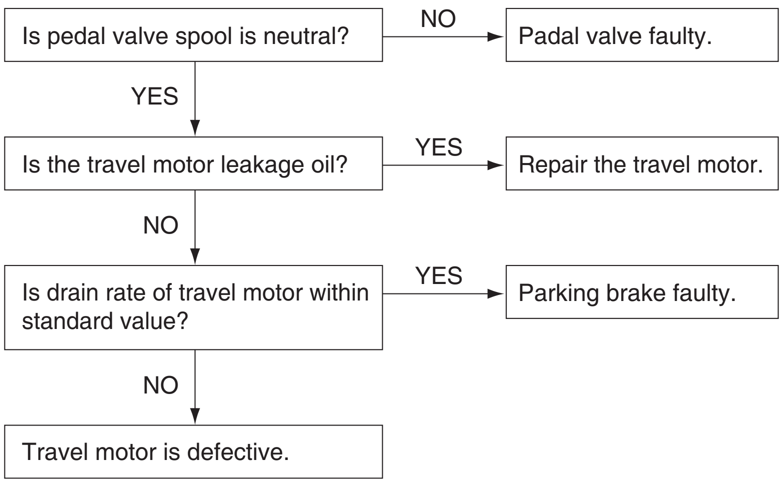
Machine Swings but Does Not Stop



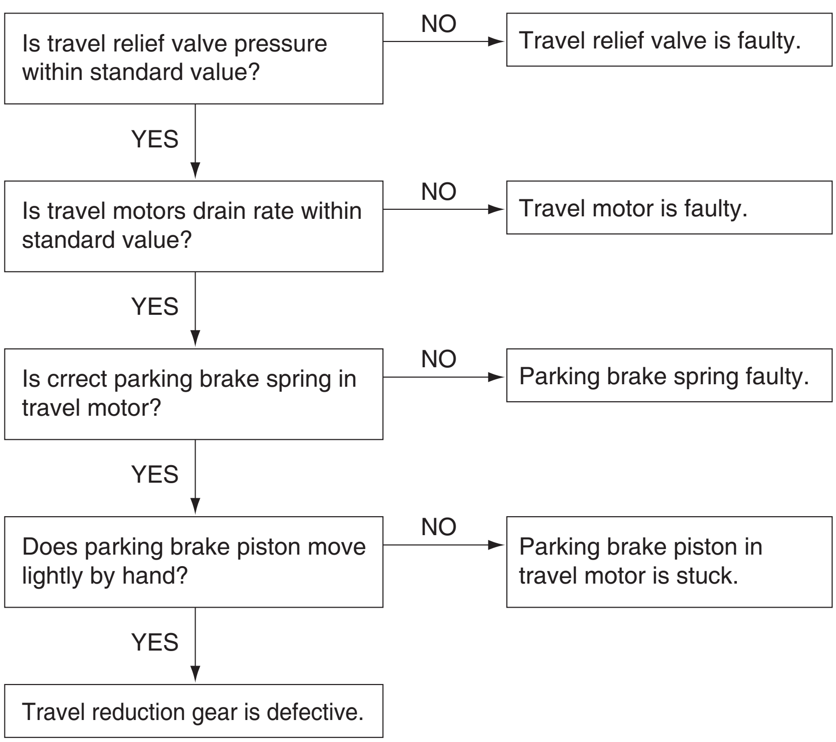
One Side Speed is Falls and the Machine Curves



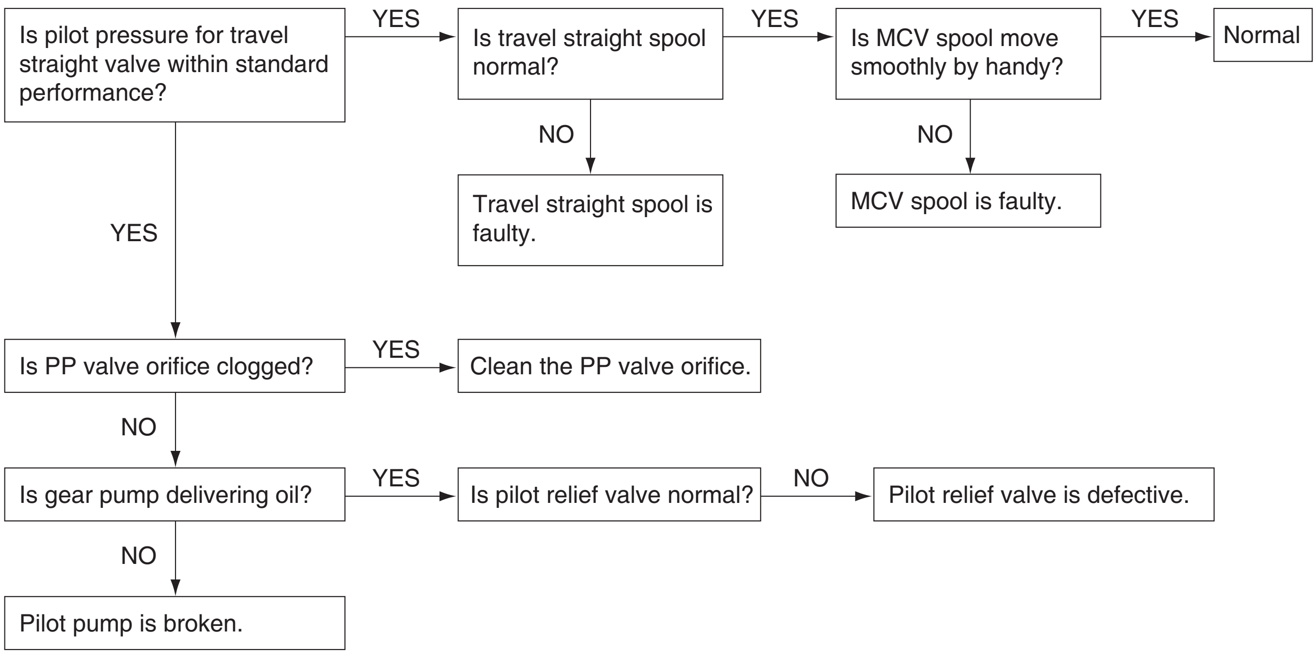
Machine Does Not Stop on a Slope



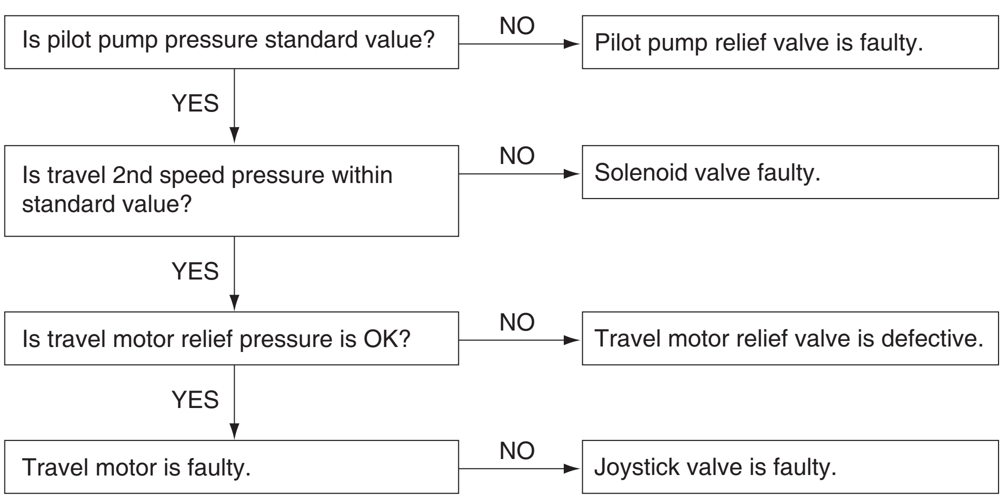
Travel Motor is Powerless (Travel Only)



Machine Makes a Curved Travel, When Travel and Actuator Operation are Executed a the Same Time



Does Not Travel is 2nd Speed or Auto Speed



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 (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 moving 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 drivetrain.	Replace broken gears and drivetrain 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 driveshaft damage.	Replace swing motor.
	Internal damage to gearbox drivetrain.	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 driveshaft or 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.
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 workload or cycling rate.
	Hydraulic oil severely neglected or incorrect for application.	Replace oil.

Problem	Possible Cause	Remedy
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 "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 refilled 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.
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:		
Pressure does not increase at all.	Main poppet or pilot poppet stuck open.	Clean/replace.

Problem	Possible Cause	Remedy
Irregular or uneven pressure.	Poppet seat damaged or pilot piston sticking to main poppet.	Clean/replace.
	Loose locknut 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 find damaged seals or gaskets that could be the cause of air leaks.*		

Electrical System

Electrical System

SAFETY INSTRUCTIONS

WARNING

AVOID DEATH OR SERIOUS INJURY

Instructions are necessary before operating or servicing machine. Read and understand the Operation & Maintenance Manual and signs (decals) on machine. Follow warnings and instructions in the manuals when making repairs, adjustments or servicing. Check for correct function after adjustments repairs or service. Untrained operators and failure to follow instructions can cause death or serious injury.

Table of Contents

Electrical System

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 electrical 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.

Electrical Wire Color

Symbol	Color
W	White
G	Green
Or	Orange
B	Black
L	Blue
Lg	Light green
R	Red
Gr	Gray
P	Pink
Y	Yellow
Br	Brown
V	Violet

NOTE: *RW: Red wire with White stripe*

R - Base Color, W - Stripe Color

NOTE: *0.85G: Nominal sectional area of wire core less insulator = 0.85 mm*^{2}

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 and fuse box.

The negative terminal of the battery is grounded to the machine body.

Even when the starter switch (5) is in the "OFF" position, electric current is supplied to the following components through battery (1) → master switch (9) → circuit breaker 1 (3) → fuse box (6).

1. Terminal "5" of stereo.
2. Terminal "B" of starter switch.
3. Hour meter.
4. Engine controller. (ECU + SCU)
5. Terminal "2" of fuel auto shutoff controller.
6. Terminal "CN7-5, CN7-6" of instrument panel controller.
7. Terminal "CN9-6" of air conditioner panel.
8. Cabin light
9. Terminal "11" of diesel heater timer.
10. Terminal "1-12" of diesel heater.
11. Terminal "1" of TMS controller.
12. Terminal "13" of wiper controller.
13. Terminal "6" of wiper motor.

When the starter switch (5) is in the "ON" or "START" positions, the current flows from the battery (1) → master switch (9) → circuit breaker 1 (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).

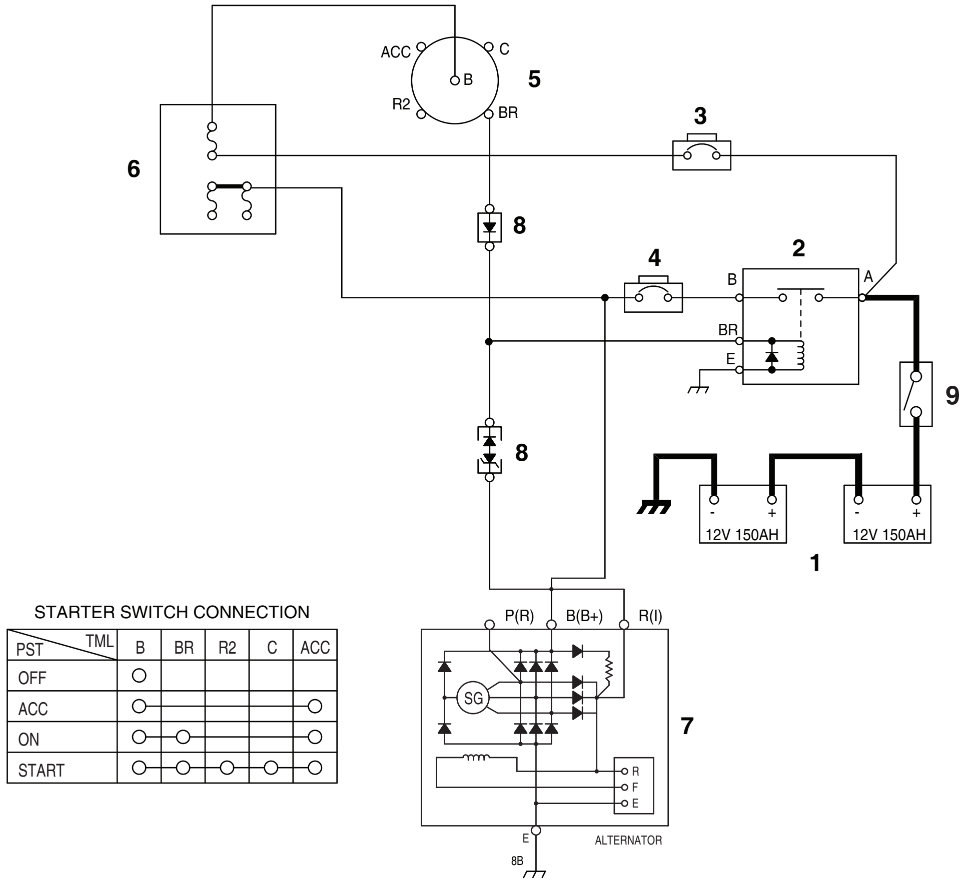


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Figure 1 Electric Power Circuit Diagram

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Circuit Breaker 2
5	Starter Switch
6	Fuse Box
7	Alternator
8	Diode
9	Master Switch

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. Now the contacts in the starter relay 1 (8) are closed by the current flow from the battery (1) → master switch (14) → circuit breaker 1 (3) → fuse box (6) → "B" terminal of starter switch (5) → "C" terminal of starter switch (5) → "30" terminal of starter relay (12) - "87a" terminal → "86" terminal of starter relay (8) - "85" terminal → "S" terminal of starter controller (7) - "E" terminal → ground.

When the contact point "30" and "87" of starter relay 1 (8) are connected, the pinion gear of the starter (9) is pushed forward and contacts the ring gear of the flywheel and the internal contacts of the starter are connected. The current flows from the battery (1) → "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.*

If the security system is locked, current flows from battery (1) → master switch (14) → circuit breaker 1 (3) → fuse box (6) → "B" terminal of starter switch (5) → "BR" terminal of starter switch (5) → "86" terminal of starter relay (12) → "85" terminal of starter relay (12) → "CN2-115" terminal of 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.

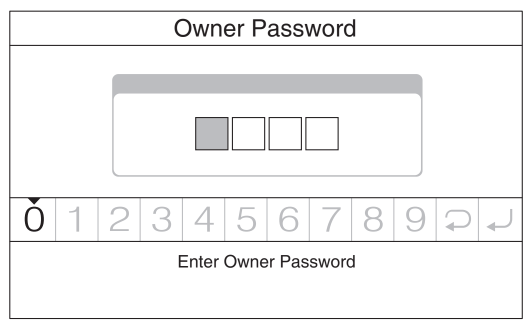
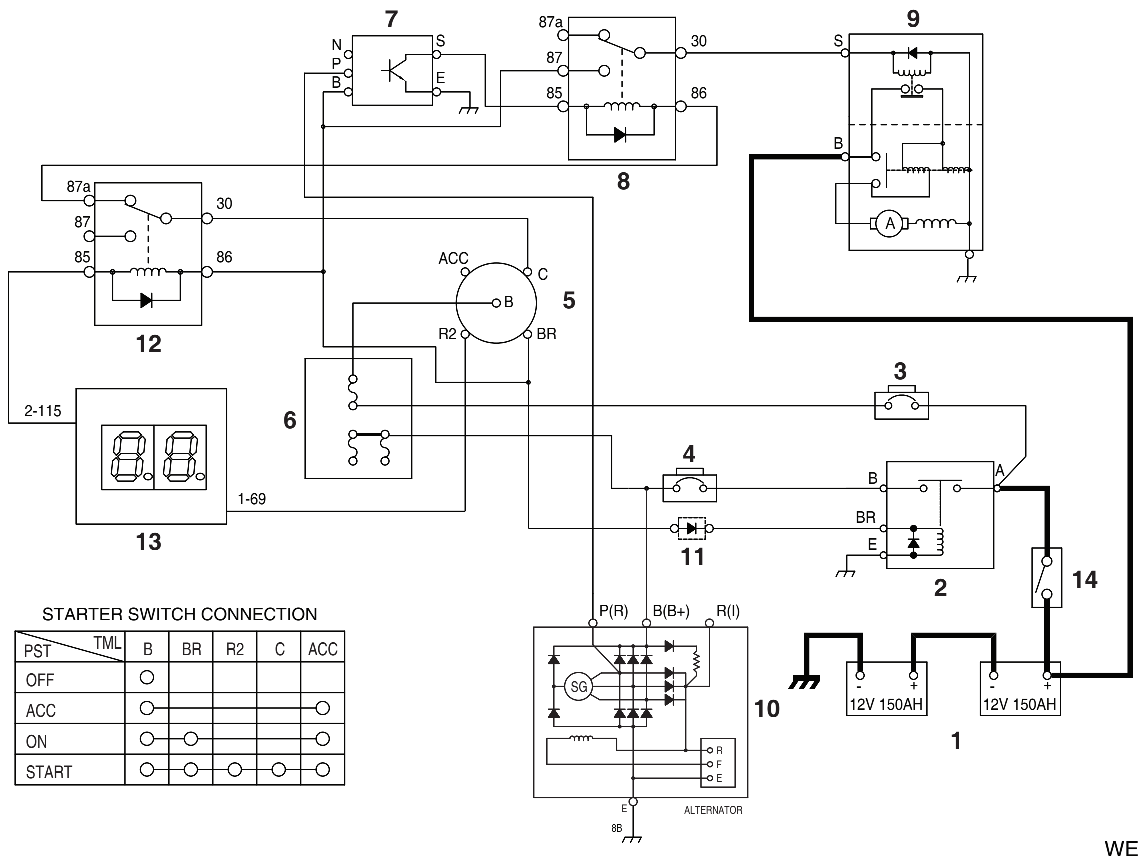


Figure 2



PST \ TML	B	BR	R2	C	ACC
OFF	O				
ACC	O				O
ON	O	O			O
START	O	O	O	O	O

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Figure 3 Starter Circuit - While Starting

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Circuit Breaker 2
5	Starter Switch
6	Fuse Box
7	Starter Controller

Reference Number	Description
8	Starter Relay 1
9	Starter
10	Alternator
11	Diode
12	Starter Relay 2
13	EPOS Controller
14	Master Switch

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

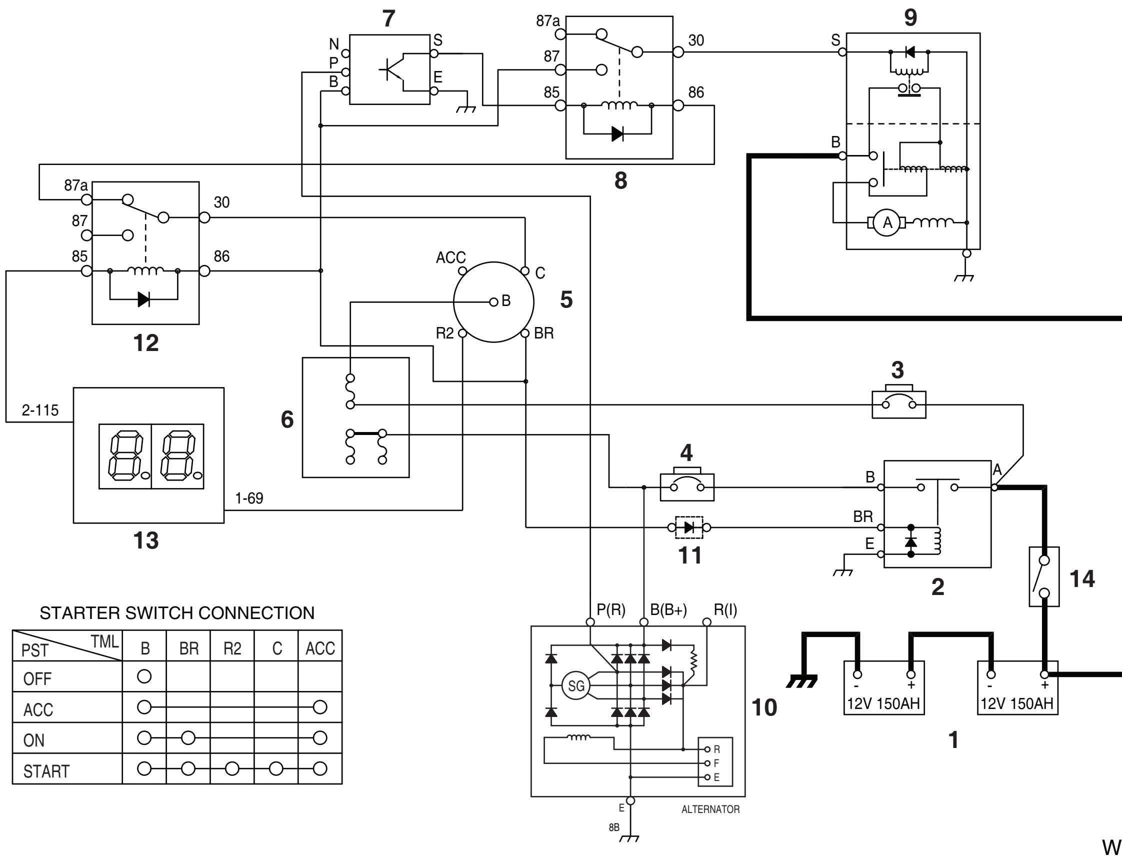

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Figure 4 Operation of Start Circuit (2) - Immediately After Start

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Circuit Breaker 2
5	Starter Switch
6	Fuse Box
7	Starter Controller

Reference Number	Description
8	Starter Relay 1
9	Starter
10	Alternator
11	Diode
12	Starter Relay 2
13	EPOS Controller
14	Master Switch

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 cylinders. Only one solenoid is shown in Figure 6.*

When starter switch (5) is turned "OFF", the engine controller stops suppling power to the injector solenoid (9). This stops fuel from being injected into the engine cylinder, thus stopping the engine.

If the engine cannot be shut down using the starter switch (5), an emergency stop switch (10) is provided to stop engine.
To activate the emergency stop switch, move it to "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 engine stops.

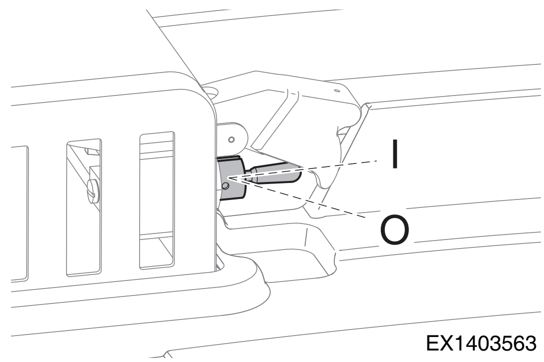


Figure 5 Engine Emergency Stop Switch

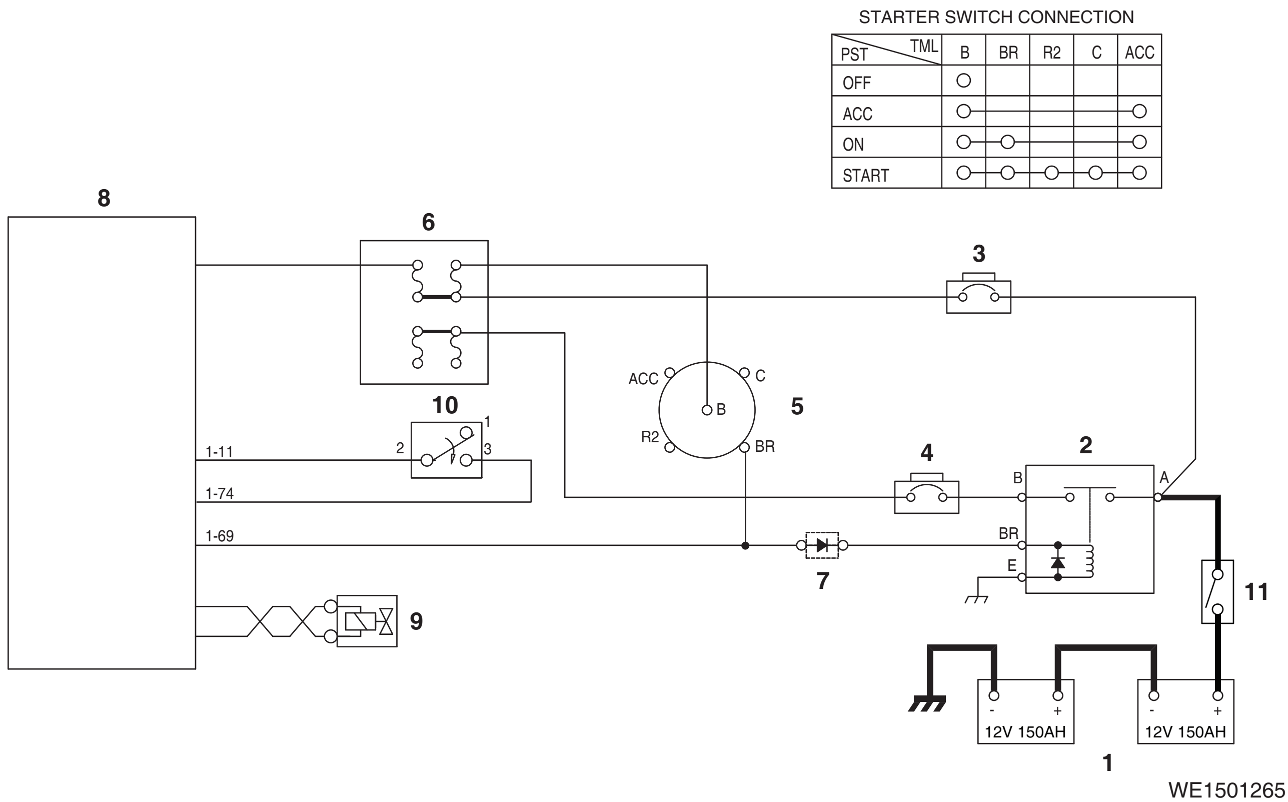


Figure 6 Engine Stop Circuit

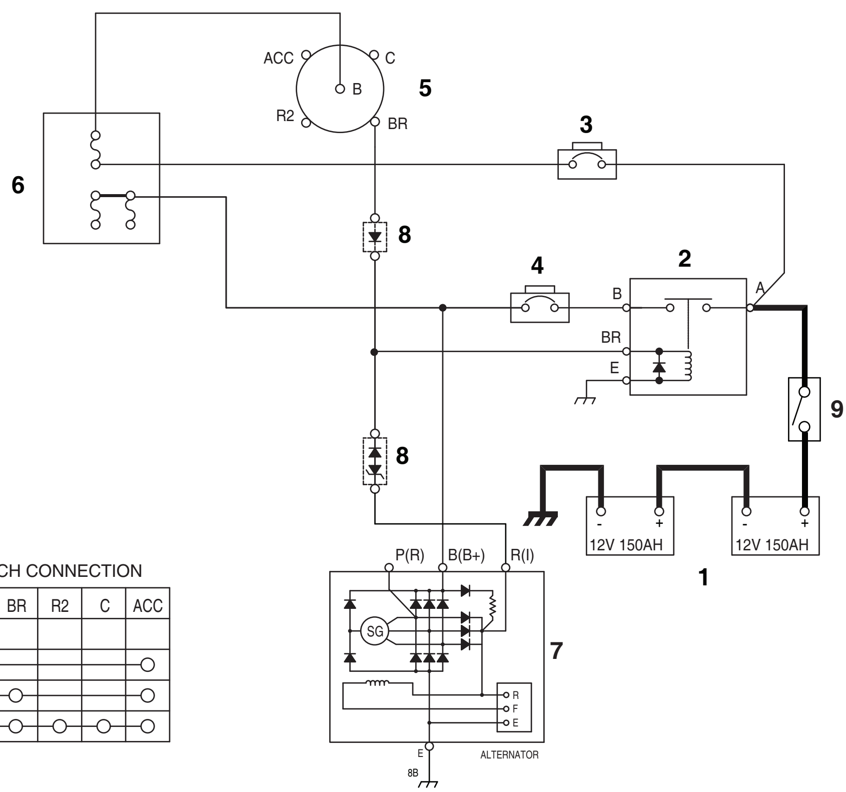
Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Circuit Breaker 2
5	Starter Switch
6	Fuse Box

Reference Number	Description
7	Diode
8	Engine Controller
9	Injector Solenoid
10	Emergency Stop Switch
11	Master Switch

CHARGING SYSTEM

When the starter switch (5) is turned to the "ON" position, an initial excitation 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) → master switch (9) → battery (1).

The alternator also supplies electric current to other electrical components. When the alternator (7) starts to operate, a current flows from the "R (I)" terminal of alternator → diode (8) → battery relay (2) coil securing a path for the charging current to the battery (1). Thus preventing the possibility of a high voltage build up and possible damage to the electrical system.



STARTER SWITCH CONNECTION

PST \ TML	B	BR	R2	C	ACC
OFF	O				
ACC	O				O
ON	O	O			O
START	O	O	O	O	O

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Figure 7 Charging Circuit

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Circuit Breaker 2
5	Starter Switch

Reference Number	Description
6	Fuse Box
7	Alternator
8	Diode
9	Master Switch

MONITORING SYSTEM

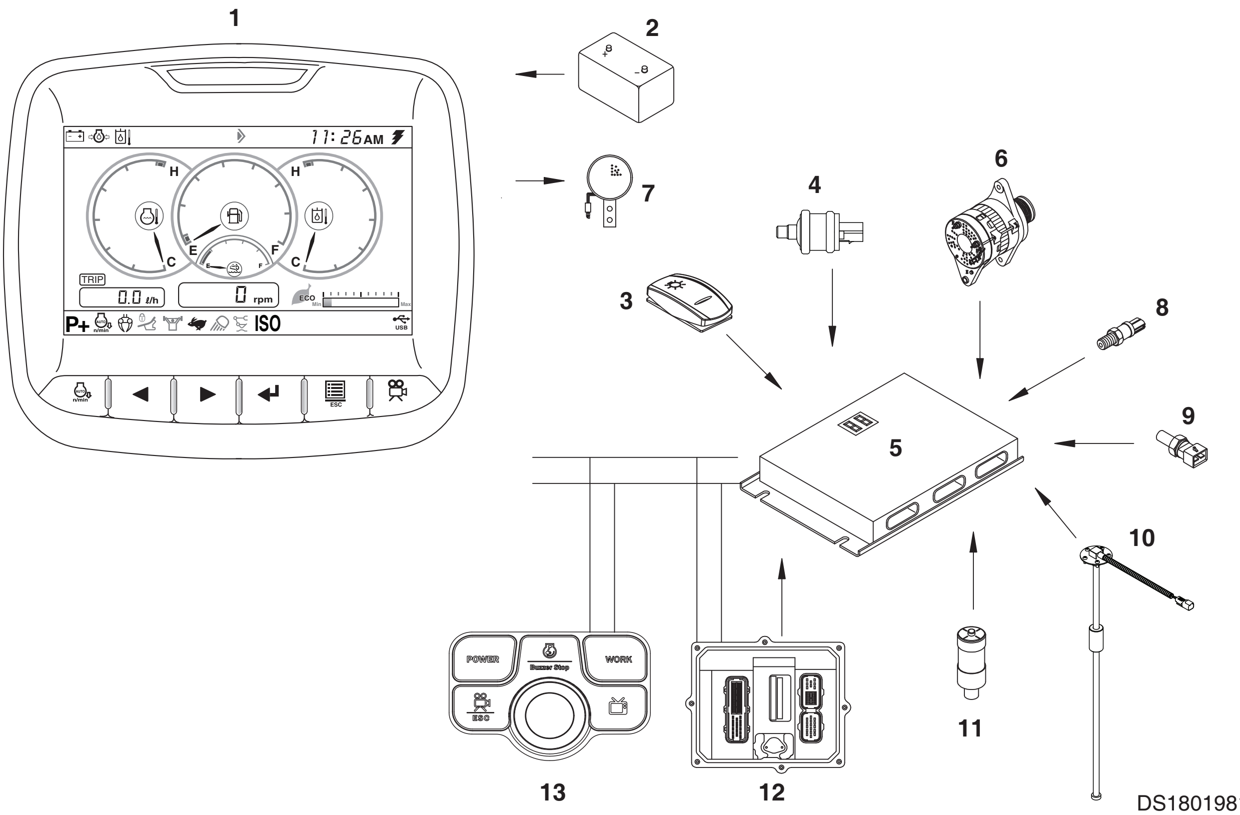


Figure 8

Reference Number	Description
1	Instrument Panel
2	Battery
3	Light Switch
4	Return Filter Switch
5	EPOS Controller
6	Alternator
7	Warning Buzzer

Reference Number	Description
8	Pump Discharge Pressure Sensor
9	Hydraulic Oil Temperature Sensor
10	Fuel Sensor
11	Air Cleaner Indicator
12	Engine Controller
13	Jog Switch Control Panel

The monitoring system displays the various data and warning signals onto the instrument panel by processing the information gathered from the EPOS controller. It displays information selected by the operator.

Instrument Panel

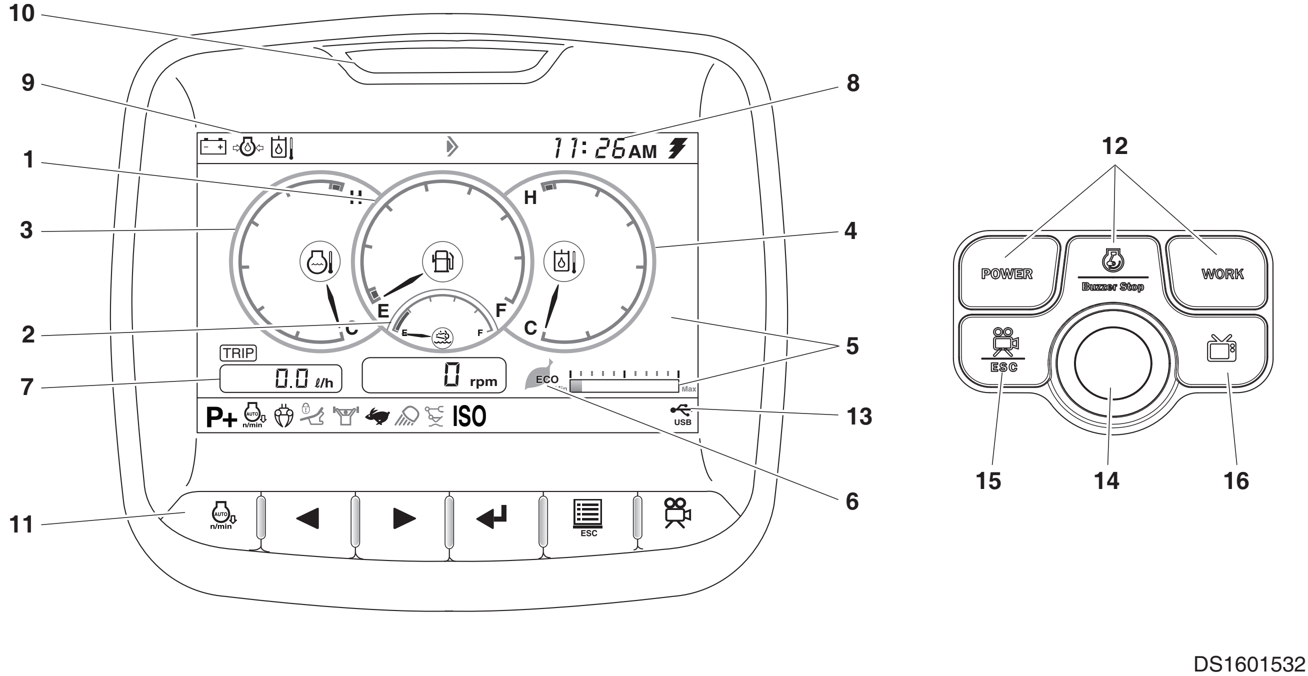


Figure 9

Reference Number	Description
1	Fuel Gauge
2	DEF (AdBlue) Level Gauge
3	Engine Coolant Temperature Gauge
4	Hydraulic Oil Temperature Gauge
5	Multifunction Gauge and Graphic Information Area
6	ECO Gauge
7	Trip Rate
8	Digital Clock

Reference Number	Description
9	Display Warning Symbols
10	Warning Light
11	Function Buttons
12	Mode Selector Buttons
13	Selector Function Display
14	Jog Switch
15	Camera Mode Selector/ ESC Button
16	Multimedia Selector Button

Functional Check

When the engine starter switch is turned to "I" (ON) position, all gauge bands, switch/button indicator lights and warning lights will turn "ON" and the alarm buzzer will sound for about three (3) seconds.

During this functional check, a LOGO will appear on the multifunction gauge in the graphic information area (3 and 4, Figure 9).

Monitoring System Schematic

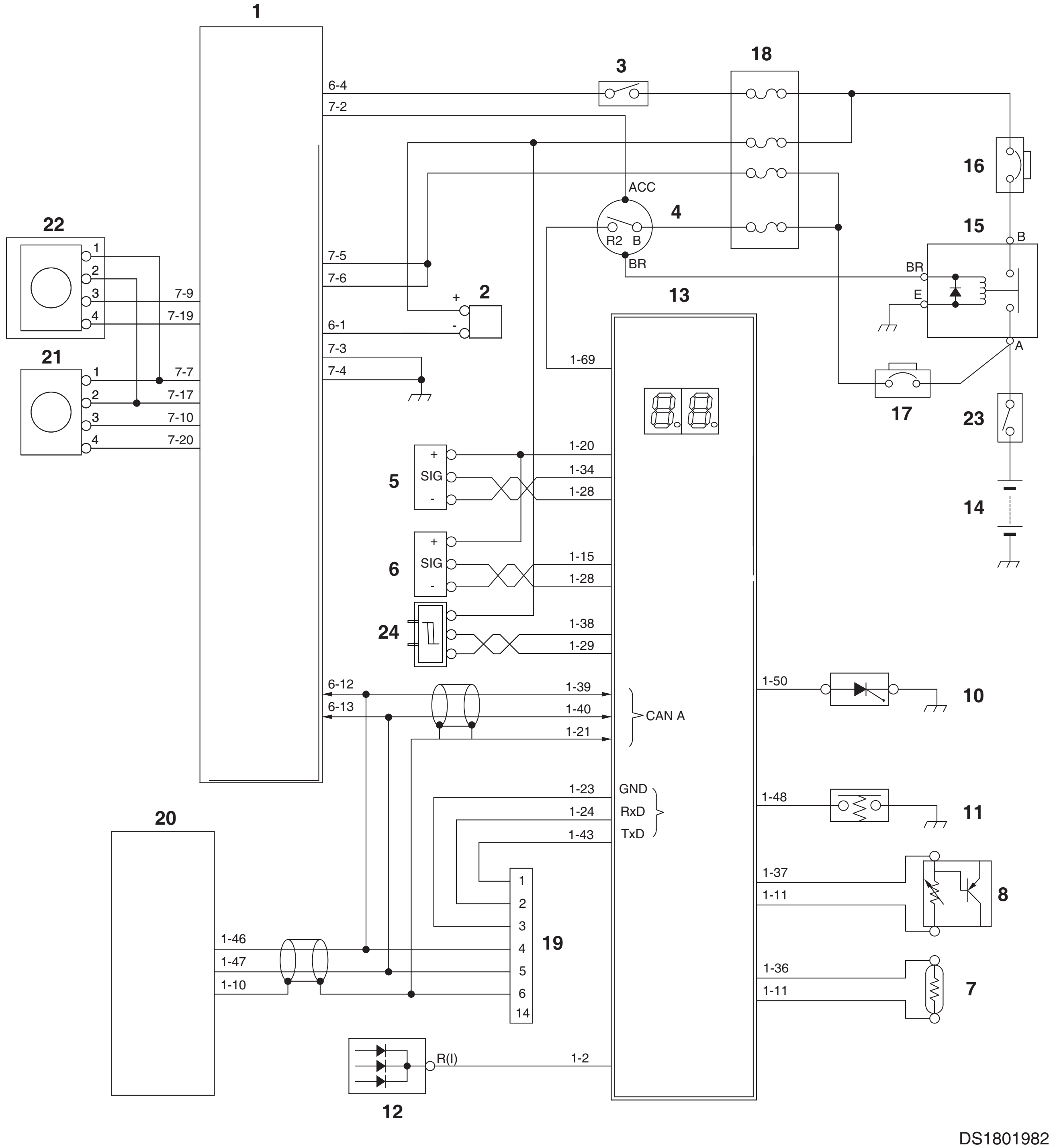


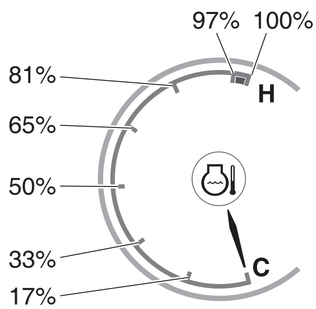
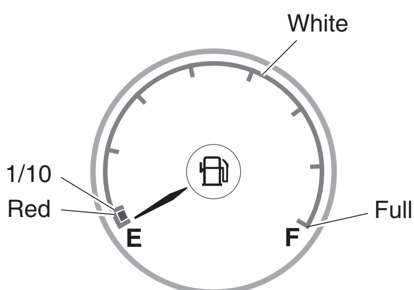
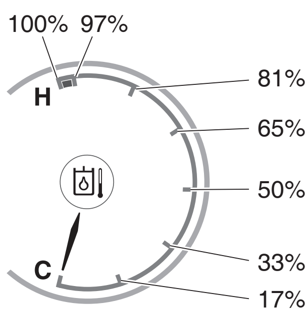
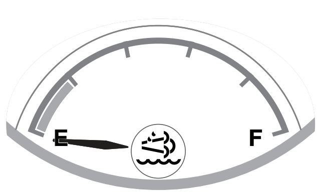
Figure 10

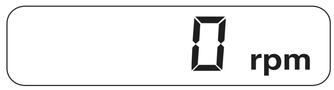
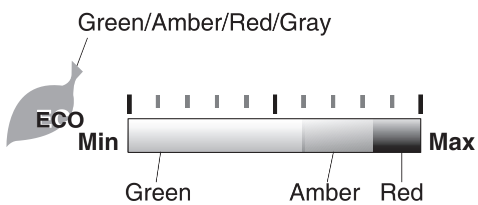
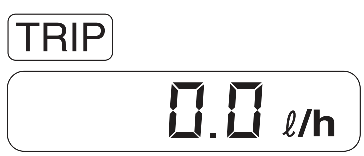
Reference Number	Description
1	Instrument Panel
2	Pilot Buzzer
3	Light Switch
4	Starter Switch
5	Front Pump Pressure Sensor
6	Rear Pump Pressure Sensor
7	Hydraulic Oil Temperature Sensor
8	Fuel Sensor
9	Pedal Pressure Switch (Optional)
10	Air Cleaner Indicator
11	Return Filter Switch
12	Alternator

Reference Number	Description
13	EPOS Controller
14	Battery
15	Battery Relay
16	Circuit Breaker 2
17	Circuit Breaker 1
18	Fuse Box
19	Check Connector
20	Engine Controller
21	Rearview Camera
22	Sideview Camera (Optional)
23	Master Switch
24	WIF Sensor

OPERATION

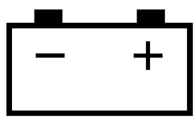
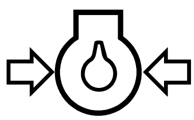
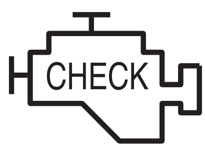
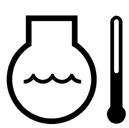
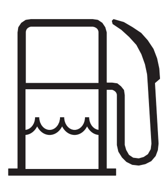
Instruments

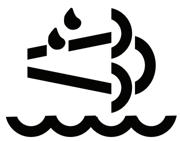
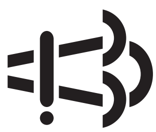
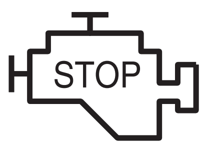
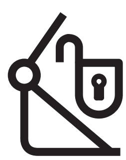
Function	Display	Sensor Specification	
		Input Terminal	Input Specification
Coolant Temperature	 EX1300991	ECU-CAN Communication	17% (47°C) 33% (63°C) 50% (89°C) 65% (99°C) 73% (103°C) (Tropical Zone Mode) 81% (107°C) (Warning Start) 97 % (110°C) 100 % (112°C)
Fuel Level	 EX1301123	CN1-37 CN1-11	1/10 LCD (Red Zone) Blinking → over 5K ohms FULL → under 525 ohms
Hydraulic Oil Temperature	 EX1300992	CN1-36 CN1-11	17% (38°C) 33% (46°C) 50% (85°C) 65% (94°C) 81% (96°C) 84% (97°C) (Tropical Zone Mode) 97% (99°C) (Warning Start) 100% (100°C)
DEF (AdBlue) Level Gauge	 EX1300993	ECU-CAN Communication	5% → Min. 20% → Red Zone 100% → Max.

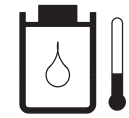
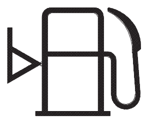
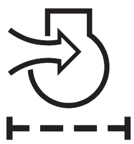
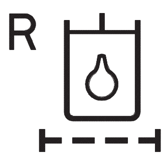
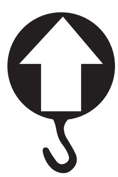
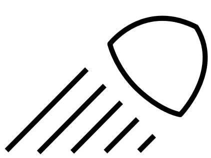
Function	Display	Sensor Specification	
		Input Terminal	**Input Specification**
Tachometer	 EX1301378	ECU-CAN Communication	
ECO Gauge	 EX1300994	EPOS-CAN Communication	ECO symbol: The instant workload - Green: Normal operation - Amber: Idling operation - Red: Heavy loading operation - Gray: ECO symbol off ECO gauge: The average fuel efficiency for 1 minute - Green: Fuel efficiency is good - Amber: Fuel efficiency is normal - Red: Fuel efficiency is not good
Trip Meter	 EX1300995	EPOS-CAN Communication	Amount of fuel use (ℓ) Operating hours (hr) Average fuel efficiency (ℓ/hr) Daily average fuel efficiency (ℓ/hr)

WARNING AND INDICATOR LIGHTS

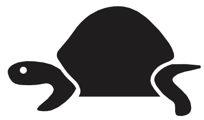
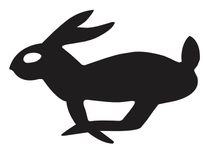
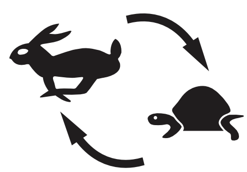
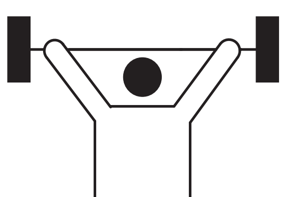
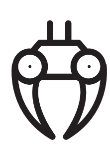
Indication of Warning Lights

Description	Symbol	Input Terminal	Operation	Remarks
Charge	 HAOA610L	CN1-2	This symbol appears in case of no charge [voltage of engine controller engine running terminal is below or overcharge] [voltage of engine controller engine running 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 fault in engine system.	
Coolant Temperature	 HAOD350L	ECU-CAN Communication	This symbol appears when engine coolant temperature sensor resistant is above about 107°C (225°F).	
Water Separator	 DS1603475	CN1-29 CN1-38	The WIF sensor voltage is under 1.5 ±0.5 V, because moisture is detected in fuel.	

Description	Symbol	Input Terminal	Operation	Remarks
DEF (AdBlue) Low	 FG019175	ECU-CAN Communic ation	Europe: 20%: Light on 10%: Flashes every 2 seconds 5%: Flashes every 0.5 seconds America: 20%: Light on 10%: Light on 5%: Flashes every 0.5 second	
SCR Fault	 FG019176	ECU-CAN Communic ation	Alarm notifying abnormal operation at the post processing side of the SCR system. Check the ECU malfunction from the current malfunction information.	
Engine Stop	 FG019003	ECU-CAN Communic ation	This symbol appears in case of fault in the engine system.	
Quick Coupler	 EX1301541	CN1-77	This symbol appears when quick coupler is operated.	The warning buzzer sounds simultaneously when quick coupler is operated.
Vehicle Check	 EX1301542	EPOS-CAN Communic ation	This symbol appears when a breakdown occurs to the vehicle.	
Vehicle STOP	 EX1301543	EPOS-CAN Communic ation	This symbol appears when there is an irregularity in the vehicle.	

Hydraulic Oil Temperature	 FG000056	CN1-36 CN1-11	When hydraulic oil temperature is above about 98°C.	
Fuel Exhausted	 FG000057	CN1-37 CN1-11	When fuel is almost exhausted.	
Air Cleaner	 FG000053	CN1-50	When air cleaner is clogged.	
Return Filter	 FG000054	CN1-48	When return filter pressure is above about 1.50 bar (21 psi)	
Overload Warning	 FG000253	CN1-32 CN1-28	Warning buzzer also starts when boom pressure sensor output voltage is about 2.68 V while overload warning switch is "ON".	It flashes in case of 2.68 V and above and lights continuously in case of 2.77 V and above (and warning buzzer also starts).
Work Light	 HB4O2003	CN1-79	This symbol appears when work light turns "ON" (24 V applied).	

Indication of Multifunction Gauge

Description	Symbol	Input Terminal	Operation	Remarks
Low-speed Travel	 EX1301575		Basic run mode	
High-speed Travel	 EX1301577	CN1-80	This symbol appears when high-speed run mode switch is operated.	It only operates when the auto idle pressure is 10.5 bar or more during running and the high-speed run solenoid valve is operated.
Automatic Travel	 EX1301577	CN1-61 CN1-80	This symbol appears when the automatic run mode switch is operated.	When the auto idle pressure is 10.5 bar or more, dial voltage is less than 2.5 V and pump pressure is 153.7 bar during running, the high-speed run solenoid valve is operated.
Intelligent Floating Boom	 EX1301578	CN1-54	This symbol appears when the Intelligent floating boom switch is operated.	
Voltage step-up	 FG000554	CN1-81	This symbol appears when the voltage step-up switch is operated or the lift mode is selected.	If the Voltage step-up switch is operated or the lift mode is selected, the voltage step-up solenoid valve is operated.
Log Loader Mode	 DS1602668	Jog Switch CAN Communic ation	This symbol appears when the log loader mode is selected.	

Description	Symbol	Input Terminal	Operation	Remarks
ISO Mode	**ISO** EX1301585	CN2-86	This symbol appears when the ISO mode is selected.	It appears only for the vehicle with pattern change option.
BHL Mode	**BHL** EX1301586	CN2-94	This symbol appears when BHL mode is selected.	It appears only for the vehicle with pattern change option.

INITIAL OPERATION

Item	Input (Terminal)	Output (Operation and Initial Setting Mode)
Initial Operation	When "CN7-2" is applied battery voltage (starter switch) shifts from "OFF" to "ON"	• Warning buzzer is activated and turned "OFF" after about 3 seconds. • Power mode: When Fuel Saving Mode is disabled, the power mode is the previous mode. When Fuel Saving Mode is enable, the power mode is standard mode or economy mode. • Auto Idle: High Output (Activation). • Display: Indicating coolant temperature, fuel level, hydraulic oil temperature, engine speed, DEF (AdBlue) level, trip meter. • Clock: Current time display.

NOTE: *Refer to method for setting clock in operation manual for setting time.*

GRAPHIC INFORMATION AREA DISPLAY

Overview

Machine condition is displayed in the letter information display department. The information display department is divided into two menus. One is main menu for the user and the other is a special menu for the specialist. These menus can be changed from normal display mode by the jog switch.

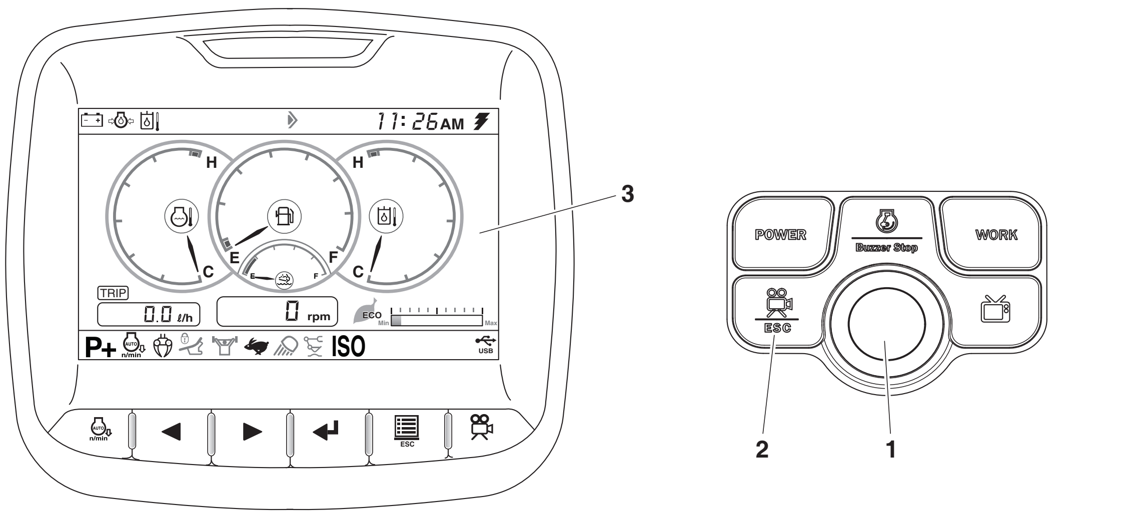


Figure 11

Selector Buttons	Graphic Display Area
1. Jog Switch	3. Letter Information Display Department
2. Escape Button	

Main Menus for the Graphic Display Area

1. User menu: Language setting, Time setting, Filter/Oil information, Brightness adjustment, Password
2. Special menu: Information of machine status, fault information, Information of machine operation.

Menu Selector Buttons

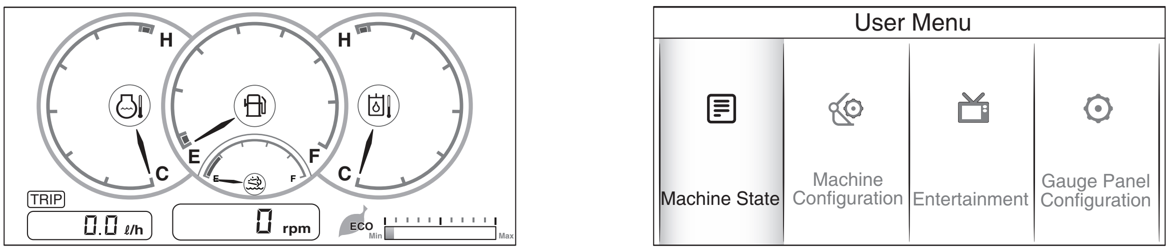
1. Jog Switch (1 on Figure 11): Move cursor and set menu.
2. Escape Button (ESC, 2 on Figure 11): Move a screen to previous menu or main menu.

USER MENU

User Menu - Access and Escape Methods

Access Method

1. On the normal display screen, click on the jog switch to access the user menu screen.
2. Proceed to the user menu using the menu/esc button on the front of the dashboard.
3. Select the user menu from the launch menu.



<Normal Indication Monitor>

<Main Menu Monitor>

DS1601342

Figure 12

Escape Method

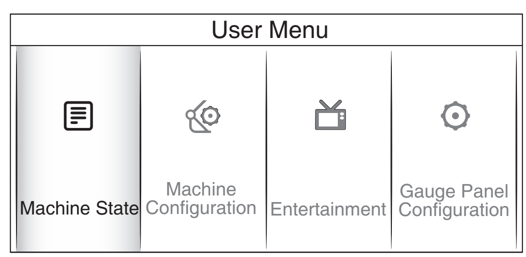
1. Press the ESC button to move to the normal display screen.
2. If 20 seconds have passed without the operation of the button, the normal display screen will be displayed.
3. Turning "OFF" the starter switch to cut off power, you will move to the normal display screen.

User Menu

Turn the jog switch and move the cursor to see a reversed display on the desired menu. Then, click on the jog switch to select the menu.

Machine State ↔ Machine Configuration ↔ Entertainment ↔ Gauge Panel Configuration

Press the ESC button to return to the previous screen.



DS1601343

Figure 13

WARNING

AVOID DEATH OR SERIOUS INJURY

Do not use machine state menu when traveling or operating.

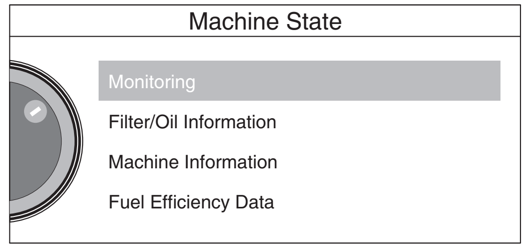
1. Machine State

This is used to check the current machine state, filter/oil information, machine information, etc.

Turn the jog switch and move the cursor to see a reversed display on the desired menu. Then, click on the jog switch to select the menu.

Monitoring ↔ Filter/Oil Information ↔ Machine Information ↔ Fuel Efficiency Data

Press the ESC button to return to the previous screen.



DS1601344

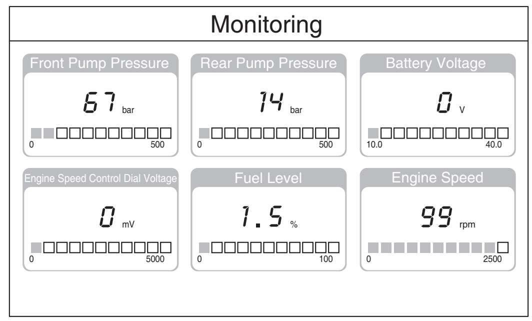
Figure 14

A. Monitoring

The monitoring screen displays the information on machine pump pressure, voltage, fuel level, etc.

At the machine state, if the cursor is placed on Monitoring, click on the jog switch to display the Monitoring screen.

Press the ESC button to return to the previous screen.



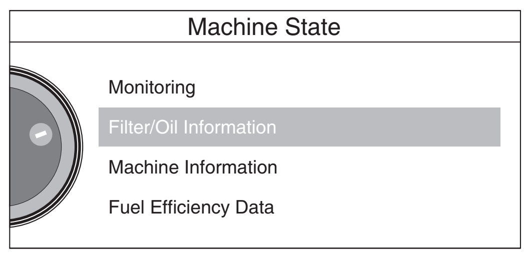
DS1601345

Figure 15

B. Filter/Oil Information

The screen displays the information on filter/oil use time, replacement period, and remaining time.

At the machine state, if the cursor is placed on the filter/oil information, click on the jog switch to display the filter/oil information.



DS1601346

Figure 16

Reset Method/Replacement Period Change Method

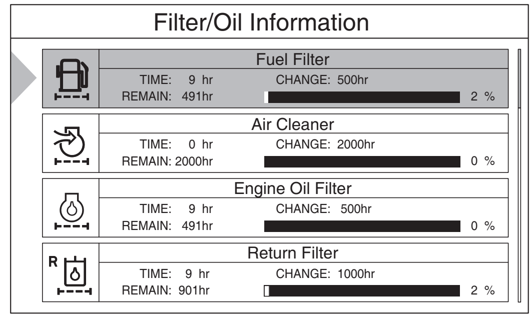
Move the cursor over the filter/oil item you wish to change using the jog switch or the ◀ and ▶ buttons on the front of the dashboard and click the jog switch or press the 'Enter' button on the front of the dashboard. A window for resetting/changing the filter/oil time will pop-up.

To reset the use time, move the cursor over 'clear' and click the jog switch or press the 'Enter' button on the front of the dashboard.

Turn the jog switch to locate it at YES. Then, click on the jog switch to reset the operation hour.

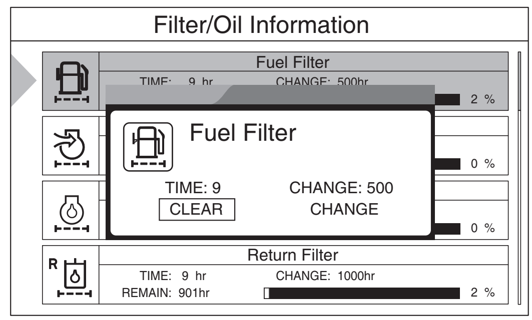
Turn the jog switch to locate it at NO. Then, click on the jog switch to allow the pop-up window to disappear without resetting the operation hour.

– The filter/oil use time shows the hours of operation after initializing the engine. It begins again with 0 hr after initialization the following the replacement of filter/oil.



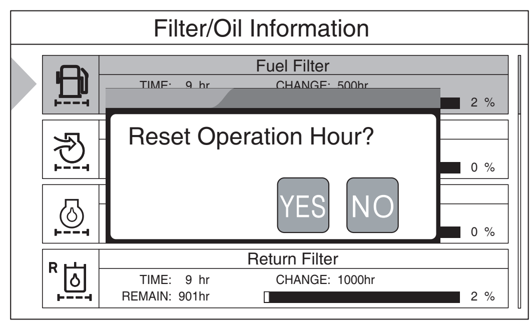
DS1601347

Figure 17



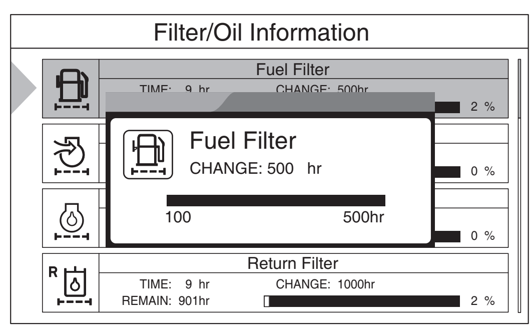
DS1601348

Figure 18



DS1601349

Figure 19



DS1601350

Figure 20

To change the filter/oil exchange period, move the cursor over 'change' in the window for resetting/ changing the filter/oil time and click the jog switch or press the 'Enter' button on the front of the dashboard.

After the exchange period change screen pops up, click the jog switch or press the 'Enter' button on the front of the dashboard and the exchange time will start flashing.

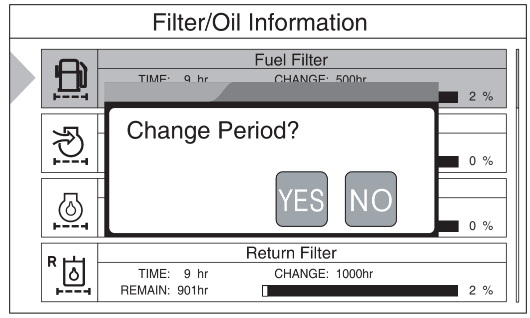
Next, change the exchange period using the jog switch or the ◀ and ▶ buttons on the front of the dashboard.

Then, turn the jog switch counterclockwise to reduce the period. Turn clockwise to extend the period.

With the replacement period change being completed, click on the jog switch to create a pop-up window to select the period change.

Turn the jog switch to locate it at YES. Then, click on the jog switch to change the replacement period.

Turn the jog switch to locate it at NO. Then, click on the jog switch to allow the pop-up window to disappear without the replacement period not being changed.



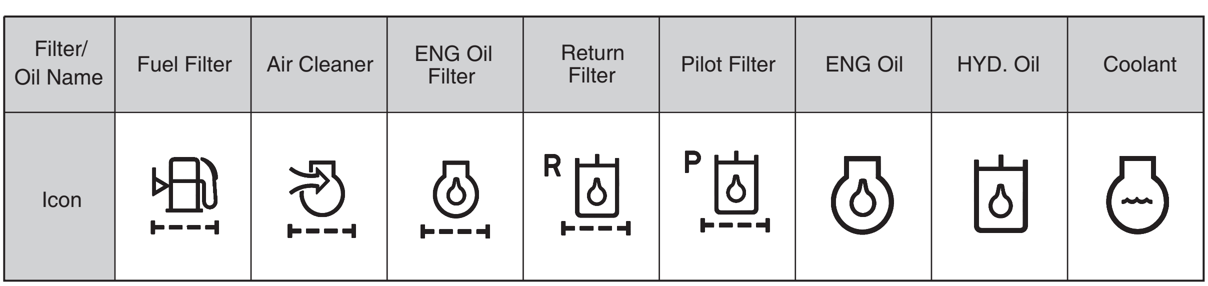
DS1601351

Figure 21

Filter/Oil Period Setup Table Unit: hr

Kind	Replacement Period		
	Basic Setup Value	**Minimum Available Setup Value**	**Change Value By Step**
Fuel Filter	500	100	50
Air Cleaner	2,000	1,000	50
Engine Oil Filter	500	100	50
Return Filter	1,000	100	50
Pilot Filter	1,000	100	50
Engine Oil	500	100	50
Hydraulic Oil	2,000	1,000	50
Coolant	2,000	1,000	50

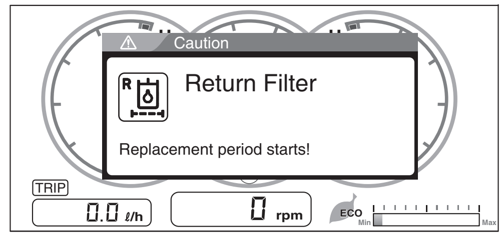
Symbol Description



DS1601604

Figure 22

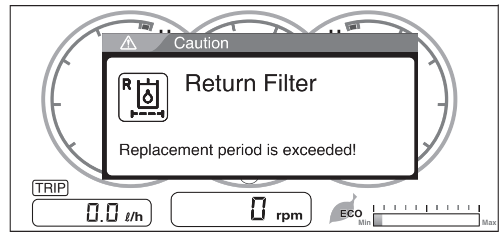
If the remaining time for filter/oil replacement is less than 10 hours, this pop-up window will be created. Press the ESC button or the jog switch to allow the pop-up window to disappear.



DS1601352

Figure 23

If the filter/oil replacement period is exceeded, this pop-up window will be created. Press the ESC button or the jog switch to allow the pop-up window to disappear.



DS1601353

Figure 24

⚠ WARNING

AVOID DEATH OR SERIOUS INJURY

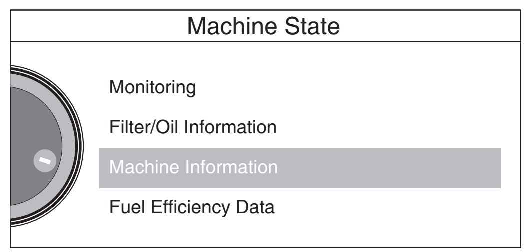
Do not use machine state menu when traveling or operating.

C. Machine Information

This is used to check the machine name, engine type and attachment options.

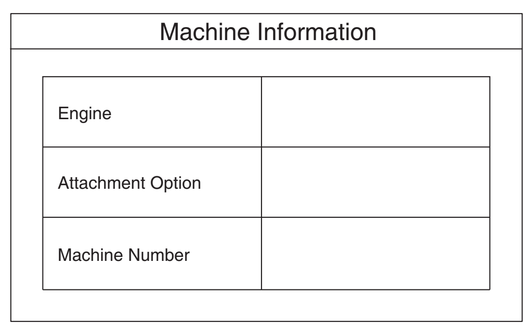
At the machine state, if the cursor is placed on the machine information, click the jog switch to access the machine information screen.

Click the ESC button to return to the previous screen.



DS1601354

Figure 25

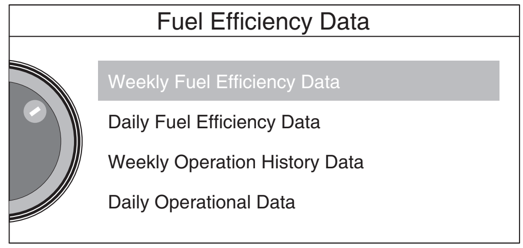


WE1500736

Figure 26

D. Fuel Efficiency Data

It is possible to check the weekly fuel efficiency data, daily fuel efficiency data, weekly operation history data and daily operation data.

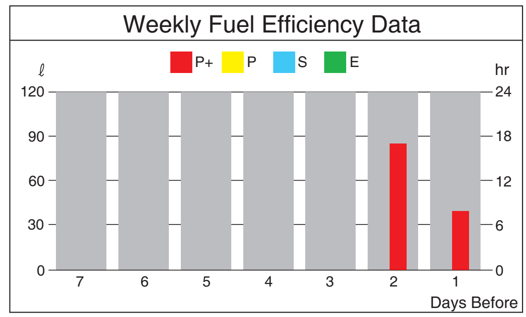


DS1601355

Figure 27

1) Weekly Fuel Efficiency Data

The amount of fuel used by each operating mode in a week can be checked.

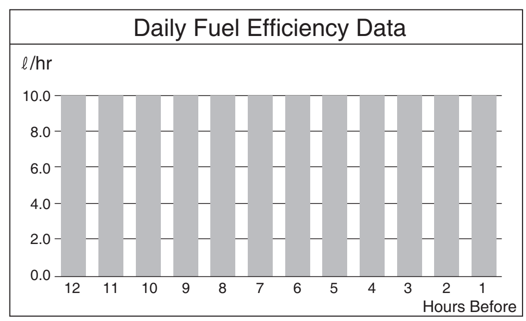


EX1402170

Figure 28

2) Daily Fuel Efficiency Data

The amount of fuel used in a day can be checked.



EX1402171

Figure 29

3) Weekly Operation History Data

The amount of fuel used, operating period and daily average fuel efficiency in a week can be checked.

Weekly Operation History Data

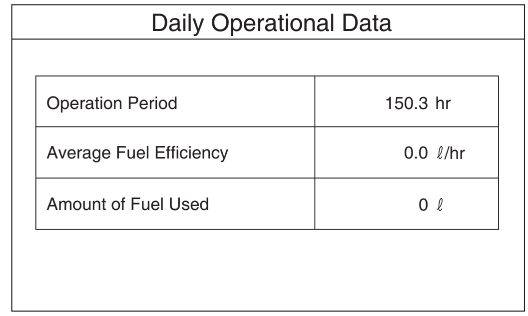
Days Before	Amount of Fuel Used	Operation Period	Daily Average Fuel Efficiency
1	0 ℓ	9.1 hr	0.0 ℓ/hr
2	0 ℓ	16.6 hr	0.0 ℓ/hr
3	0 ℓ	0.0 hr	0.0 ℓ/hr
4	0 ℓ	0.0 hr	0.0 ℓ/hr
5	0 ℓ	0.0 hr	0.0 ℓ/hr
6	0 ℓ	0.0 hr	0.0 ℓ/hr
7	0 ℓ	0.0 hr	0.0 ℓ/hr

EX1402172

Figure 30

4) Daily Operational Data

The operation period, average fuel efficiency and amount of fuel used in a day can be checked.



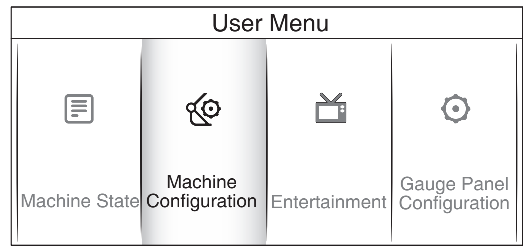
EX1402173

Figure 31

2. Machine Configuration

This is used when selecting the functions such as camera setting, forced dial input and auto shut-off setting.

Turn the jog switch and move the cursor to see an reversed display on the desired menu. Then, click the jog switch to select the menu.

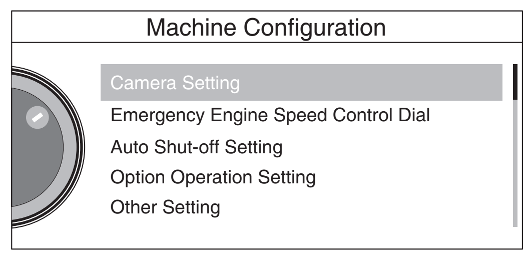


DS1601356

Figure 32

Camera Setting ↔ Emergency Engine Speed Control Dial ↔ Auto Shut-off Setting ↔ Option Operation Setting ↔ Other Setting ↔ Breaker Operation Time Setting

Press the ESC button to return to the previous screen.



DS1601357

Figure 33

A. Camera Setting

The camera setting screen is designed to set up various cameras "ON/OFF" and normal/mirror.

From the machine configuration, select camera setting to access the camera setting list screen.

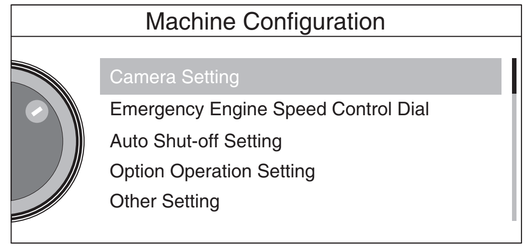


Figure 34

The camera setting list screen displays various camera states (ON/OFF, NORMAL/MIRROR).

Select a camera and click the jog switch to access the relevant camera setting screen.

Press the ESC button to return to the previous screen.

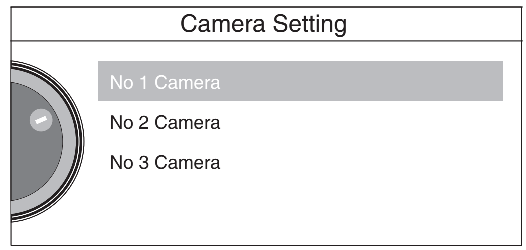


Figure 35

On the camera setting screen, set up the camera state (ON/OFF, NORMAL/MIRROR).

Also, see the actual image of the currently installed camera.

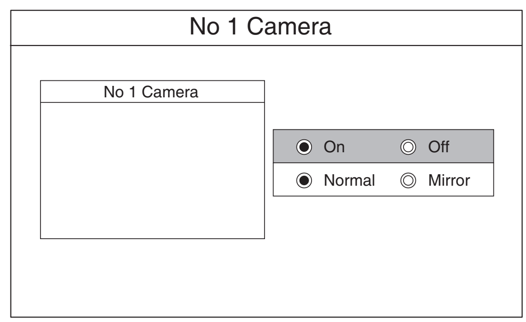


Figure 36

If a camera is not installed, the camera image section is shown as a blue screen.

If the cursor is placed on "ON/OFF", click on the jog switch to set up "ON" ↔ "OFF".

Turn the jog switch to locate the cursor at normal/ mirror. Then, click on the jog switch to set up normal ↔ mirror.

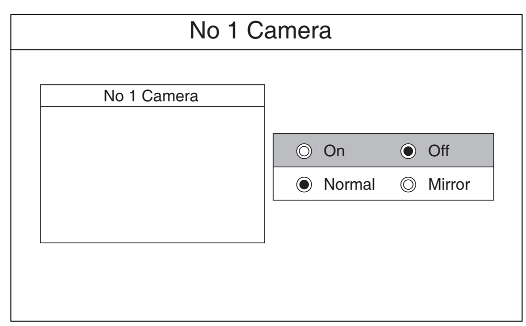


Figure 37

B. Emergency Engine Speed Control Dial

The emergency engine speed control dial screen provides a method whereby to use the jog switch and control the engine rpm, replacing the engine control dial.

From the machine configuration, select the emergency engine speed control dial to access it.

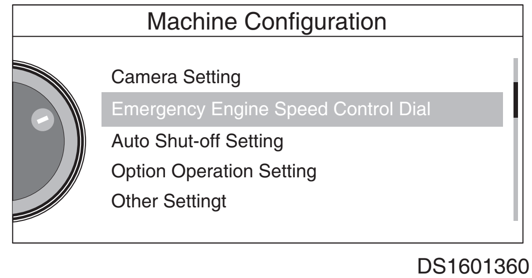


Figure 38

If you access the emergency engine speed control dial screen, the initial cursor is located at the selector dial.

If the selector dial is shown as disable, the cursor cannot be moved.

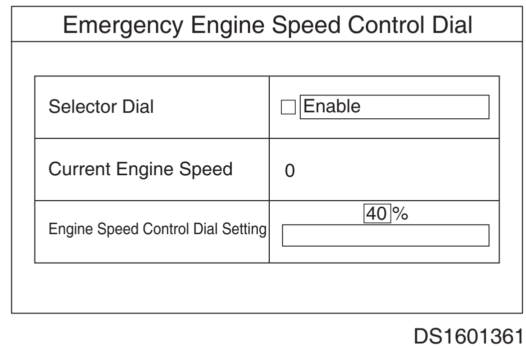


Figure 39

When the cursor is placed at the selector dial, if you click on the jog switch, a pop-up window will be created, saying "Do you want to use manual Dial Control for Engine rpm?".

Operate the jog switch and select "YES/NO" to determine whether to use jog shuttle for dial.

If you select "YES", then selector dial is enabled, causing the pop-up window to disappear.

If you select "NO", then selector dial remains disabled, causing the pop-up window to disappear.

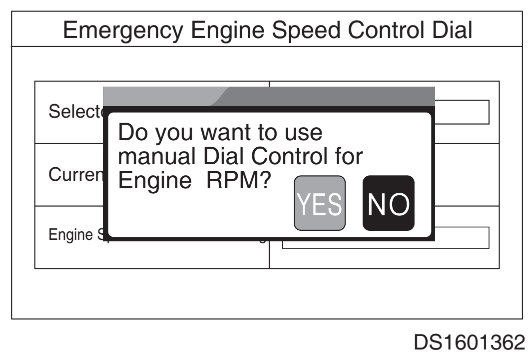


Figure 40

If the selector dial is shown as enable, operate the jog switch clockwise and move the cursor to the setting rpm dial. When the cursor is placed at the setting rpm dial, click on the jog switch to cause the cursor to flicker, changing into an editing mode to set up the rpm dial. When the cursor is placed at the editing mode, operate the jog switch clockwise/ counterclockwise, thus setting up the engine rpm.

When the cursor is at the editing mode, press the ESC button to disable the editing mode. When the cursor is not at the editing mode, press the ESC button to return to the previous screen.

Before reboot the gauge panel or disabling the selector dial, control the engine rpm only with the shuttle of the gauge panel's jog shuttle.

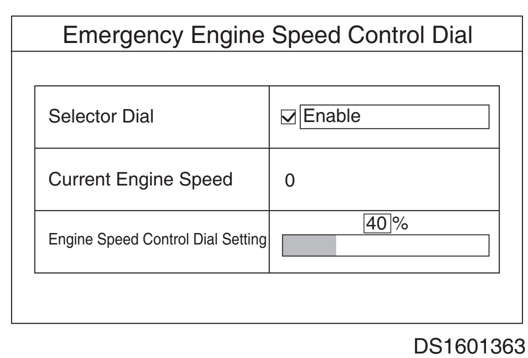
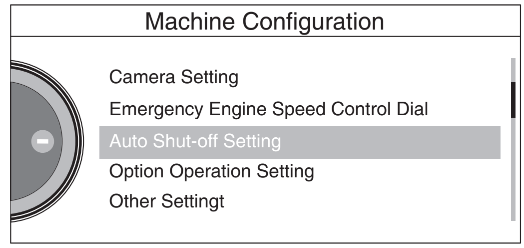


Figure 41

C. Auto Shut-off Setting

In the auto shut-off setting screen, the engine of the equipment can be set to shut off automatically when the equipment is not operated for a preset time.

Select auto shut-off setting in the machine settings and proceed to the setting screen.



DS1601364

Figure 42

In the auto shut-off setting screen, the cursor will initially be over auto shut-off function in use.

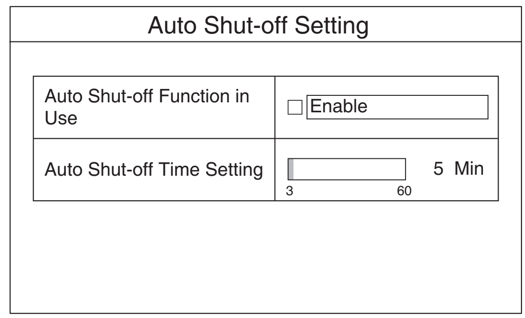
NOTE: *This feature is off in factory defaults.*

To use the feature, place the cursor over auto shut-off function in use and click the jog switch to select the feature.

The engine can be set to shut off automatically after a maximum of 60 minutes to a minimum of 3 minutes.

In factory defaults, the time is set to 5 minutes.
Further, this feature is off in factory defaults.

The following conditions must be met if this feature is to be used.



DS1601365

Figure 43

Auto Shut-off (ASD) Active Condition

	Input								Output		
	Gauge Panel Menu	**Auto Idle Mode**	**Pilot Cutoff Switch**	**Engine rpm**	**Coolant Temp.**	**Hydraulic Temp.**	**Dial Status**	**Time**	**Signal**	**Pop-up**	**Alarm**
Active	ON	ON	OFF	Low rpm	More than 50°C	More than 20°C	Normal	at Setting Time	Engine Stop Signal	1 minute Before Stopping	10 seconds Before Stopping
Deactive	Except Above Condition								Time Count Reset		

When this feature is activated and the above conditions are met, "Engine will shut off" will pop up 1 minute before the engine shuts off.
Further, 10 seconds before the engine shuts off, the pilot buzzer will be activated to alert the user.

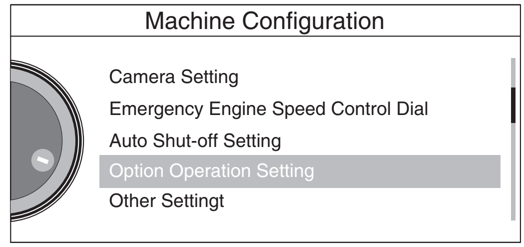
WARNING

AVOID DEATH OR SERIOUS INJURY

When the auto shut-off feature is used, the engine shuts off automatically after the preset time, and thus particular care must be taken that no safety problems occur when it is used.

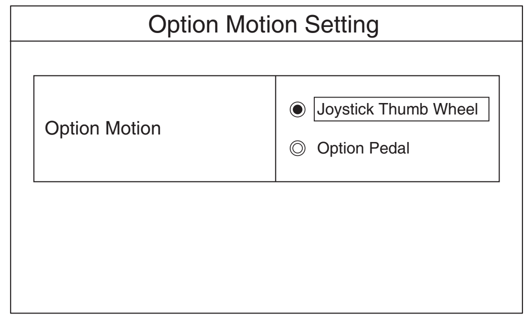
D. Option Operation Setting (Option)

This menu is not used in the machine.



DS1601366

Figure 44

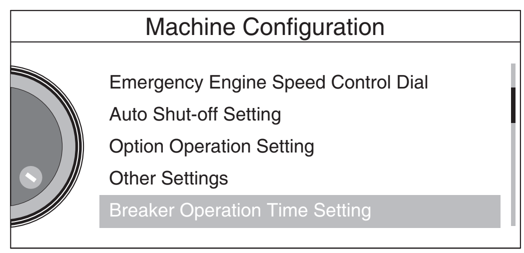


EX1301429

Figure 45

E. Breaker Operation Time Setting (Road Builder Only)

This machine limits the continuous operation time of the breaker in order to prevent damages to its components.

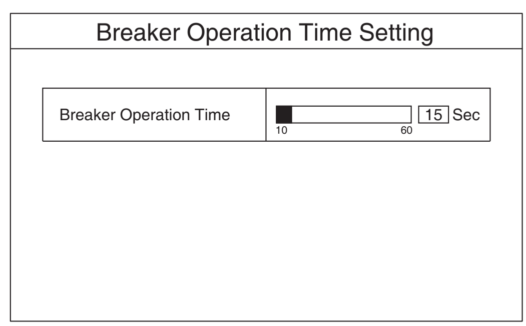


DS1601787

Figure 46

You can adjust this time limit in the page of Breaker Operation Time Setting.

- Setting Time Range: 10 ~ 60 sec
- Default Time: 15 sec



DS1601788

Figure 47

3. Entertainment

This menu is used to replay videos and MP3.

Turn the jog switch and move the cursor to see a reversed display on the desired menu. Then, click on the jog switch to select the menu.

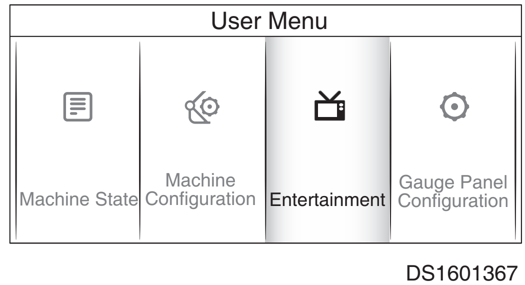


Figure 48

Video ↔ MP3

Press the ESC button to return to the previous screen.

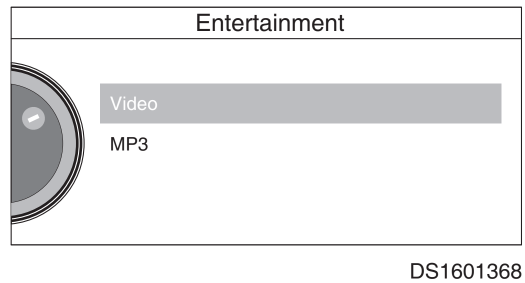


Figure 49

If the use of entertainment is limited, this pop-up window will be created.

To lift the use limits, you should change the limit setup in the Gauge Panel configuration.

The pop-up window will automatically disappear in 3 seconds. Press the ESC button or the jog switch to remove pop-up window.

For details, See ?$paratext>? on page -47.

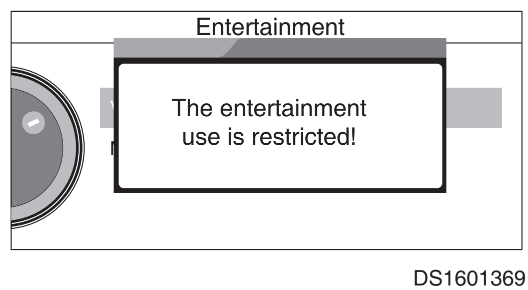


Figure 50

If the use of entertainment is not limited, this pop-up window will be created. The pop-up window will automatically disappear in 3 seconds.

Press the ESC button or the jog switch to remove pop-up window.

WARNING

AVOID DEATH OR SERIOUS INJURY

Listening to entertainment clips, such as video, music, etc., can cause an accident, resulting in death or serious injury. Do not play entertainment files when operating the machine.

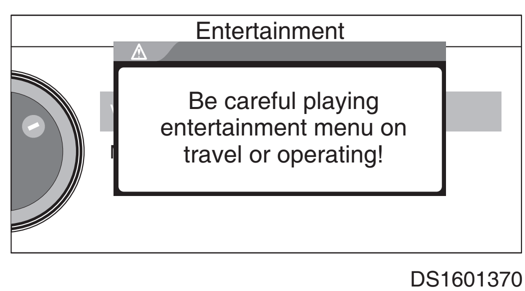
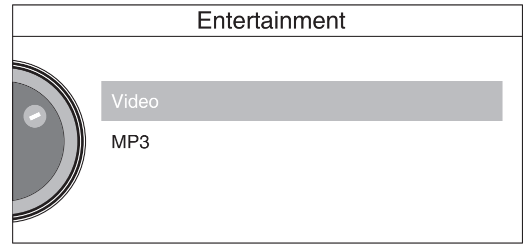


Figure 51

A. Video

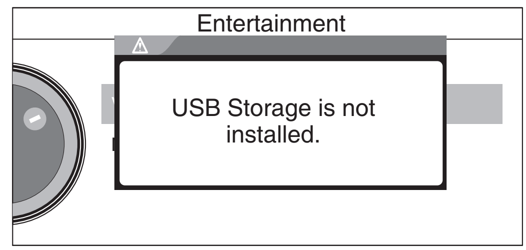
From the entertainment screen, select video to access it.



DS1601368

Figure 52

When there is no USB storage system, a pop-up window is displayed for 3 seconds, saying "USB" Storage is not installed". and the video is not played.

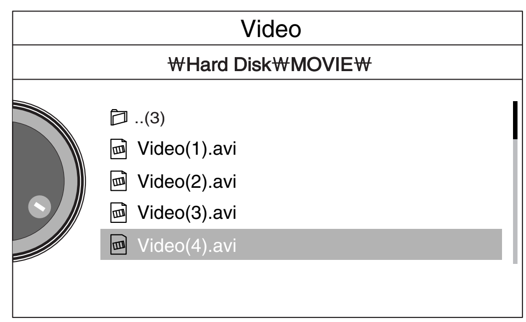


DS1601371

Figure 53

When initially accessing the video player, the USB storage system file tree is displayed on the screen, operate the jog switch clockwise/counterclockwise to select and play a video.

If there is a video file that played last, it will automatically be replayed.



FG018511

Figure 54

If the format is not supported, a pop-up window is displayed for 3 seconds, saying "This file is not available!" and the video is not played.

EX1301451

Figure 55

Formats that can be supported are given below.

Formats that can be supported	
File Type	AVI, MP4, MKV, MOV
Supported Resolution	720*480, 720*384, 720*304, 704*448, 704*304, 640*480, 640*360, 640*272, 640*352, 672*288, 512*384, 576*432, 480*320, 480*360, 320*240
Supported Video Codec	H.264, MPEG4, Xvid, MPEG1/2
Supported Audio Codec	MP3
Supported File Size	Under 1.7 GB
Supported USB Format	FAT32

The screen composition of the video player is given below.

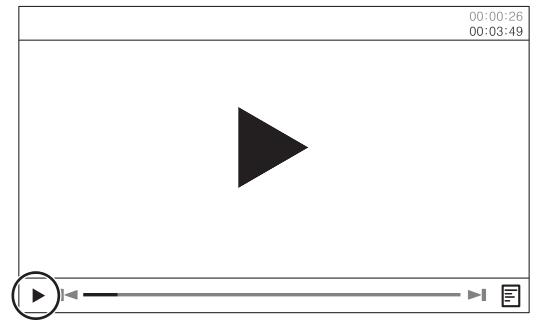
The top section displays the current playing time of the total playing time.

The screen center shows the video being played.

The bottom displays the video player function operation symbol and cursor.

The video player function operation symbol and jog switch are operated in the following order.

Play/Pause ↔ Replay the Previous File ↔ Video Progress Bar ↔ Replay the Next File ↔ Video Files List

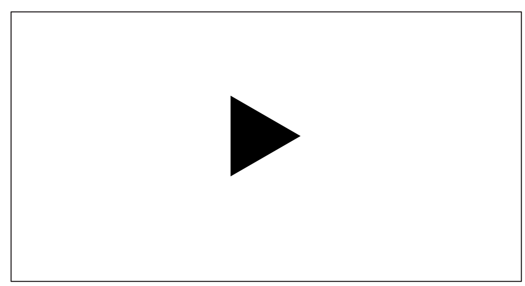


EX1301452

Figure 56

If no operation continues for more than 5 seconds, the video will automatically be converted into the whole screen.

On the whole screen, click on the jog switch or the ESC button to remove whole screen.



FG018214

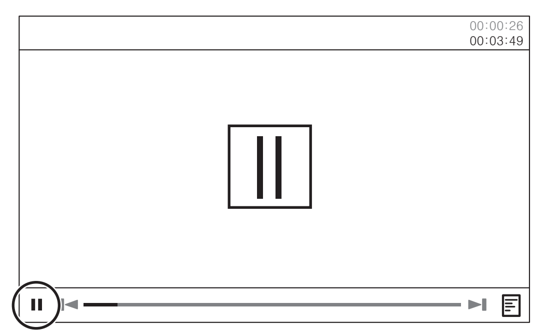
Figure 57

Play/Pause

Locate the cursor on the play/pause symbol and click on the jog switch to execute the video's play/pause functions.

With the play being on, click on the jog switch to display the pause symbol at the center of the screen, thus allowing the video to pause.

With the pause being on, click on the jog switch to cause the pause symbol at the center of the screen to disappear, resuming the video playing.

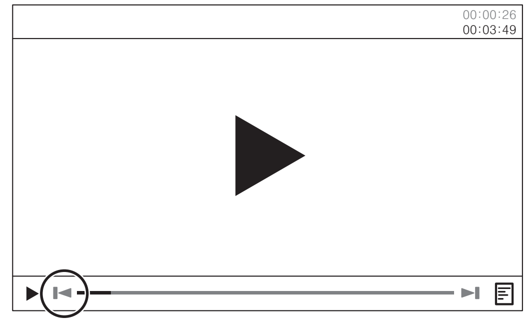


EX1301453

Figure 58

Replay the Previous File

Locate the cursor at the replay the previous file symbol and click on the jog switch to replay the previous file.



EX1301454

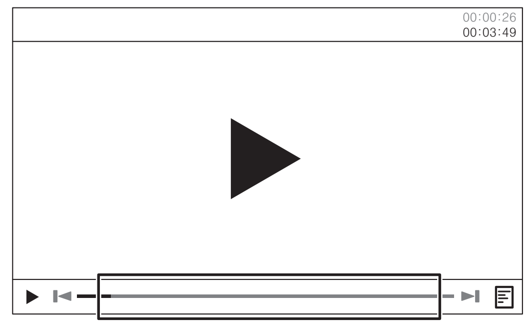
Figure 59

Locate the cursor at the video progress bar and click on the jog switch to convert into the fast forward/ rewinding mode.

On the fast forward/rewinding mode, operate the jog switch clockwise/counterclockwise to conduct fast forward/rewinding.

Fast forward/rewinding can be conducted at an interval of 30 seconds per click during which the jog switch is turned.

On the fast forward/rewinding mode, press the ESC button to disable the fast forward/rewinding mode.

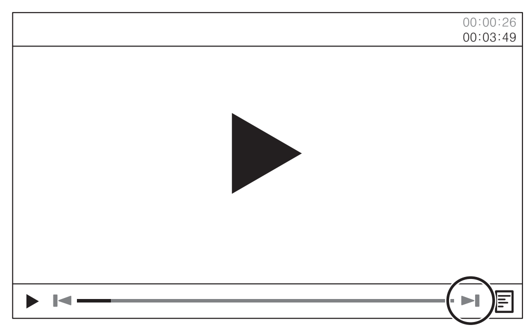


EX1301455

Figure 60

Replay the Next File

Locate the cursor at the replay the next file symbol and click on the jog switch to replay the next file.

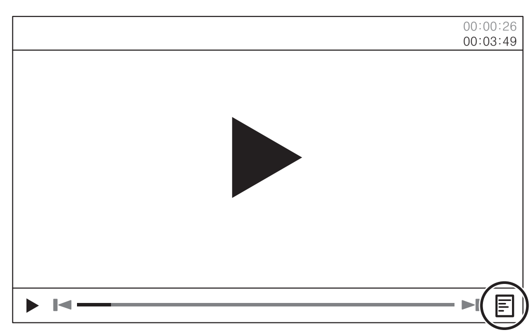


EX1301456

Figure 61

Video Files List

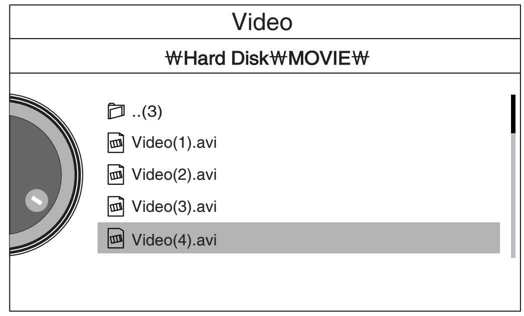
Locate the cursor at the video files list symbol and click on the jog switch to move to the video file list screen.



EX1301457

Figure 62

Select and replay a video.

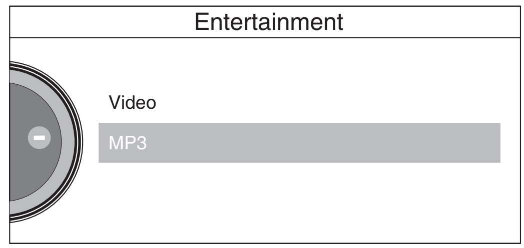


FG018557

Figure 63

B. MP3

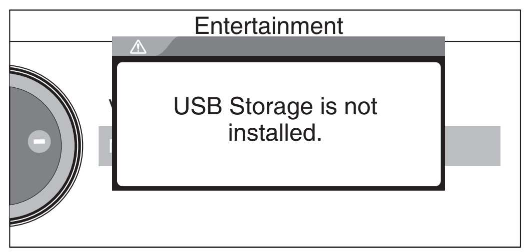
From the entertainment screen, select MP3 to access it.



DS1601372

Figure 64

If there is no USB storage system, a pop-up window is displayed for 3 seconds, saying "USB Storage is not installed". and the MP3 player is not run.

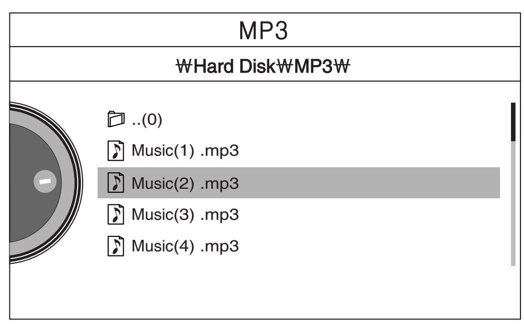


DS1601373

Figure 65

When initially accessing the MP3 player, the file tree screen of USB storage system is displayed. Operate the jog switch clockwise/counterclockwise to select and play an MP3 file.

If there is an MP3 file played last, the file will automatically be played.



FG018560

Figure 66

The screen composition of MP3 player is given below.

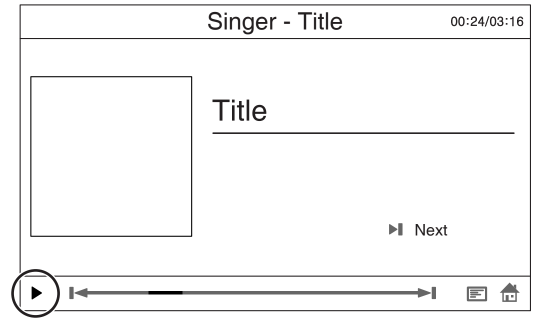
The top section displays the name of the file being played and the current playing time of the total playing time.

The screen center shows the album image of the file being played, the album name, the song name and the name of the next file to be played.

The bottom displays the MP3 player function operation symbol and cursor.

The MP3 player function operation symbol and jog switch are operated in the following order.

Play/Pause ↔ Replay the Previous File ↔ MP3 Progress Bar ↔ Replay the Next File ↔ MP3 Files List ↔ Background MP3 Play



FG020124

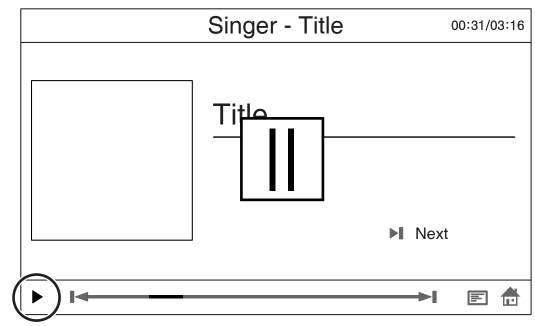
Figure 67

Play/Pause

Locate the cursor at the play/pause symbol and click on the jog switch to execute the MP3 play/pause functions.

With play being on, click the jog switch to display the pause symbol at the center of the screen, causing the MP3 to pause.

With pause being on, click on the jog switch to cause the pause symbol at the center of the screen to disappear, resuming the MP3 playing.

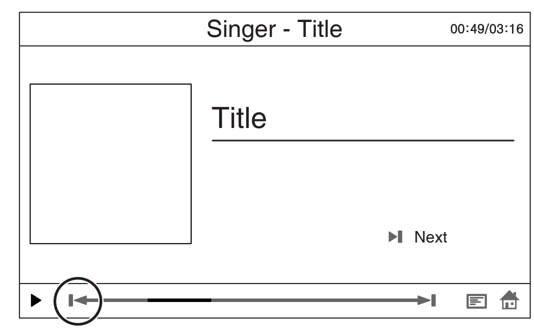


FG020125

Figure 68

Replay the Previous File

Locate the cursor at the replay the previous file symbol, and click on the jog switch to replay the previous file.



FG020126

Figure 69

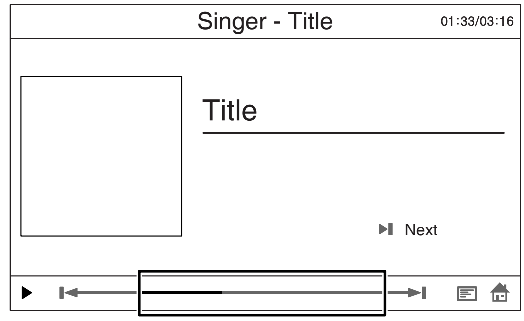
Fast Forward/Rewinding

Locate the cursor at the video progress bar and click on the jog switch to convert into the fast forward/ rewinding mode.

On the fast forward/rewinding mode, operate the jog switch clockwise/counterclockwise to conduct fast forward/rewinding.

Fast forward/rewinding can be conducted at an interval of 30 seconds per click during which the jog switch is turned.

On the fast forward/rewinding mode, press the ESC button to disable the fast forward/rewinding mode.

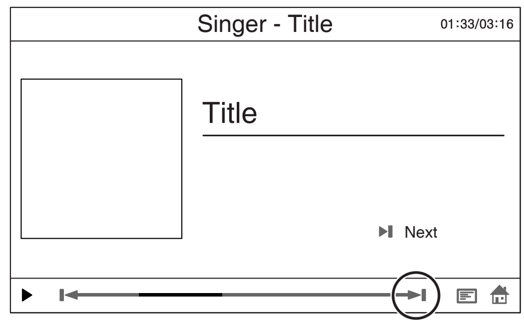


FG020127

Figure 70

Replay the Next File

Locate the cursor at the replay the previous file symbol and click on the jog switch to replay the next file.

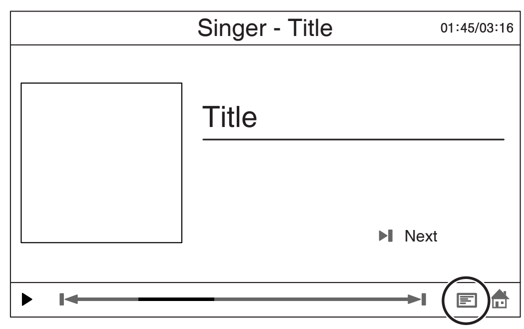


FG020128

Figure 71

MP3 Files List

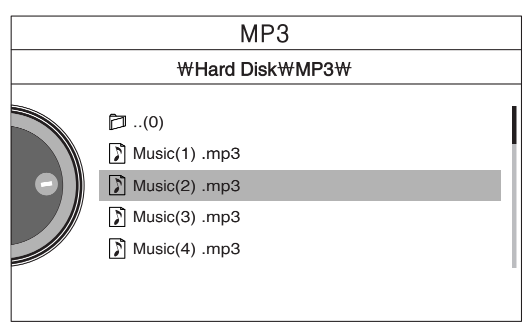
Locate the cursor at the MP3 files list symbol and click on the jog to move to the file list screen.



FG020129

Figure 72

Select a file and replay the MP3.

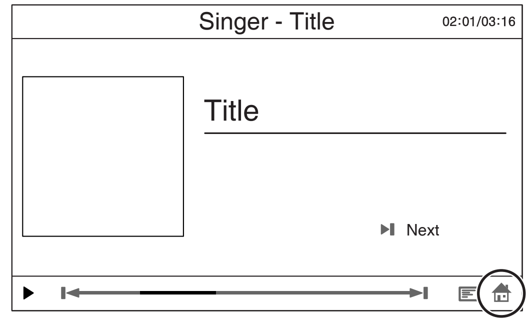


FG018560

Figure 73

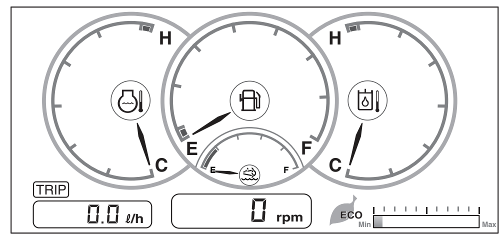
Background MP3 Play

Position the cursor on the "HOME" button and pressing the jog switch, MP3 is played by the initial screen.



FG020130

Figure 74



DS1601374

Figure 75

4. Gauge Panel Configuration

This menu is used to set up password, brightness, default screen and time, and to input service phone number. Turn the jog switch and move the cursor to see an reversed display on the desired menu. Then, click on the jog switch to select the menu.

Password Setting ↔ Brightness Setting ↔ Default Power Mode Setting ↔ Default Screen Setting ↔ Time Setting ↔ Service Phone Number Setting ↔ Unit Setting ↔ Language Setting ↔ Notification Setting ↔ Entertainment Use Setting

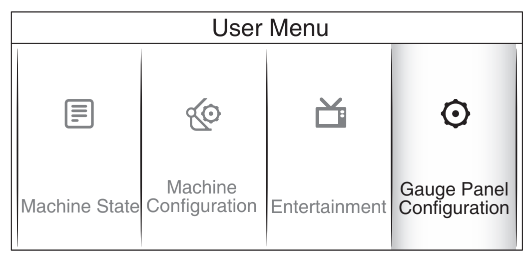
Press the ESC button to return to previous screen.

A. Password Setting

Password Setting

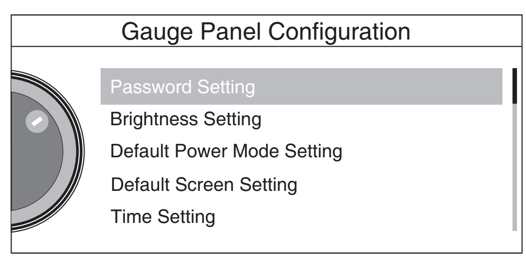
An owner passwords and user passwords can be set (Only the owner password is selected in the default shipment state).

By using the password setting function, you can manage usage of operations and functions of the machine.



DS1601375

Figure 76



DS1601376

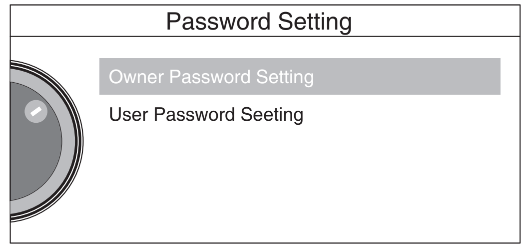
Figure 77

Owner Password Setting

1) Selection

An owner password can be set for managing functions of equipment and use privileges of the equipment for different users.

To set an owner password, place the cursor over Owner Password Setting in the settings screen and click the jog switch (or press "Enter" on the keypad).



DS1601377

Figure 78

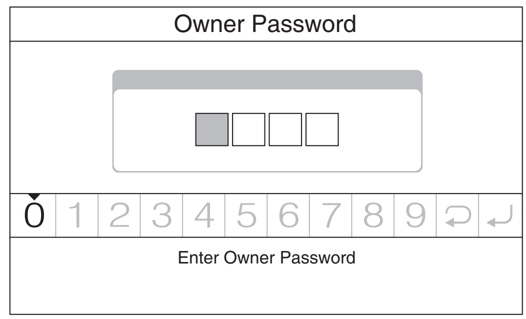
2) Password entry

When the password entry screen appears, use the jog switch (or the keypad) to enter the password and move to the settings screen.

The default password is "1111".

How to enter the password
Rotate the jog switch to select digits from 0 to 9 below, and click Enter on the jog switch to input the password.

If the password is input incorrectly, use the ↩ button on the lower right to delete the input password.

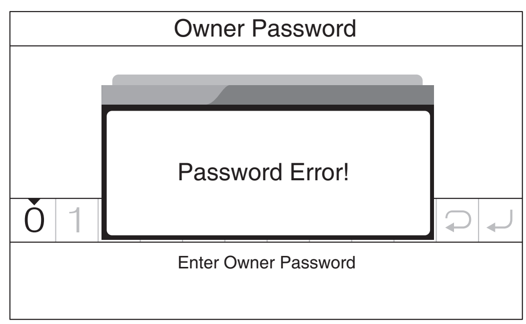


EX1301416

Figure 79

IMPORTANT

If the password is input incorrectly three times in a row, you will be redirected to the main screen and the system will not start for the next 10 minutes.

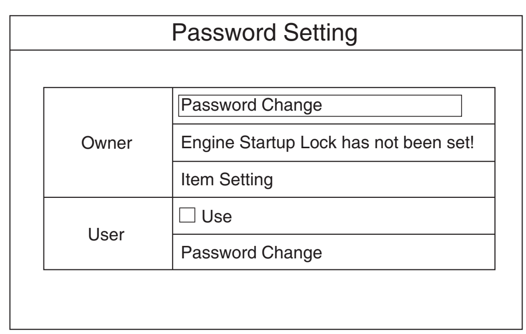


EX1301433

Figure 80

3) Structure

Owner password settings include password change, start-up restriction settings, function item settings, user password use settings, and user password change.

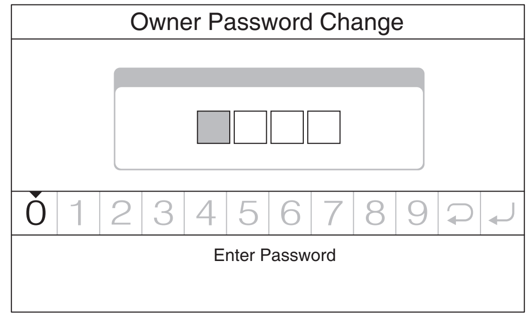


EX1301434

Figure 81

Password change

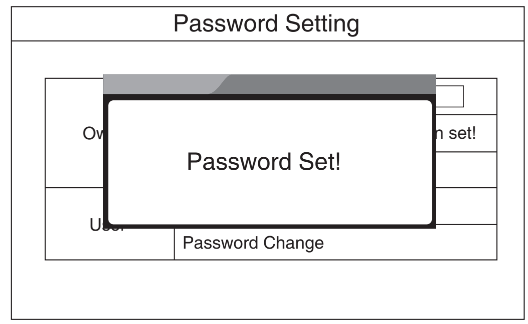
To change the owner password, select password change with the jog switch (or the keypad).



EX1301435

Figure 82

When the owner password has been changed, "Password Set!" will pop-up.



EX1301436

Figure 83

Item setting

User privileges and settings for engine start-up, attachment settings, and entertainment use settings can be set.

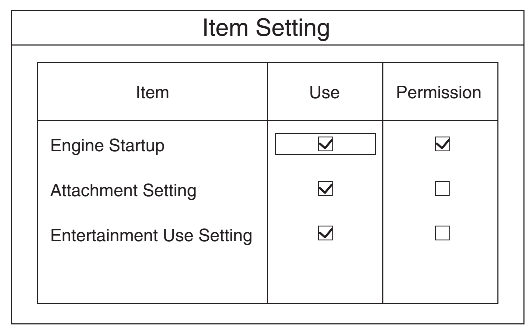
NOTE: *Permission, which gives certain users permission touse certain features, can only be checked when use ischecked.*
In this case, the user has the same privileges as the owner, and the user's settings take precedence in equipment settings.

NOTE: *This setting is off by default.*

a) Engine startup
Setting of password input upon operation of equipment.

b) Attachment setting
Setting of password input for attachment setting.

c) Entertainment use setting
Setting of password input for entertainment (video/MP3) use setting.



EX1301437

Figure 84

Engine start-up setting

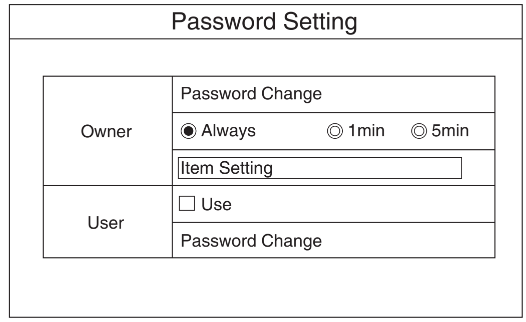
By selecting "Engine Start-up" among item settings the reentry time for password entry upon start-up of the equipment can be set.

NOTE: *No password for start-up of the equipment is setby default.*

a) Always
Password is entered with each start-up.

b) 1 min
If the system is started again within 1 minute from key-off after the password is input, the password is not requested again.

c) 5 min
If the system is started again within 5 minutes from key-off after the password is input, the password is not requested again.



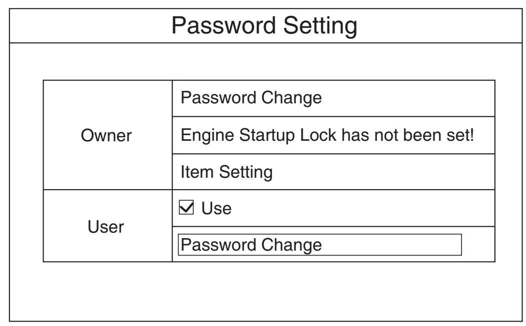
EX1301438

Figure 85

User password setting

a) User password use setting
Sets use of the user password.

b) User password change
After setting use privileges for the user password, the owner can change the user password.



EX1301439

Figure 86

User Password Setting

1) Selection

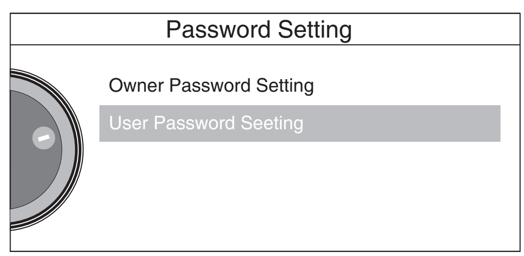
If the owner checks user password use in owner password setting, user password setting will appear in the password setting screen so user password can be set. (refer to "Owner Password Setting" on page -48).

To set a user password, place the cursor over User Password Setting in the Password Setting screen and click the jog switch (or press "Enter" on the keypad).

2) Password entry

When the password input screen appears, input the password with the jog switch (or keypad) and move to the settings screen. (refer to "Owner Password Setting 2" on page 2-71.)

The default password is "1111".

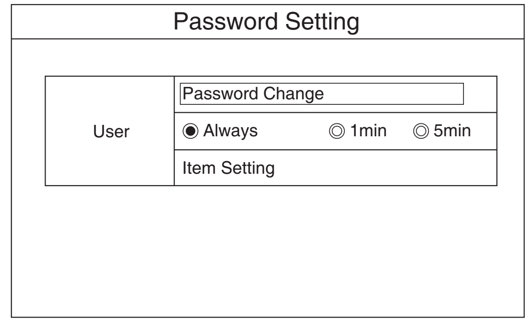


DS1601378

Figure 87

3) Structure

User password settings include password change, start-up restriction settings, and function item settings.

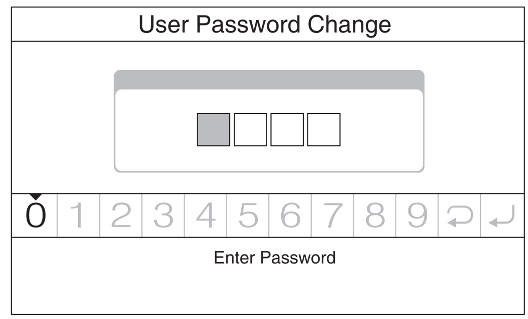


EX1301441

Figure 88

Password change

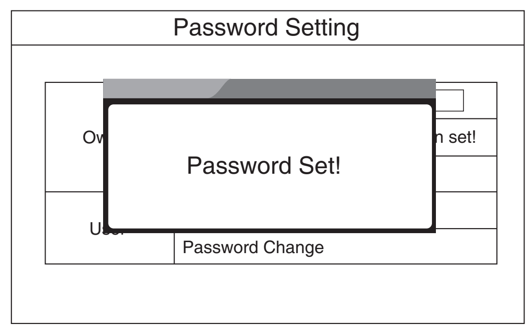
To change the user password, select password change, and change the user password using the jog switch (or keypad).



EX1301442

Figure 89

When the user password is changed,"Password Set!" will pop-up.



EX1301436

Figure 90

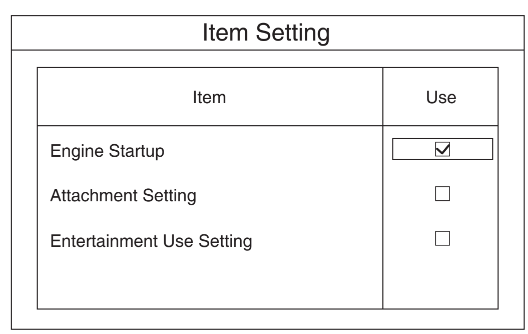
Item setting

Use of engine start-up, attachment setting, and entertainment use setting can be set.

NOTE: *This is only possible when permitted by the owner.*

a) Engine startup
Setting of password input upon operation of equipment.

b) Attachment setting
Setting of password input for attachment setting.



EX1301443

Figure 91

c) Entertainment use setting
Setting of password input for entertainment (video/MP3) use setting.

Engine start-up setting

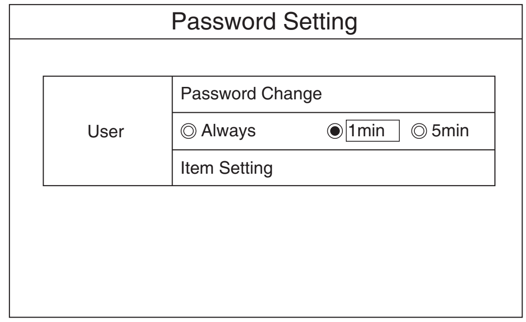
By selecting "Engine Start-up" among item settings the reentry time for password entry upon start-up of the equipment can be set.

a) Always
Password is entered with each start-up.

b) 1 min
If the system is started again within 1 minute from key-off after the password is input, the password is not requested again.

c) 5 min
If the system is started again within 5 minutes from key-off after the password is input, the password is not requested again.

NOTE: *If the owner uses the engine start-up feature but does not permit the user to use it, the user cannot select whether to use the feature, but can select the password reentry time.*

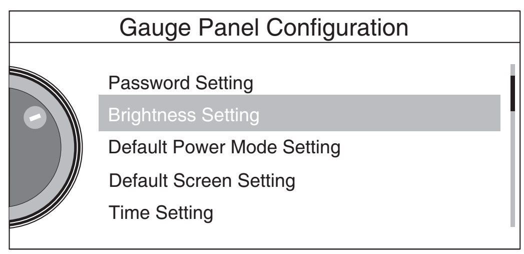


EX1301444

Figure 92

B. Brightness Setting

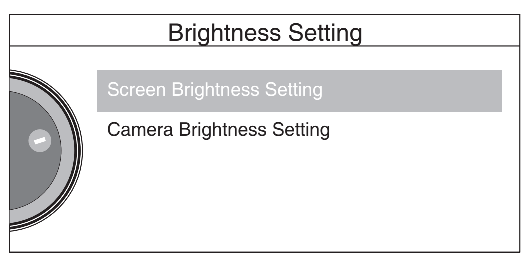
On the Gauge Panel configuration screen, when cursor is placed on brightness setting, click on the jog switch to display the screen brightness setting and camera brightness setting screen.



DS1601379

Figure 93

If you want to change the screen brightness, select the screen brightness setting to display the brightness adjustment screen.



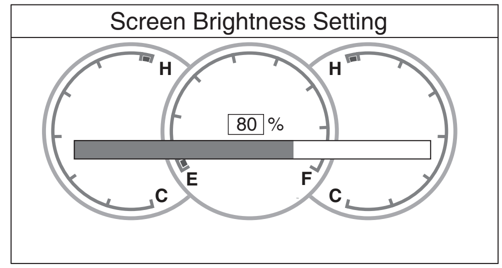
DS1601380

Figure 94

Turn the jog switch and adjust the brightness of 0 - 100% at an interval of 10%.

The screen brightness when manufactured is set as 80%.

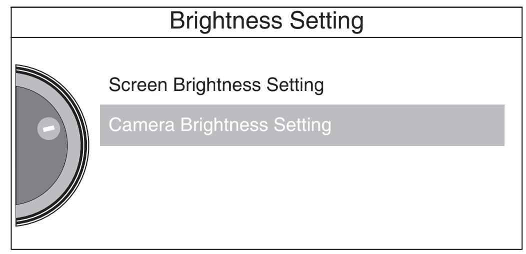
Press the ESC button to return to the previous screen.



EX1404972

Figure 95

If you want to change the camera screen brightness, select the camera brightness setting to display the camera screen brightness adjustment screen.



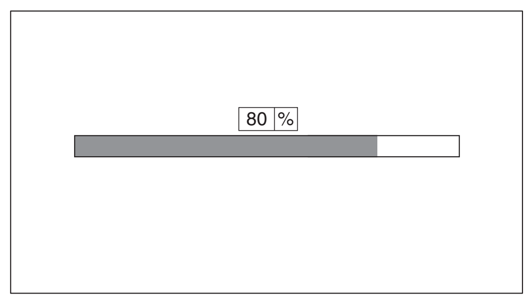
DS1601381

Figure 96

Turn the jog switch to adjust the brightness of 0 - 100% at an interval of 10%.

The camera screen brightness at the machine release time is set as 80%.

Press the ESC button to return to the previous screen.



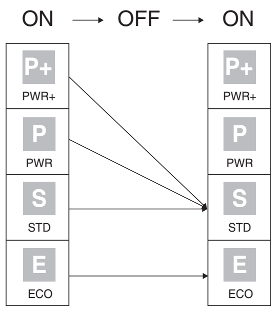
EX1404851

Figure 97

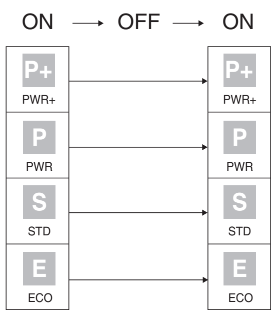
C. Default Power Mode Setting

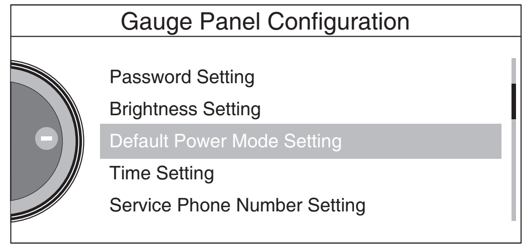
On the Gauge Panel configuration screen, when cursor is placed on default power mode setting, click on the jog switch to access the default power mode setting.

Fuel Saving Mode is Enable



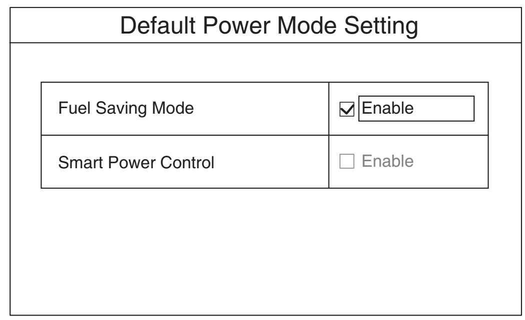
Fuel Saving Mode is Disable





DS1601382

Figure 98

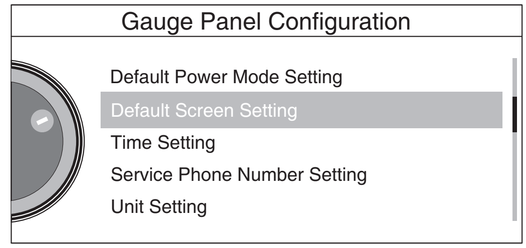


DS1601383

Figure 99

D. Default Screen Setting

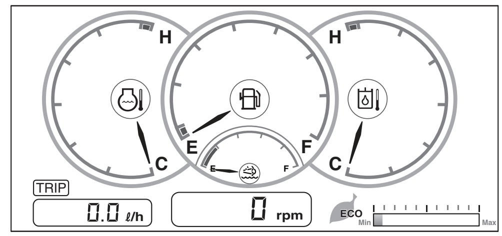
Sets the main screen display on the instrument panel.



DS1601384

Figure 100

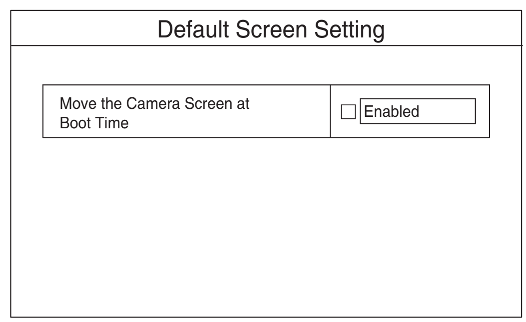
The initial screen shows basic information, including the fuel level, coolant temperature and hydraulic oil temperature.



DS1601385

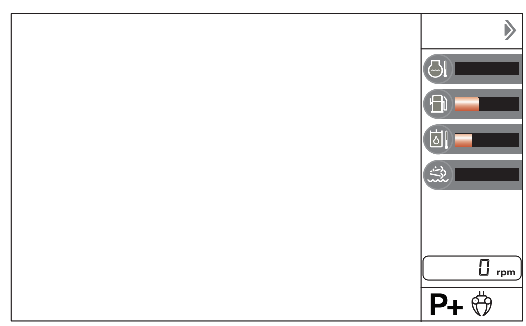
Figure 101

Enter the "Default Screen Setting" menu and select "Enable" for this function. Then, the main screen shows the camera view next time the starter switch is turned to the ON position.



EX1402182

Figure 102



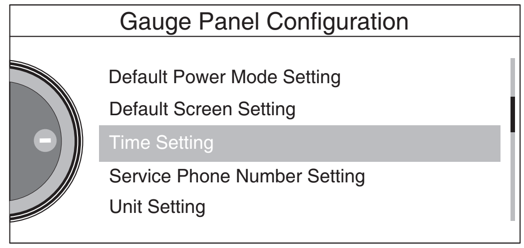
DS1601546

Figure 103

E. Time Setting

On the Gauge Panel configuration screen, when cursor is placed on time setting, click the jog switch to access the time setting.

Turn the jog switch and locate the cursor at a target of change. Then, click on the jog switch to change the target.



DS1601386

Figure 104

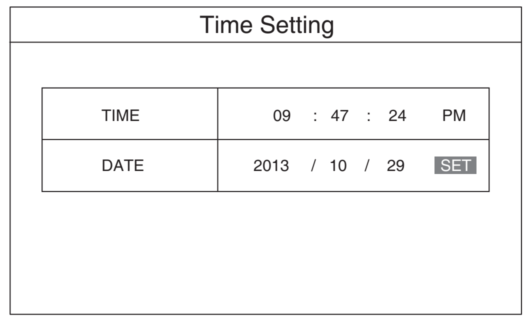
Turn the jog switch to change numbers of each item.

If the setup is completed, click on the jog switch to store the setup details.

When the time setting is completed, locate cursor to 'SET' and press the job switch.

If the SET button is not pressed, time setting would not be completed.

Press the ESC button to return to the previous screen.

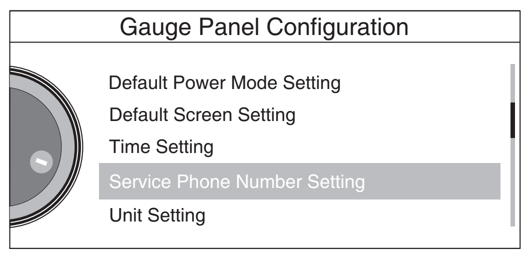


EX1301447

Figure 105

F. Service Phone Number Setting

On the Gauge Panel configuration screen, when cursor is placed on service phone number setting, click on the jog switch to access the service phone number setting.

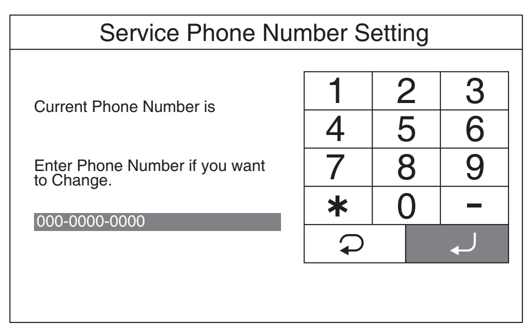


DS1601387

Figure 106

Turn the jog switch and locate the cursor at a desired number. Then, click on the jog switch to input the number. If number input is completed, press the ↵ key to enter the input phone numbers.

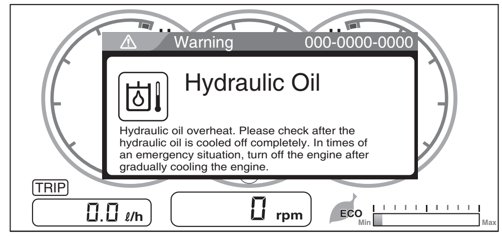
Use the ↩ key and delete erroneously input numbers.



EX1301448

Figure 107

When you input service phone numbers, if warning/ alarm is issued, check the input phone numbers in the pop-up window.

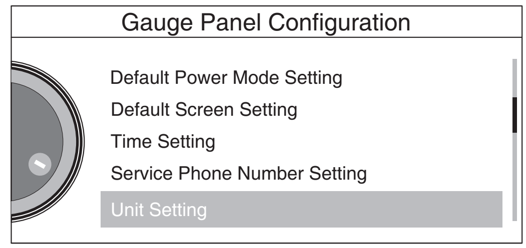


DS1601388

Figure 108

G. Unit Setting

On the Gauge Panel configuration screen, when cursor is placed on unit setting, click the jog switch to access the unit setting.



DS1601389

Figure 109

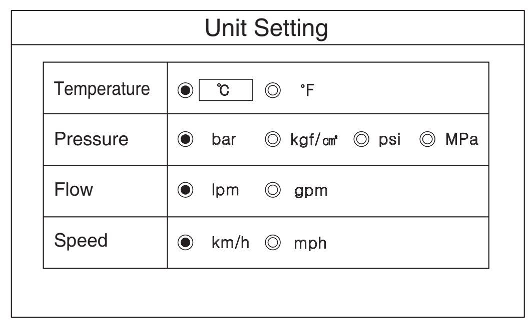
On the unit setting screen, change the units of temperature, pressure, flow rate, and speed. These figures at the machine release time are set as below:

Temperature: °C

Pressure: bar

Flow rate: lpm

Speed: km/h

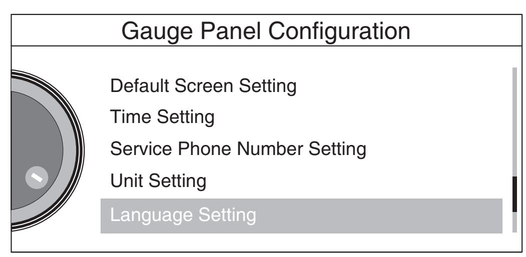


EX1502445

Figure 110

H. Language Setting

On the Gauge Panel configuration screen, when cursor is placed on language setting, click on the jog switch to access the language setting.



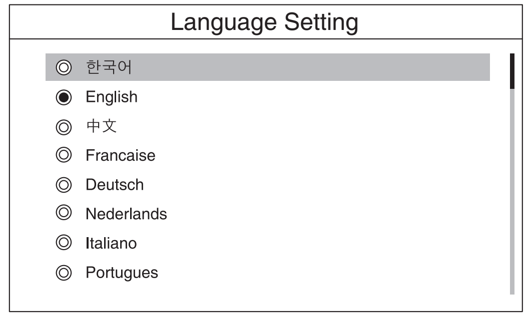
DS1601390

Figure 111

On the language selection screen, turn the jog switch and move the cursor to select a language. Then, click on the jog switch to adopt the selected language.

Press the ESC button to return to the previous screen.

Language
Korean, English, Chinese, Persian, Turkish, Indonesian, Polish, Arabic, Russian, Thai, Hindi, Japanese, French, German, Nederlands, Italian, Portuguese, Spanish, Finnish, Swedish, Norwegian, Danish, Vietnamese, Greek

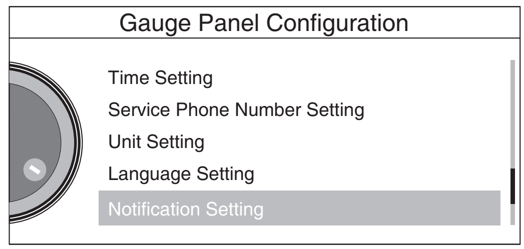


EX1301062

Figure 112

I. Notification Setting

On the Gauge Panel configuration screen, when cursor is placed on notification setting, click on the jog switch to access the notification setting.



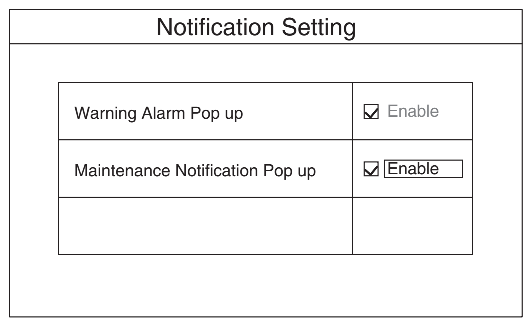
DS1601391

Figure 113

Depending on the notification setting screen details, pop-ups are created on the main screen when warning/alarm is issued, when the switch is operated, and when the supplies replacement period expires.

On the notification setting screen, turn the jog switch and move the cursor to a desired location. Then, click on the jog switch to select enable or disable.

All notice items at the machine release time are set as Enable.



EX1502448

Figure 114

J. Entertainment Use Setting

On the Gauge Panel configuration screen, when cursor is placed on entertainment use setting, click on the jog switch to access the entertainment use setting.

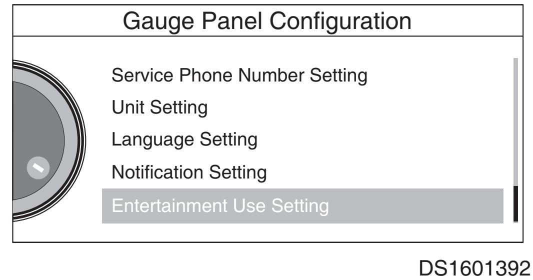


Figure 115

Depending on the entertainment use setting details, the use of video and MP3 is limited.

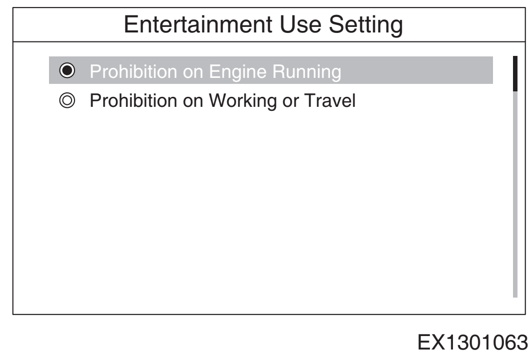


Figure 116

SPECIAL MENU

In this menu, many types of operating conditions and functions can be accessed and displayed, including the EPOS controller. This menu is mainly used for machine testing and fault diagnostics.

The special menu offers five submenus:

1. Monitoring.
2. Graph.
3. Failure Information.
4. Operating Hour Information.
5. Machine Configuration.

Entering/Accessing and Exiting/Escaping Menus

Entering/Accessing Menus

When normal mode screen is displayed, if jog switch (1, Figure 117), power mode selector button (2, Figure 117) and multimedia button are pressed simultaneously for more than 3 seconds, normal mode screen (Figure 118) will be changed to special menu screen (Figure 119).

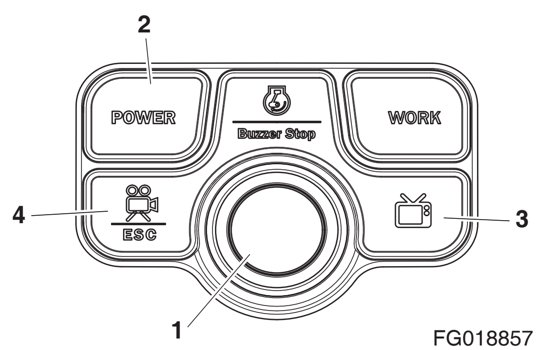
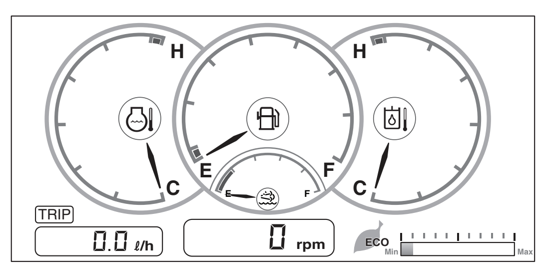


Figure 117

Normal Mode Screen

NOTE: *Normal mode screen display fuel gauge, engine coolant temperature gauge, hydraulic oil temperature gauge, ECO gauge and engine speed (rpm), DEF(AdBlue) gauge, trip meter.*



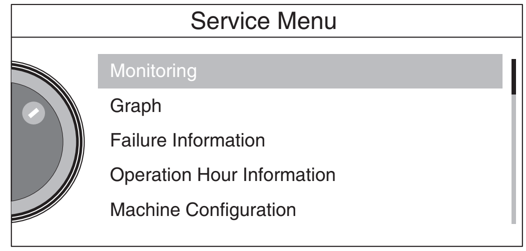
EX1301002

Figure 118

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.



DS1602670

Figure 119

Exiting/Escaping Menus

1. If escape button (ESC, 4 on Figure 117) is pressed 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 return to the normal mode screen.
3. After the turning starter switch to "OFF" position, turn it back to "ON" position, and the normal mode screen displayed once again.

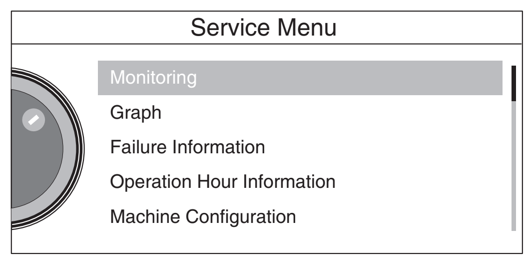
Special Menu Selections

Submenu Selection Method

Various submenus can be selected by turning the jog switch and moving the cursor to see a reversed display on the desired menu. Then, click on the jog switch to select the menu.

Press the ESC button to return to the previous screen.

Entering Submenus: When cursor is located on "Machine Info" of special menu screen, press "Enter (↵, 3 on Figure 117)" button and the "Machine Info" will be displayed.

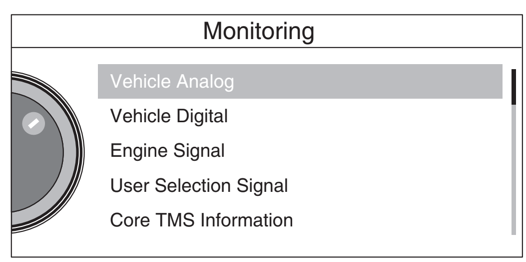


DS1602670

Figure 120

Monitoring

1. Entering Submenus: When cursor is located on "Monitoring" of special menu screen, press the jog switch and the "Monitoring" will be displayed.
2. Exiting Submenus: If escape button (ESC, 4 on Figure 117) is pressed display will be turned to previous screen.



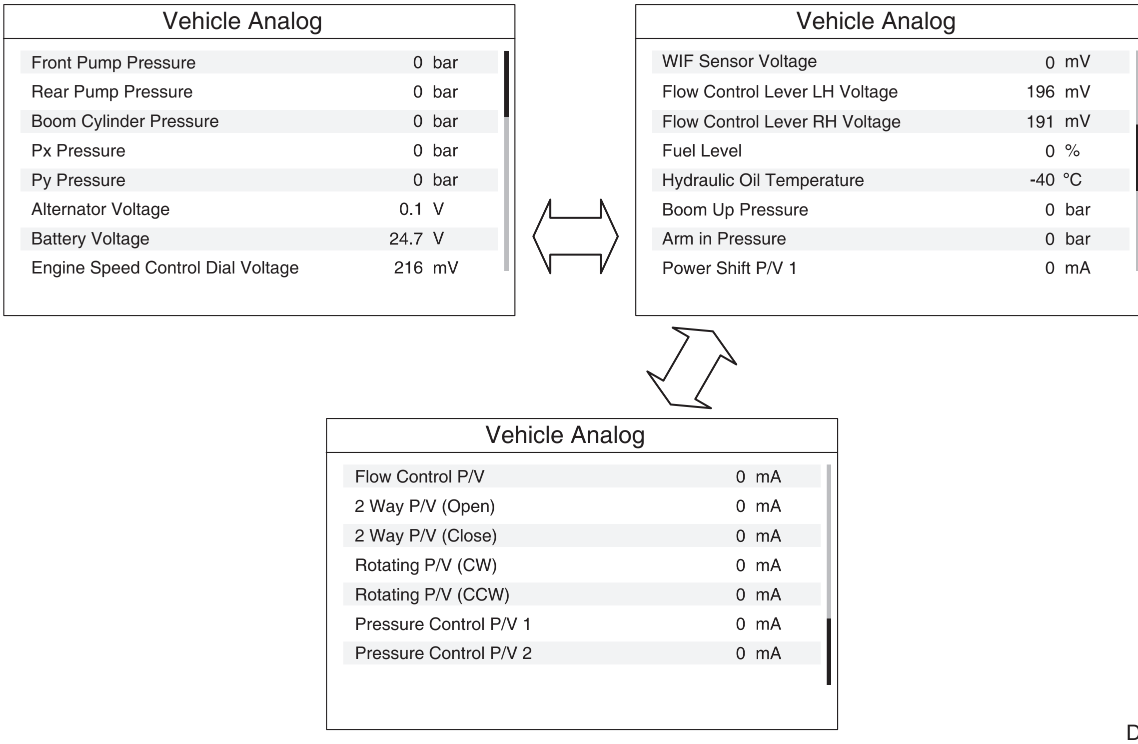
DS1602671

Figure 121

Vehicle Analog Description

Analog Items	Display	Remark
1. Front Pump Pressure	bar	Front pump pressure
2. Rear Pump Pressure	bar	Rear pump pressure
3. Boom Cylinder Pressure	bar	Boom cylinder head pressure
4. Px Pressure	bar	Px pressure
5. Py Pressure	bar	Py pressure
6. Alternator Voltage	V	Indicating alternator voltage.
7. Battery Voltage	V	Indicating battery voltage.
8. Engine Speed Control Dial Voltage	mV	Indicating dial voltage.
9. WIF Sensor Voltage	mV	Current in WIF
10. Flow Control Lever LH Voltage	mV	Indicating LH joystick thumb wheel switch voltage
11. Flow Control Lever RH Voltage	mV	Indicating RH joystick thumb wheel switch voltage
12. Fuel Level	%	Fuel residual quantity radio of fuel tank
13. Hydraulic Oil Temperature	°C	Hydraulic oil temperature
14. Boom Up Pressure	bar	Boom up pilot pressure
15. Arm in Pressure	bar	Arm in pilot pressure
16. Power Shift P/V 1	mA	Current in pump proportional valve.
17. Flow Control P/V	mA	Current in flow control proportional valve.
18. 2 Way P/V (Open)	mA	Current in two-way (open) flow control proportional valve.
19. 2 Way P/V (Close)	mA	Current in two-way (close) flow control proportional valve.
20. Rotating P/V (CW)	mA	Current in rotating (CW) flow control proportional valve.
21. Rotating P/V (CCW)	mA	Current in rotating (CCW) flow control proportional valve.
22. Pressure Control P/V 1	mA	Current in 1 way pressure proportional valve.
23. Pressure Control P/V 2	mA	Current in 2 way pressure proportional valve.

Submenu Selections



DS1602848

Figure 122

Vehicle Digital Descriptions

Digital Items	Mark	Remark
1. Alternator	ON/OFF	Lights up when output at alternator "R (I)" terminal is above 12 ±1 V.
2. Power Max Switch		Lights up when the boost button is "ON" with the work mode selected to "BOOST".
3. One Way Operator Switch		Lights up when the one way operator switch is "ON".
4. Hi-Speed Select Switch-M		Lights up when the travel speed selector switch is set to "I" position.
5. Hi-Speed Select Switch-A		Lights up when the travel speed selector switch is set to "II" position.
6. Working Lamp Switch		Lights up when the light switch is set to "II" position.
7. Quick Coupler		
8. Air Conditioning Switch		Lights up when the air-conditioning relay in the air-conditioning unit is "ON".
9. One Touch Deceleration Switch		Lights up when the one touches deceleration button is "ON".
10. Intelligent Floating Boom Switch		Lights up when the intelligent floating boom switch is "ON".
11. Pilot Cut Off Switch		Lights up when the pilot cutoff switch is "ON".
12. Air Cleaner Indicator		Lights up when the air cleaner indicator contact is "ON".
13. Return Filter		Lights up when the return filter pressure switch is "ON".
14. OWD Select Switch		Lights up when the OWD select switch is "ON".
15. Swing Pressure Switch		Lights up when the swing pressure switch is "ON".
16. Water in Fuel		Lights up when the WIF sensor is "ON".
17. Start up Switch		Lights up when the starter switch is "START"
18. Swing Alarm Select Switch		Lights up when the swing alarm selector switch is "ON".
19. Travel Alarm Select Switch		Lights up when the travel alarm selector switch is "ON".
20. SPC Switch		Lights up when the SPC switch is "ON".
21. Option Pedal Pressure Switch (1 way)		Lights up when the option pedal pressure switch is "ON".
22. One Way S/V		Lights up when the one way solenoid valve is "ON".
23. Relief Pressure S/V		Lights up when the relief pressure solenoid valve is "ON".
24. High Speed S/V		Lights up when the high-speed solenoid valve is "ON".
25. 2 Pump Select S/V		Lights up when the 2 Pump select solenoid valve is "ON".
26. Starter Relay		Lights up when the starter relay is "ON".
27. Back Buzzer Relay		Lights up when the back buzzer relay is "ON".
28. Core TMS Status		Lights up when the core TMS status is "ON".

Submenu Selections

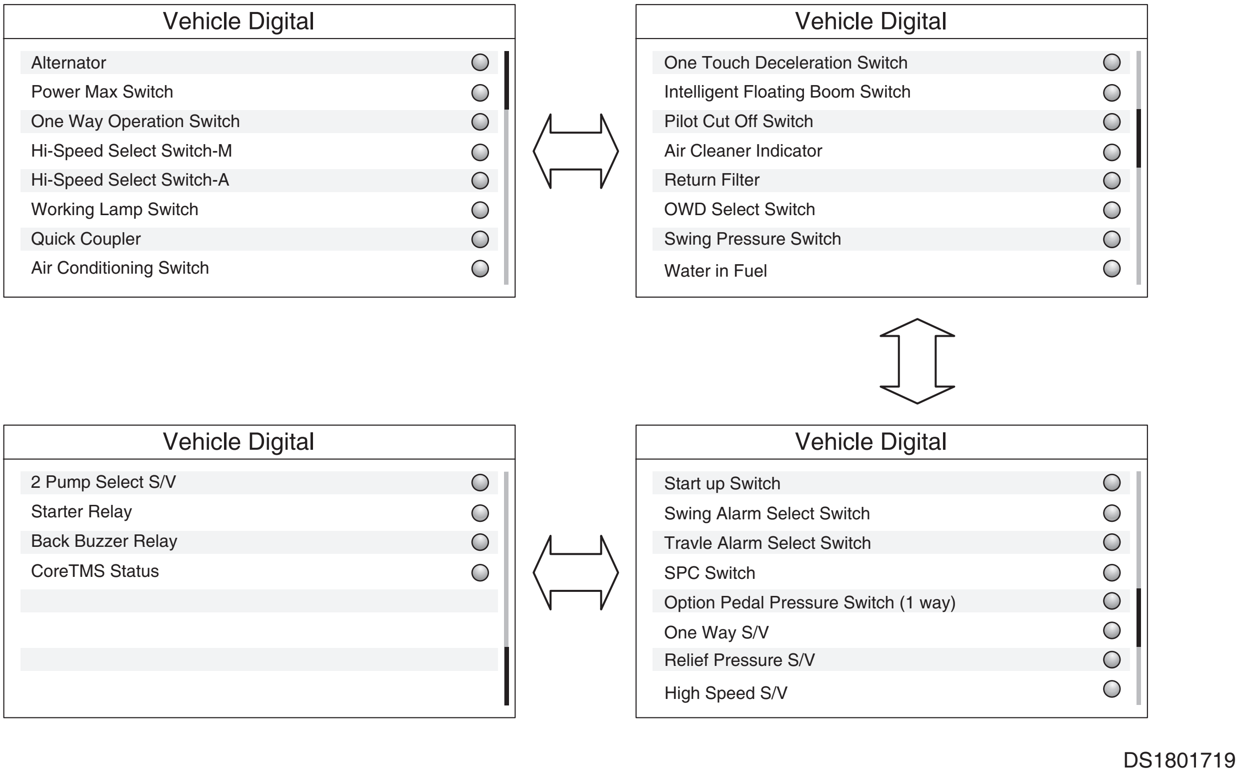


Figure 123

Engine Signal Description

Analog Items	Display	Remark
1. Engine Speed	rpm	Engine Speed
2. Throttle Position	%	Throttle Position
3. % Load at Current Speed	%	% Load at Current Speed
4. Fuel Rate	L/H	Fuel Rate
5. Boost Pressure	bar	Boost Pressure
6. Engine Oil Pressure	bar	Engine Oil Pressure
7. Fuel Temperature	°C	Fuel Temperature
8. Engine Oil Temperature	°C	Engine Oil Temperature
9. Coolant Water Temperature	°C	Coolant Water Temperature
10. DOC Intake Temperature	°C	DOC Intake Temperature
11. Intake Manifold Temperature	°C	Intake Manifold Temperature
12. APP Command	%	APP Command
13. Total Fuel Used	L	Total Fuel Used
14. SCR Upstream Temperature	°C	SCR Upstream Temperature
15. SCR Downstream Temperature	°C	SCR Downstream Temperature
16. DEF Level	%	DEF Level
17. DEF Temperature	°C	DEF Temperature

Submenu Selections

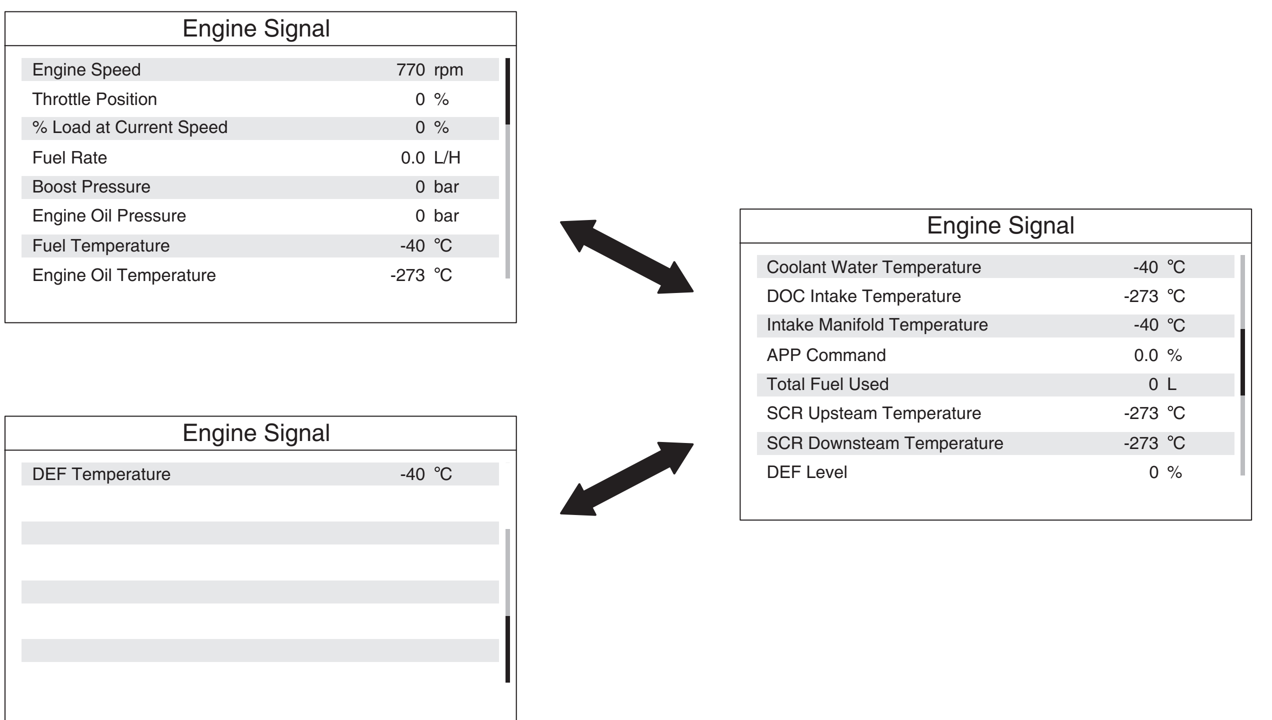
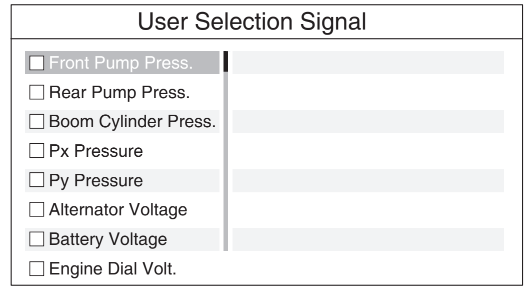


Figure 124

User Selection Signal

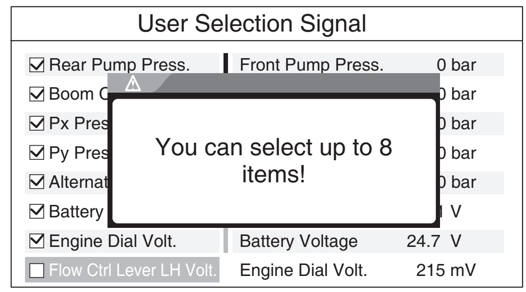
User can select signals of all monitoring items.

The maximum limit of monitoring signal is 8.



EX1301613

Figure 125



EX1301614

Figure 126

Graph

1. Entering Submenus: When a cursor is located in "Graph" of special menu screen press enter jog switch (1 on Figure 117) and "Graph" screen is displayed.
2. Exiting Submenus: If escape button (ESC, 4 on Figure 117) is pressed, this information screen will be returned to previous screen.

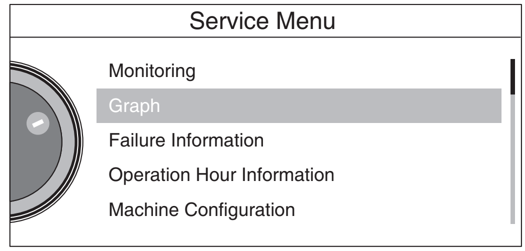


Figure 127

Graph Data Monitoring

Real time monitoring of the selected data.

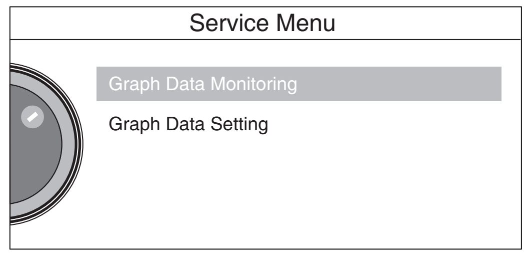
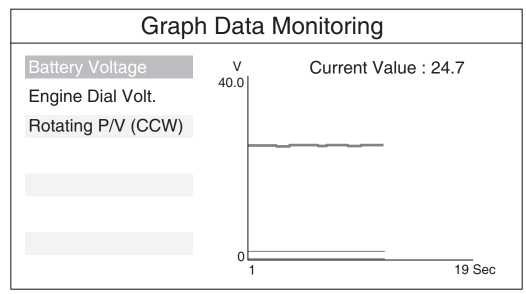


Figure 128



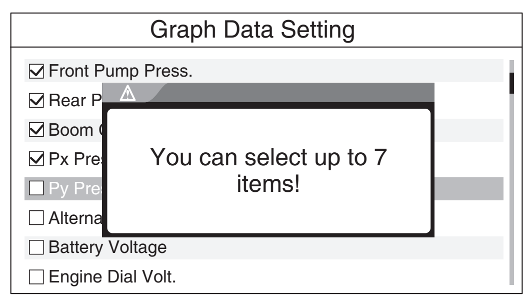
EX1301616

Figure 129

Graph Data Setting

User can be graph data setting.

The maximum limit of the graph data setting is 7.



EX1301617

Figure 130

Failure Information

1. Entering Submenus: When a cursor is located in "Failure Info" of special menu screen press jog switch (1 on Figure 117) and "Failure Info" screen is displayed.
2. Exiting Submenus: If escape button (ESC, 4 on Figure 117) is pressed, this information screen will be returned to previous screen.

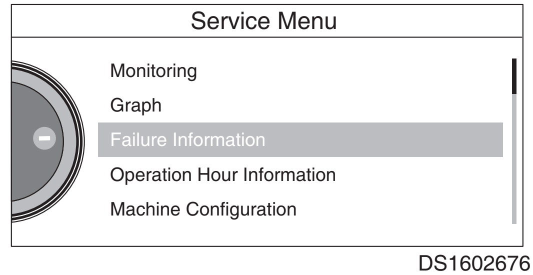


Figure 131

* Real-time Failure: Current status of fault is displayed.

* Failure Log: Memorized record of past fault is displayed.

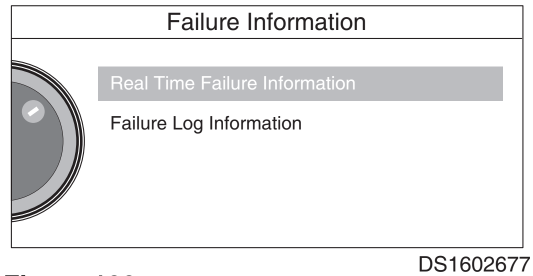


Figure 132

A. Current fault information

Current status of fault is displayed (Failure code, fault contents).

When several faults are produced, fault information can be checked using the jog switch (1, Figure 117).

No: Number of currently occurring failure

Code: Display of current failure code

VXXyyy-zz: Method of displaying machine related failure code

- V: Display of machine related failure code
- XX: Display of failed part
- yyy: Serial number of failed part
- zz: FMI (Failure Mode Identifier) number

Eyyyyyy-zz: Method of displaying engine related failure code

- E: Engine related failure code
- yyyyyy: Serial number of failed part
- zz: FMI (Failure Mode Identifier) number

* Method of displaying failed part of machine (VXX)

1) VCO: Communication related failure
2) VPV: EPPR valve related failure
3) VSV: Solenoid valve related failure
4) VRY: Relay related failure
5) VSP: Pressure sensor related failure

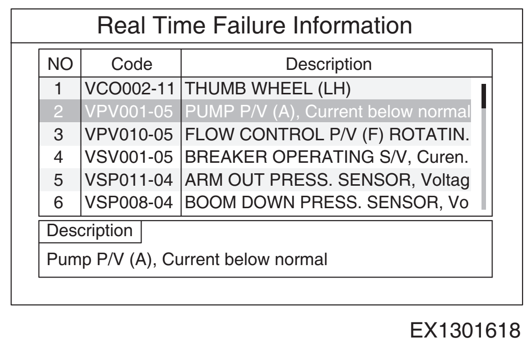


Figure 133

6) VSE: Sensor related failure except for pressure sensor

7) VS5: 5V sensor related failure

8) VAL: Other failures.

Example)

VPV001-05: EPPR valve (A) current is lower than normal current.

Description: Shows the description of the details of machine failure.

Refer to the failure information code for unique codes and FMI numbers.

This example shows one of two faults.

B. Past failure information

Memorized record of past failure is displayed (Failure code, fault contents).

When several faults are produced, failure information can be checked using the jog switch (1, Figure 117).

NOTE: *"Count: xxx": "xxx" means that totally counted number of the same* fault*.*

"Occurrence Time": It indicates the period for which machine has operated until a fault *takes place. (For more than two occurrences of the same* fault*, until first occurrence time.)*

Failure Log Information

NO	Code	Count	Occurrence Time	
5	VPV007-05	9	21 Hr	20 Min
6	VCO002-11	25	21 Hr	27 Min
7	VSP011-04	2	21 Hr	56 Min
8	VSP008-04	1	21 Hr	56 Min
9	VSV001-05	4	21 Hr	56 Min
10	VPV001-05	15	21 Hr	56 Min

Description

BREAKER OPERATING S/V, Current below normal

EX1301619

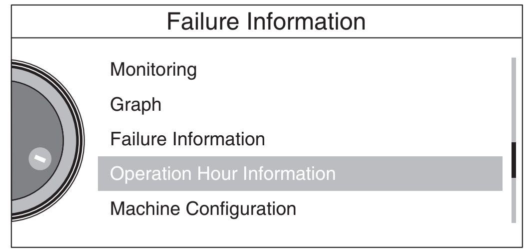
Figure 134

Information of Machine Operation

Accumulated operation hour of each mode and status is displayed.

Operation Hour Information

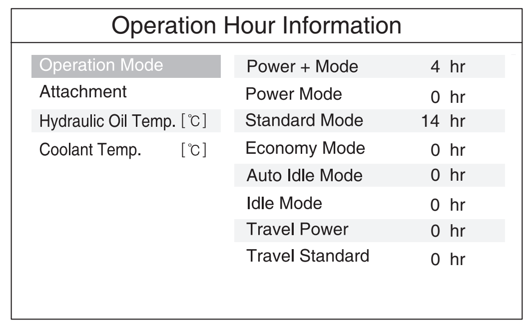
1. Entering Submenus: When a cursor is located in "Operation Hrs" of special menu screen (Figure 135) press jog switch (1 on Figure 117) and "Operation Hrs" screen will be displayed (Figure 136).



DS1602678

Figure 135

2. Operation Hours Screen



DS1602679

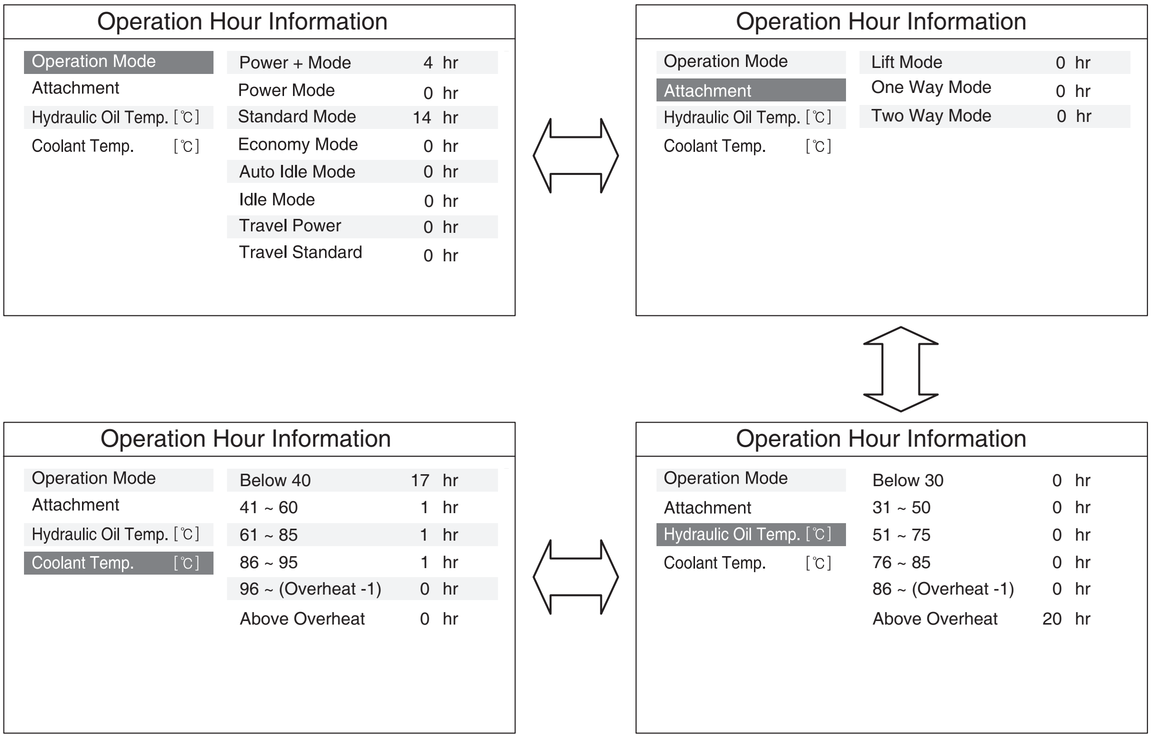
Figure 136

3. Exiting Submenus: If escape button (ESC, 4 on Figure 117) is pressed for more than 1 second, this information screen will be returned to previous screen.

Information contents of operation hour

Item	Information Contents	Detection Method
Power Plus Mode	Operation hours used Power Plus Mode are displayed.	Power Plus Mode status (Instrument panel) and Alternator signal (CN1-2) is "HI"
Power Mode	Operation hours used Power Mode are displayed.	Power Mode status (Instrument panel) and Alternator signal (CN1-2) is "HI"
Standard Mode	Operation hours used standard mode are displayed.	Standard Mode status (Instrument panel) and Alternator signal (CN1-2) is "HI".
Economy Mode	Operation hours used economy mode are displayed.	Economy Mode status (Instrument panel) and Alternator signal (CN1-2) is "HI"
Auto Idle	Operation hours used auto idle status are displayed.	Auto Idle Mode status (Instrument panel) and Alternator signal (CN1-2) is "HI"
Lift Mode	The operation hours for Lift Mode are displayed.	
One Way Mode	The operation hours for One Way Mode are displayed.	
Two Way Mode	The operation hours for Two Way Mode are displayed.	
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 - Overheat -1°C (187 - Overheat -1°F) Above Overheat	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 - Overheat -1°C (205 - Overheat -1°F) Above Overheat	The resistance delivered from coolant sensor is classified 6 steps, and operation hours of each step are displayed. (Alternator output HI status)

Example of Machine Operation Info Screen



DS1602680

Figure 137

Machine Configuration

1. Machine Configuration

   A. Entering Submenus: When a cursor is located in "Machine Configuration" of special menu screen (Figure 138) press jog switch (1 on Figure 117) and "Machine Configuration" screen will be displayed (Figure 140).

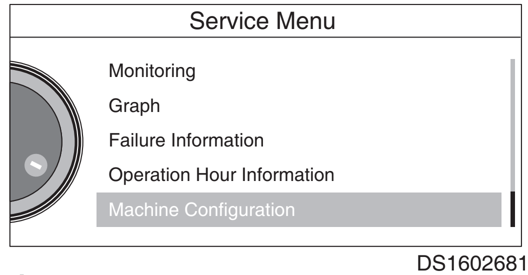


Figure 138

Entering service password is required when accessing the menu.

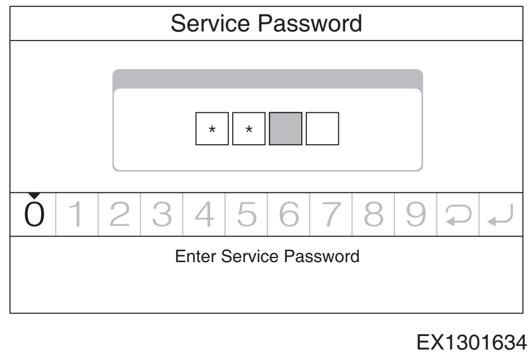


Figure 139

   B. Machine Configuration Screen (Figure 140).

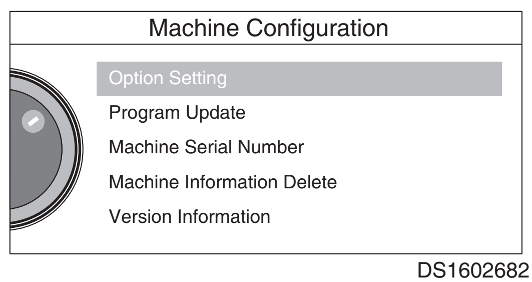
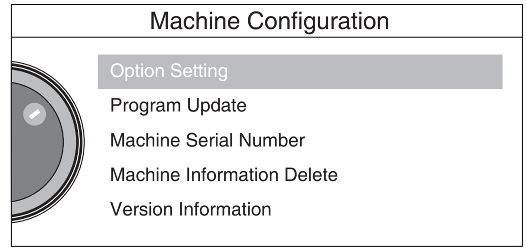


Figure 140

   C. Exiting Submenus: If escape button (ESC, 4 on Figure 117) is pressed, this information screen will be returned to previous screen.

Option Setting

1. Entering Submenus: When a cursor is located in "Option Setting" of special menu screen (Figure 141) press jog switch (1 on Figure 117) and "Option Setting screen" will be displayed (Figure 142)



DS1602682

Figure 141

2. Option Setting

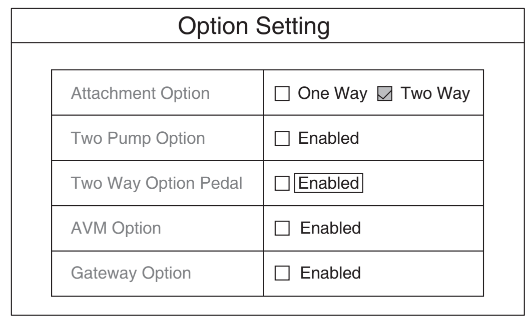
   - Attachment Option

     When a cursor is located in check box of breaker or two-way, press jog switch (1 on Figure 117) and then, the check box light turns "ON".

   - Two-way Option Pedal (Not installed)

     Place the cursor on the check box for the two-way option pedal and select a function by pressing the jog switch.

     NOTE: *Option setting can only be made for those machines with the option in question. Selecting a machine without the option can cause a problem in terms of performance and safety.*



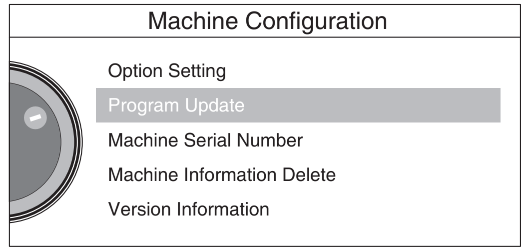
DS1602683

Figure 142

3. Program Update

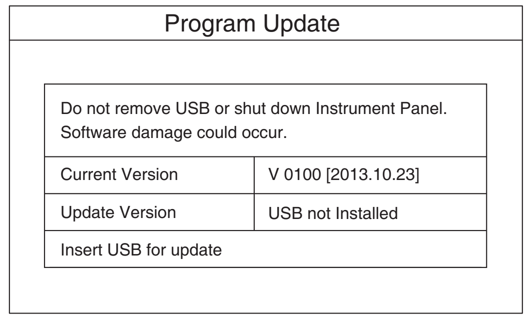
Entering Submenus: When a cursor is located in "Program Update" of special menu screen (Figure 143) press jog switch (1 on Figure 117) and "Program Update Screen" will be displayed (Figure 144).

NOTE: *When USB memory is installed in USB port, program update can be updated.*



DS1602684

Figure 143



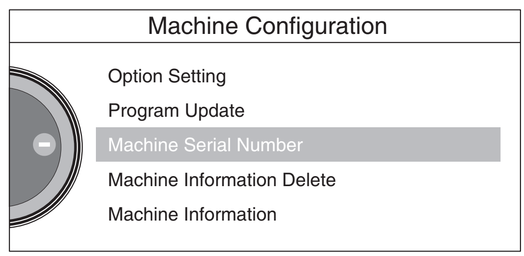
DS1602685

Figure 144

4. Machine Serial Number

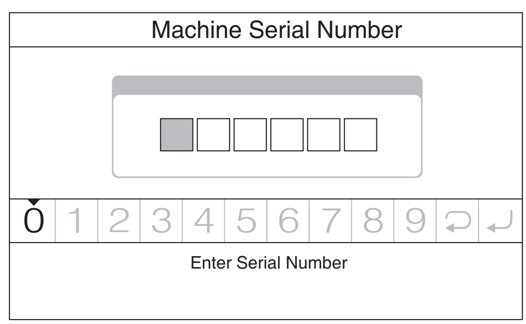
Entering Submenus: When a cursor is located in "Machine Serial Number" of special menu screen (Figure 145) press jog switch (1 on Figure 117) and "Machine Serial Number Screen" will be displayed (Figure 146).

Machine serial number can be input by turning the jog switch and pressing the jog switch.



DS1602686

Figure 145



DS1602053

Figure 146

5. Machine Information Delete

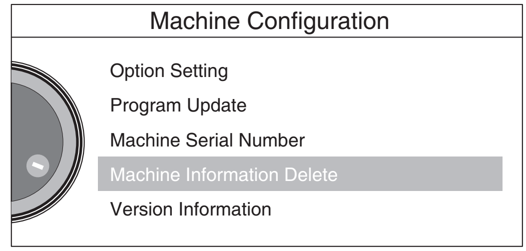
Entering Submenus: When a cursor is located in "Machine Information Delete" of special menu screen (Figure 147) press jog switch (1 on Figure 117) and "Machine Information Delete Screen" will be displayed (Figure 148)

NOTE: *When press* jog *switch (1 on Figure 117) in the selected menu the menu will be initialized.*

- Delete Failure Log

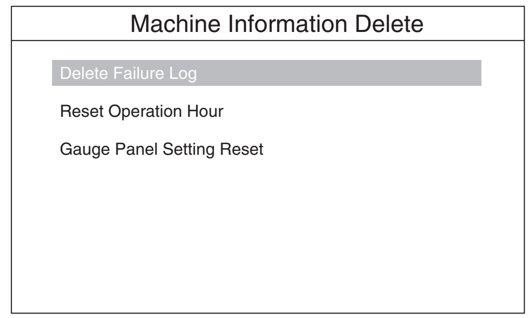
- Reset Operation Hour

- Gauge Panel Setting Reset



DS1602687

Figure 147

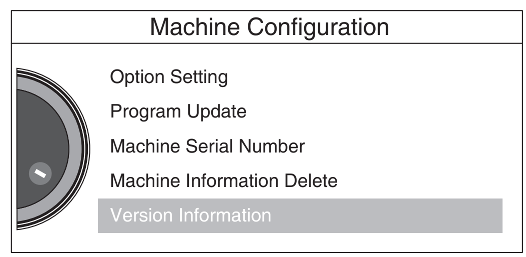


EX1501553

Figure 148

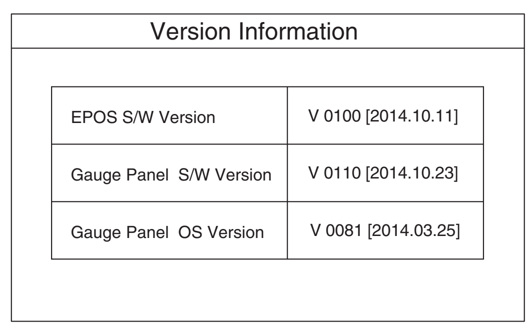
6. Version Information

Entering Submenus: When a cursor is located in "Version Information" of special menu screen (Figure 149) press jog switch (1 on Figure 117) and "Version Information Screen" will be displayed (Figure 150).



DS1602688

Figure 149



EX1501555

Figure 150

FAILURE CODE

Failure Code at Machine

GP (Graphic Panel): Code displays on Panel Gauge
FMI (Failure Mode Identifier): Code displays on DMS
DTC (Diagnostic Trouble Code): Code displays on Diagnostic tool
HEX: Hexadecimal, DEC: Decimal number

GP Display Code	SPN Name	FMI	GP Display Description	Measuring Point	Correct Value		Severity Level	Remark
					Active	Passive		
VCO001	Can (Gauge Panel)	11	Gauge Panel Communication Error	6-12/ 6-13		R = 60 ±5 Ω	4	It is a composite resistance of CAN line. This value has to be measured by connected condition of CAN line.
VCO002	Can (ECU)	11	E-ECU Communication Error	1-39/ 1-40			4	
VPV001	Pump P/V (A)	5	Current of Pump P/V (A) Is Below Normal	2-98/ 2-99		R = 13.5 ±2 Ω (25°C (77°F))	3	
		6	Current of Pump P/V (A) Is Above Normal					
VPV003	Flow Control P/V (C)	5	Current of Flow Control P/V (C) is Below Normal	2-108/ 2-109		R = 13.5 ±2 Ω (25°C (77°F))	3	
		6	Current of Flow Control P/V (C) is Above Normal					
VPV004	Fan Control P/V (D)	5	Current of FAN Control P/V (D) is Below Normal	2-110/ 2-111		R = 22.5 ±2 Ω (25°C (77°F))	3	
		6	Current of Fan Control P/V (D) is Above Normal					
VPV005	Press. Control 1 P/V (E)	5	Current of Press. Control 1 P/V (E) is Below Normal	1-26/ 1-27		R = 9.5 ±2 Ω (25°C (77°F))	3	
		6	Current of Press. Control 1 P/V (E) is Above Normal					
VPV006	Press. Control 2 P/V (F)	5	Current of Press. Control 2 P/V (F) is Below Normal	1-44/ 1-63		R = 9.5 ±2 Ω (25°C (77°F))	3	
		6	Current of Press. Control 2 P/V (F) is Above Normal					
VPV007	Flow Control P/V (C) 2-way RH-open	5	Current of Flow Control P/V (C) 2-way Rh-open Is Below Normal	1-6/ 1-25		R = 18 ±2 Ω (25°C (77°F))	3	
		6	Current of Flow Control P/V (C) 2-way RH-open is Above Normal					
VPV008	Flow Control P/V (D) 2-way RH-close	5	Current of Flow Control P/V (D) 2-way RH-close is Below Normal	2-82/ 2-83		R = 18 ±2 Ω (25°C (77°F))	3	
		6	Current of Flow Control P/V (D) 2-way RH-close is Above Normal					
VPV009	Flow Control P/V (E) Rotating CW	5	Current of Flow Control P/V (E) Rotating CW is Below Normal	1-7/ 1-8		R = 18 ±2 Ω (25°C (77°F))	3	
		6	Current of Flow Control P/V (E) Rotating CW is Above Normal					
VPV010	Flow Control P/V (F) Rotating CCW	5	Current of Flow Control P/V (F) Rotating CCW is Below Normal	2-90/ 2-91		R = 18 ±2 Ω (25°C (77°F))	3	
		6	Current of Flow Control P/V (F) Rotating CCW is Above Normal					

GP Display Code	SPN Name	FMI	GP Display Description	Measuring Point	Correct Value		Severity Level	Remark
					Active	Passive		
VSV001	Breaker Operating S/V	5	Current of Breaker Operating S/V is Below Normal	1-1/ 2-97	V = V_volt (Note 4)		3	
		6	Current of Breaker Operating S/V is Above Normal					
VSV002	Relief Press. Up S/V (B)	5	Current of Relief Press. Up S/V (B) Is Below Normal	1-1/ 2-96	V = V_volt		3	
		6	Current of Relief Press. Up S/V (B) is Above Normal					
VSV003	High-speed S/V (C)	5	Current of High-speed S/v (C) Is Below Normal	1-1/ 2-89	V = V_volt		3	
		6	Current of High-speed S/V (C) is Above Normal					
VSV007	Option Safety S/V	5	Current of Option Safety S/v Is Below Normal	1-1/ 2-116	V = V_volt		3	
		6	Current of Option Safety S/V is Above Normal					
VSV011	2 Pump Select S/V (I)	5	Current of 2 Pump Select S/v (I) Is Below Normal	1-1/ 2-104	V = V_volt		3	
		6	Current of 2 Pump Select S/V (I) is Above Normal					
VRY001	Glow Plug Relay	5	Current of Glow Plug Relay is Below Normal	1-1/ 2-115	V = V_volt		3	
		6	Current of Glow Plug Relay is Above Normal					
VRY002	Alarm Relay	5	Current of Alarm Relay is Below Normal	1-1/ 2-119	V = V_volt		3	
		6	Current of Alarm Relay is Above Normal					
VSP001	Front Pump Press. Sensor	3	Voltage of Front Pump Press. Sensor is Above Normal	1-34/ 1-28	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Front Pump Press. Sensor is Below Normal					
VSP002	Rear Pump Press. Sensor	3	Voltage of Rear Pump Press. Sensor is Above Normal	1-15/ 1-28	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Rear Pump Press. Sensor is Below Normal					
VSP003	Owd Press. Sensor	3	Voltage of OWD Press. Sensor is Above Normal	1-32/ 1-28	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of OWD Press. Sensor is Below Normal					
VSP004	Px (Front) Press. Sensor	3	Voltage of Px (Front) Press. Sensor is Above Normal	1-33/ 1-29	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Px (Front) Press. Sensor is Below Normal					
VSP005	Py (Travel) Press. Sensor	3	Voltage of Py (Travel) Press. Sensor is Above Normal	1-14/ 1-29	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Py (Travel) Press. Sensor is Below Normal					
VSP006	Boom Up Press. Sensor	3	Voltage of Boom Up Press. Sensor is Above Normal	1-65/ 1-29	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Boom Up Press. Sensor is Below Normal					

GP Display Code	SPN Name	FMI	GP Display Description	Measuring Point	Correct Value		Severity Level	Remark
					Active	Passive		
VSP010	Arm in Press. Sensor	3	Voltage of Arm in Press. Sensor is Above Normal	1-46/ 1-29	V = 1 V		2	It has to be measured in engine stop state
		4	Voltage of Arm in Press. Sensor is Below Normal					
VSE001	Oil Temp. Sensor	0	Oil Temp. Sensor Signal is Above Normal Range	1-36/ 1-11		R = 2.45 ±0.25 Ω (25°C (77°F)) R = 320 ±32 Ω (80°C (176°F))	3	
		3	Oil Temp. Sensor Voltage is Above Normal					
		4	Oil Temp. Sensor Voltage is Below Normal					
VSE002	Fuel Sensor	3	Fuel Sensor Voltage is Above Normal	1-37/ 1-11		Empty: 5 ±0.2 Ω Full: 500 ±10 Ω	3	
		4	Fuel Sensor Voltage is Below Normal					
VSE004	Wif Sensor	1	Wif Sensor Signal is Above Normal Range	1-38/ 1-29			3	
		3	Wif Sensor Voltage is Above Normal					
		4	Wif Sensor Voltage is Below Normal					
VS5001	Thumb Wheel (RH)	3	Thumb Wheel (RH) Voltage is Above Normal	1-30/ 1-10	V = 1.0 ±0.1 V V = 2.5 ±0.2 V neutral V = 4.0 ±0.1 V		3	
		4	Thumb Wheel (RH) Voltage is Below Normal					
VS5002	Thumb Wheel (LH)	3	Thumb Wheel (LH) Voltage is Above Normal	1-66/ 1-10	V = 1.0 ±0.1 V V = 2.5 ±0.2 V neutral V = 4.0 ±0.1 V		3	
		4	Thumb Wheel (LH) Voltage is Below Normal					
VS5005	Dial	3	Dial Voltage is Above Normal	1-31/ 1-10	V = 1.0 ±0.1 V V = 4.0 ±0.1 V		3	
		4	Dial Voltage is Below Normal					
VAL001	Alternator Potential	3	Alternator Potential Voltage is Above Normal	1-2	V = 27 ±0.1 V		4	
		4	Alternator Potential Voltage is Below Normal					

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 Code at Engine Side

GP (Graphic Panel): Code displays on Panel Gauge
FMI (Failure Mode Identifier): Code displays on DMS
DTC (Diagnostic Trouble Code): Code displays on Diagnostic tool
HEX: Hexadecimal, DEC: Decimal number

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E000051-03	2E9	33	51	03	Throttle valve position sensor: DFC for throttle valve position sensor voltage SRC high	2	
E000051-04	2E8	33	51	04	Throttle valve position sensor: DFC for throttle valve position sensor voltage SRC low	2	
E000091-03	123	5B	91	03	Accelerator pedal position: Signal range check high for APP1	1	
E000091-04	122	5B	91	04	Accelerator pedal position: Signal range check low for APP1	1	
E000100-00	521	64	100	00	Oil pressure sensor: Maximum oil pressure error in plausibility check	3	
E000100-01	1521	64	100	01	Oil pressure sensor: Minimum oil pressure error in plausibility check	3	
E000100-03	1522	64	100	03	Oil pressure sensor: SRC high for oil pressure sensor	3	
E000100-04	1523	64	100	04	Oil pressure sensor: SRC low for oil pressure sensor	3	
E000102-03	238	66	102	03	Boost pressure sensor: SRC high for boost pressure sensor	3	
E000102-04	237	66	102	04	Boost pressure sensor: SRC low for boost pressure sensor	3	
E000105-03	113	69	105	03	Air inlet temperature: SRC high for charge air cooler downstream temperature	2	
E000105-04	112	69	105	04	Air inlet temperature: SRC low for charge air cooler downstream temperature	2	
E000105-05	1113	69	105	05	Air Inlet temperature: Diagnostic fault check for SRC high in engine inlet valve air temperature upstream sensor	2	
E000105-06	1112	69	105	06	Air Inlet temperature: Diagnostic fault check for SRC low in engine inlet valve air temperature upstream sensor	2	
E000108-00	2227	6C	108	00	Barometric pressure sensor in ECU: Physical range check high for environment pressure	3	
E000108-01	1227	6C	108	01	Barometric pressure sensor in ECU: Physical range check low for environment pressure	3	
E000108-03	2229	6C	108	03	Barometric pressure sensor in ECU: SRC high for environment pressure	3	
E000108-04	2228	6C	108	04	Barometric pressure sensor in ECU: SRC low for environment pressure	3	
E000110-00	116	6E	110	00	Coolant temperature: Physical range check high for coolant temperature	3	
E000110-01	1118	6E	110	01	Coolant temperature: Physical range check low for coolant temperature	2	
E000110-03	118	6E	110	03	Coolant temperature: SRC high for coolant temperature	3	
E000110-04	1119	6E	110	04	Coolant temperature: SRC low for coolant temperature	3	
E000110-12	1117	6E	110	12	Coolant temperature: Defect fault check for dynamic plausibility test of coolant temperature	3	
E000129-00	1093	81	129	00	Rail pressure sensor: Maximum rail pressure exceeded (1)	2	
E000129-01	1320	81	129	01	Rail pressure sensor: Check of minimum rail pressure	2	
E000129-03	193	81	129	03	Rail pressure sensor: Rail pressure sensor voltage above upper limit	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E000129-04	192	81	129	04	Rail pressure sensor: Rail pressure sensor voltage below lower limit	3	
E000129-05	191	81	129	05	Rail pressure sensor: Rail pressure raw value is above maximum offset	3	
E000129-06	1191	81	129	06	Rail pressure sensor: Rail pressure raw value is below minimum offset	3	
E000129-12	1095	81	129	12	Rail pressure sensor: Maximum rail pressure exceeded (2)	1	
E000129-31	1096	81	129	31	Rail pressure sensor: Maximum rail pressure exceeded (3)	1	
E000132-00	1101	84	132	00	Air mass flow sensor: Sensitivity drift high error for HFM sensor	1	
E000132-01	101	84	132	01	Air mass flow sensor: Sensitivity drift error low for HFM sensor	3	
E000132-03	103	84	132	03	Air mass flow sensor: SRC high error for raw value in HFM sensor	3	
E000132-04	102	84	132	04	Air mass flow sensor: SRC low error for raw value in HFM sensor	3	
E000132-12	100	84	132	12	Air mass flow sensor: SCB of hardware signal of HFM sensor	3	
E000132-31	1100	84	132	31	Air mass flow sensor: Battery voltage error of HFM sensor	2	
E000157-03	1255	9D	157	03	CP metering unit: Signal range check high error of metering unit	2	
E000157-04	1256	9D	157	04	CP metering unit: Signal range check low error of metering unit	2	
E000157-05	125B	9D	157	05	CP metering unit: Open load of metering unit output	3	
E000157-12	252	9D	157	12	CP metering unit: Over temperature of device driver of metering unit	3	
E000157-31	125A	9D	157	31	CP metering unit: Intermittent contact between ECU and MeUn	2	
E000158-00	563	9E	158	00	Battery: High battery voltage indication	2	
E000158-01	562	9E	158	01	Battery: Low battery voltage indication	2	
E000158-03	1563	9E	158	03	Battery: SRC high for battery voltage sensor	3	
E000158-04	1562	9E	158	04	Battery: SRC low for battery voltage sensor	3	
E000172-00	96	AC	172	00	Air mass flow sensor temperature: Physical range high error for air temperature sensor	2	
E000172-03	98	AC	172	03	Air mass flow sensor temperature: SRC high for air temperature sensor	2	
E000172-04	97	AC	172	04	Air mass flow sensor temperature: SRC low for air temperature sensor	2	
E000174-00	181	AE	174	00	Fuel temperature sensor: Physical range check high for fuel temperature	3	
E000174-01	180	AE	174	01	Fuel temperature sensor: Physical range check low for fuel temperature	2	
E000174-03	183	AE	174	03	Fuel temperature sensor: SRC high for fuel temperature sensor	2	
E000174-04	182	AE	174	04	Fuel temperature sensor: SRC low for fuel temperature sensor	2	
E000175-00	196	AF	175	00	Oil temperature sensor: Physical range check high for oil temperature	2	
E000175-01	195	AF	175	01	Oil temperature sensor: Physical range check low for oil temperature	2	
E000175-03	198	AF	175	03	Oil temperature sensor: SRC high for oil temperature	2	
E000175-04	197	AF	175	04	Oil temperature sensor: SRC low for oil temperature	2	
E000606-00	219	25E	606	00	Overspeed detection in component engine protection: Overspeed detection in component engine protection	2	
E000734-05	201	2DE	734	05	Solenoid powerstage 1 (cylinder 1): Open load of solenoid powerstage 1	2	
E000734-06	262	2DE	734	06	Solenoid powerstage 1 (cylinder 1): General short circuit of solenoid powerstage 1	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E000734-12	263	2DE	734	12	Solenoid powerstage 1 (cylinder 1): Special pattern for special cases of solenoid powerstage 1	2	
E000735-05	202	2DF	735	05	Solenoid powerstage 2 (cylinder 5): Open load of solenoid powerstage 2	2	
E000735-06	265	2DF	735	06	Solenoid powerstage 2 (cylinder 5): General short circuit of solenoid powerstage 2	3	
E000735-12	266	2DF	735	12	Solenoid powerstage 2 (cylinder 5): Special pattern for special cases of solenoid powerstage 2	2	
E000736-05	203	2E0	736	05	Solenoid powerstage 3 (cylinder 3): Open load of solenoid powerstage 3	2	
E000736-06	268	2E0	736	06	Solenoid powerstage 3 (cylinder 3): General short circuit of solenoid powerstage 3	3	
E000736-12	269	2E0	736	12	Solenoid powerstage 3 (cylinder 3): Special pattern for special cases of solenoid powerstage 3	2	
E000737-05	204	2E1	737	05	Solenoid powerstage 4 (cylinder 6): Open load of solenoid powerstage 4	2	
E000737-06	271	2E1	737	06	Solenoid powerstage 4 (cylinder 6): General short circuit of solenoid powerstage 4	3	
E000737-12	272	2E1	737	12	Solenoid powerstage 4 (cylinder 6): Special pattern for special cases of solenoid powerstage 4	2	
E000738-05	205	2E2	738	05	Solenoid powerstage 5 (cylinder 2): Open load of solenoid powerstage 5	2	
E000738-06	274	2E2	738	06	Solenoid powerstage 5 (cylinder 2): General short circuit of solenoid powerstage 5	3	
E000738-12	275	2E2	738	12	Solenoid powerstage 5 (cylinder 2): Special pattern for special cases of solenoid powerstage 5	2	
E000739-05	120B	2E3	739	05	Solenoid powerstage 6 (cylinder 4): Open load of solenoid powerstage 6	2	
E000739-06	1277	2E3	739	06	Solenoid powerstage 6 (cylinder 4): General short circuit of solenoid powerstage 6	3	
E000739-12	1278	2E3	739	12	Solenoid powerstage 6 (cylinder 4): Special pattern for special cases of solenoid powerstage 6	2	
E000977-03	694	3D1	977	03	Auto fan clutch PWM out: Short circuit to battery error of fan clutch PWM out	2	
E000977-05	481	3D1	977	05	Auto fan clutch PWM out: No load error of fan clutch PWM out	2	
E000977-06	693	3D1	977	06	Auto fan clutch PWM out: Short circuit to ground error of fan clutch PWM out	2	
E000977-12	1481	3D1	977	12	Auto fan clutch PWM out: Over temperature error of fan clutch PWM out	2	
E001207-00	669	4B7	1207	00	Engine ECU temperature: Physical range check high for ECU temperature sensor (1)	2	
E001207-01	668	4B7	1207	01	Engine ECU temperature: Physical range check low for ECU temperature sensor (1)	2	
E001207-03	1669	4B7	1207	03	Engine ECU temperature: SRC high for ECU temperature sensor	2	
E001207-04	1668	4B7	1207	04	Engine ECU temperature: SRC low for ECU temperature sensor	2	
E001207-12	166A	4B7	1207	12	Engine ECU temperature: Physical range check high for ECU temperature sensor (2)	2	
E001207-31	166B	4B7	1207	31	Engine ECU temperature: Physical range check low for ECU temperature sensor (2)	2	
E001322-12	300	52A	1322	12	Monitoring misfire detection multiple cylinder: Monitoring misfire detection multiple cylinder	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E001323-12	301	52B	1323	12	Injection misfire detection cylinder 1: Injection misfire detection cylinder 1	2	
E001324-12	302	52C	1324	12	Injection misfire detection cylinder 5: Injection misfire detection cylinder 5 - (P302)	2	
E001325-12	303	52D	1325	12	Injection misfire detection cylinder 3: Injection misfire detection cylinder 3 - (P303)	2	
E001326-12	304	52E	1326	12	Injection misfire detection cylinder 6: Injection misfire detection cylinder 6 - (P304)	2	
E001327-12	305	52F	1327	12	Injection misfire detection cylinder 2: Injection misfire detection cylinder 2 - (P305)	2	
E001328-12	306	530	1328	12	Injection misfire detection cylinder 4: Injection misfire detection cylinder 4 - (P306)	2	
E001482-12	D121	5CA	1482	12	Timeout error of CAN receive frame TCU: Timeout error of CAN−Receive−Frame TSC1TE	1	
E001639-03	527	667	1639	03	Auto fan clutch speed: Fan speed above maximum threshold	2	
E001639-04	528	667	1639	04	Auto fan clutch speed: Fan speed below minimum threshold	2	
E001639-12	526	667	1639	12	Auto fan clutch speed: Fan speed signal long period fault path	2	
E001761-00	103B	6E1	1761	00	Urea tank level sensor: Error of urea tank level sensor evaluation with physical range check high	1	
E001761-01	203B	6E1	1761	01	Urea tank level sensor: Error of urea tank level sensor evaluation with physical range check low	1	
E001761-03	203D	6E1	1761	03	Urea tank level sensor: DFC for SRC high error of the urea tank level sensor	3	
E001761-04	203C	6E1	1761	04	Urea tank level sensor: DFC for SRC low error of the urea tank level sensor	3	
E001761-12	103C	6E1	1761	12	Urea tank level sensor: Status of tank level	3	
E003031-00	205B	BD7	3031	00	Urea temperature sensor: Physical range check high for urea temperature sensor	2	
E003031-01	105B	BD7	3031	01	Urea temperature sensor: Physical range check low for urea temperature sensor	1	
E003031-02	115B	BD7	3031	02	Urea temperature sensor: Error tank temperature sensor plausibility max threshold	1	
E003031-03	205D	BD7	3031	03	Urea temperature sensor: SRC high for urea temperature sensor	3	
E003031-04	205C	BD7	3031	04	Urea temperature sensor: SRC low for urea temperature sensor	3	
E003031-12	115A	BD7	3031	12	Urea temperature sensor: Error tank temperature sensor plausibility min threshold	1	
E003031-31	115C	BD7	3031	31	Urea temperature sensor: Error urea tank temperature is overheated	2	
E003363-03	20B4	D23	3363	03	Urea tank heating valve (coolant valve): Short circuit to battery error for urea tank heating valve	3	
E003363-04	20B3	D23	3363	04	Urea tank heating valve (coolant valve): Short circuit to ground error for urea tank heating valve	3	
E003363-12	20B1	D23	3363	12	Urea tank heating valve (coolant valve): No load error for urea tank heating valve	3	
E003363-31	10B1	D23	3363	31	Urea tank heating valve (coolant valve): Over temperature error for urea tank heating valve	3	
E003464-00	12E1	D88	3464	00	Throttle valve control: Permanent governor deviation max for throttle valve	2	
E003464-01	12E2	D88	3464	01	Throttle valve control: Permanent governor deviation min for throttle valve	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E003464-12	2E1	D88	3464	12	Throttle valve control: DFC for throttle valve drift at open position	2	
E003509-02	643	DB5	3509	02	Monitoring of sensor supply voltage in ECU: Error sensor supplies 1	3	
E003059-31	699	BF3	3059	31	Monitoring of sensor supply voltage in ECU: Error sensor supplies 2	3	
E003509-12	653	DB5	3509	12	Monitoring of sensor supply voltage in ECU: Error sensor supplies 3	3	
E003510-03	1602	DB6	3510	03	Monitoring of 12 V sensor supply voltage in ECU: 12 V Sensor supply 1 voltage is too high	2	
E003510-04	1603	DB6	3510	04	Monitoring of 12 V sensor supply voltage in ECU: 12 V Sensor supply 1 voltage is too low	2	
E003511-03	6B2	DB7	3511	03	Sensor supply voltage monitoring 1: Over voltage on sensor supply 1	3	
E003511-04	6B1	DB7	3511	04	Sensor supply voltage monitoring 1: Under voltage on sensor supply 1	3	
E003512-03	6B5	DB8	3512	03	Sensor supply voltage monitoring 2: Over voltage on sensor supply 2	3	
E003512-04	6B4	DB8	3512	04	Sensor supply voltage monitoring 2: Under voltage on sensor supply 2	3	
E003513-03	16B2	DB9	3513	03	Sensor supply voltage monitoring 3: Over voltage on sensor supply 3	3	
E003513-04	16B1	DB9	3513	04	Sensor supply voltage monitoring 3: Under voltage on sensor supply 3	3	
E003516-00	206D	DBC	3516	00	Urea quality sensor: Diagnostic fault check for urea quality sensor whether physical signal above the maximum limit	3	
E003516-01	206C	DBC	3516	01	Urea quality sensor: Diagnostic fault check for urea quality sensor whether physical signal below the minimum limit	3	
E003519-05	1128	DBF	3519	05	SAE J1939 error for SCR catalyst reagent temperature 2 preliminary FMI: SAE J1939 error for catalyst reagent temperature 2 preliminary FMI message (open circuit)	3	
E003519-31	112A	DBF	3519	31	SAE J1939 error for SCR catalyst reagent temperature 2 preliminary FMI: SAE J1939 error for catalyst reagent temperature 2 preliminary FMI message (short circuit)	3	
E003520-00	1120	DC0	3520	00	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message	1	
E003520-01	1121	DC0	3520	01	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message	1	
E003520-05	1122	DC0	3520	05	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message (tank open circuit)	3	
E003520-06	206A	DC0	3520	06	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message	1	
E003520-12	1123	DC0	3520	12	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message	1	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E003520-31	1124	DC0	3520	31	SAE J1939 error for SCR catalyst reagent properties preliminary FMI: SAE J1939 error for diesel exhaust fluid properties preliminary FMI message (tank short circuit)	3	
E003532-05	203A	DCC	3532	05	SAE J1939 error for SCR catalyst tank level preliminary FMI: SAE J1939 error for SPN3532 catalyst tank level preliminary FMI (open circuit)	3	
E003532-31	1126	DCC	3532	31	SAE J1939 error for SCR catalyst tank level preliminary FMI: SAE J1939 error for SPN3532 catalyst tank level preliminary FMI (short circuit)	3	
E003597-03	1604	E0D	3597	03	Monitoring of internal 12 V supply voltage in ECU: Internal 12 V supply voltage is too high	2	
E003597-04	1605	E0D	3597	04	Monitoring of internal 12 V supply voltage in ECU: Internal 12 V supply voltage is too low	2	
E004332-12	1704	10EC	4332	12	Supply module monitoring 2: Detection of filled system in Init−State (supply module monitoring)	1	
E004334-00	204B	10EE	4334	00	Urea pump module pressure sensor: Physical range check high for urea pump module pressure sensor	1	
E004334-01	104B	10EE	4334	01	Urea pump module pressure sensor: Physical range check low for urea pump module pressure sensor	2	
E004334-03	204D	10EE	4334	03	Urea pump module pressure sensor: SRC error max for urea pump module pressure sensor	3	
E004334-04	204C	10EE	4334	04	Urea pump module pressure sensor: SRC error min for urea pump module pressure sensor	3	
E004334-12	1726	10EE	4334	12	Urea pump module pressure sensor: plausibility error min for urea pump module pressure sensor	3	
E004334-31	1725	10EE	4334	31	Urea pump module pressure sensor: Plausibility error max for urea pump module pressure sensor	3	
E004354-03	20BC	1102	4354	03	Backflow line heater: Short circuit to battery error for backflow line heater	3	
E004354-04	20BB	1102	4354	04	Backflow line heater: Short circuit to ground error for backflow line heater	1	
E004354-12	20B9	1102	4354	12	Backflow line heater: No load error for backflow line heater	3	
E004354-31	10B9	1102	4354	31	Backflow line heater: Over temperature error for backflow line heater	3	
E004355-03	20C0	1103	4355	03	Pressure line heater: Short circuit to battery error for pressure line heater	3	
E004355-04	20BF	1103	4355	04	Pressure line heater: Short circuit to ground error for pressure line heater	1	
E004355-12	20BD	1103	4355	12	Pressure line heater: No load error for pressure line heater	3	
E004355-31	10BD	1103	4355	31	Pressure line heater: Over temperature error for pressure line heater	3	
E004356-03	20C4	1104	4356	03	Suction line heater: Short circuit to battery error for suction line heater	3	
E004356-04	20C3	1104	4356	04	Suction line heater: Short circuit to ground error for suction line heater	1	
E004356-12	20C1	1104	4356	12	Suction line heater: No load error for suction line heater	3	
E004356-31	10C1	1104	4356	31	Suction line heater: Over temperature error for suction line heater	3	
E004357-03	20C8	1105	4357	03	Supply module heater: Short circuit to battery error for supply module heater	3	
E004357-04	20C7	1105	4357	04	Supply module heater: Short circuit to ground error for supply module heater	1	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E004357-12	20C5	1105	4357	12	Supply module heater: No load error for supply module heater	3	
E004357-31	10C5	1105	4357	31	Supply module heater: Over temperature error for supply module heater	3	
E004360-00	436	1108	4360	00	Urea catalyst upstream temperature: Physical range check high for urea catalyst upstream temperature	3	
E004360-01	1436	1108	4360	01	Urea catalyst upstream temperature: Physical range check low for urea catalyst upstream temperature	2	
E004360-03	438	1108	4360	03	Urea catalyst upstream temperature: SRC high for urea catalyst upstream temperature sensor	3	
E004360-04	437	1108	4360	04	Urea catalyst upstream temperature: SRC low for urea catalyst upstream temperature sensor	3	
E004363-00	43B	110B	4363	00	SCR downstream temperature: Physical range check high for urea catalyst downstream temperature sensor	3	
E004363-01	143B	110B	4363	01	SCR downstream temperature: Physical range check low for urea catalyst downstream temperature sensor	2	
E004363-03	43D	110B	4363	03	SCR downstream temperature: SRC high for urea catalyst downstream temperature sensor	3	
E004363-04	43C	110B	4363	04	SCR downstream temperature: SRC low for urea catalyst downstream temperature sensor	3	
E004363-12	143C	110B	4363	12	SCR downstream temperature: Diagnostic fault check for plausibility errors in urea catalyst downstream temperature	1	
E004365-05	205A	110D	4365	05	SAE J1939 error for SCR catalyst reagent tank 1 temperature preliminary FMI: SAE J1939 error for SPN 4365 catalyst reagent tank 1 temp prelim FMI (open circuit)	3	
E004365-31	112C	110D	4365	31	SAE J1939 error for SCR catalyst reagent tank 1 temperature preliminary FMI: SAE J1939 error for SPN 4365 catalyst reagent tank 1 temp prelim FMI (short circuit)	3	
E004375-12	1721	1117	4375	12	Urea pump motor 1: Pump motor speed deviation	1	
E004375-31	1722	1117	4375	31	Urea pump motor 1: Permanent pump motor speed deviation	3	
E004376-03	20A3	1118	4376	03	Urea reverting valve: Short circuit to battery error for urea reverting valve	3	
E004376-05	20A0	1118	4376	05	Urea reverting valve: No load error for urea reverting valve	3	
E004376-06	20A2	1118	4376	06	Urea reverting valve: Short circuit to ground error for urea reverting valve	3	
E004376-12	10A0	1118	4376	12	Urea reverting valve: Over temperature error for urea reverting valve	3	
E004376-31	10A2	1118	4376	31	Urea reverting valve: Reverting valve is blocked closed	1	
E004765-00	2080	129D	4765	00	DOC upstream temperature: Physical range check high for DOC upstream temperature sensor	3	
E004765-03	546	129D	4765	03	DOC upstream temperature: Diagnostic fault check for SRC high in DOC upstream temperature	3	
E004765-04	545	129D	4765	04	DOC upstream temperature: Diagnostic fault check for SRC low in DOC upstream temperature	3	
E005465-00	2263	1559	5465	00	Pressure control regulator: PCR governor deviation above limit	2	
E005465-01	1263	1559	5465	01	Pressure control regulator: PCR governor deviation below limit	1	
E520196-12	251	7F004	520196	12	Rail pressure monitoring 1: Maximum positive deviation of rail pressure exceeded	3	
E520197-12	C046	7F005	520197	12	Timeout error of CAN module C: Busoff error CAN C	3	
E520197-31	C054	7F005	520197	31	Timeout error of CAN module C: Error passive CAN C	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520199-02	336	7F007	520199	02	Crankshaft sensor: DFC for crankshaft signal diagnosis – disturbed signal	3	
E520199-05	335	7F007	520199	05	Crankshaft sensor: DFC for crankshaft signal diagnosis – no signal	3	
E520200-02	341	7F008	520200	02	Camshaft sensor: DFC for camshaft signal diagnosis – disturbed signal	2	
E520200-05	340	7F008	520200	05	Camshaft sensor: DFC for camshaft signal diagnosis – no signal	2	
E520200-12	1340	7F008	520200	12	Camshaft sensor: DFC for camshaft offset angle exceeded	2	
E520201-12	62F	7F009	520201	12	EEPROM erase error: EEP erase error based on the error in erasing of sector (for emulation only)	2	
E520202-12	162F	7F00A	520202	12	EEPROM read error: EEP read error based on the error in reading blocks from memory media	2	
E520203-12	89	7F00B	520203	12	Monitoring of PRV -1: Pressure relief valve reached maximum allowed opening count	2	
E520204-12	1630	7F00C	520204	12	EEPROM write error: EEP write error based on the error in storing the blocks in memory media	2	
E520205-03	1484	7F00D	520205	03	Monitoring in case of digital signal controlled fans: Short circuit to battery error of fan digital signal	2	
E520205-05	480	7F00D	520205	05	Monitoring in case of digital signal controlled fans: No load error of fan digital signal	2	
E520205-06	485	7F00D	520205	06	Monitoring in case of digital signal controlled fans: Short circuit to ground error of fan digital signal	2	
E520205-12	484	7F00D	520205	12	Monitoring in case of digital signal controlled fans: Over temperature error of fan digital signal	2	
E520206-12	C028	7F00E	520206	12	Timeout error of CAN module A: Busoff error CAN A	3	
E520206-31	C036	7F00E	520206	31	Timeout error of CAN module A: Error passive CAN A	3	
E520336-12	1000	7F090	520336	12	Engine temperature sensor plausibility 0: Air temperature monitoring plausibility check array 0	3	
E520337-12	1001	7F091	520337	12	Engine temperature sensor plausibility 1: Air temperature monitoring plausibility check array 1	3	
E520338-12	1002	7F092	520338	12	Engine temperature sensor plausibility 2: Air temperature monitoring plausibility check array 2	3	
E520339-12	1003	7F093	520339	12	Engine temperature sensor plausibility 3: Air temperature monitoring plausibility check array 3	3	
E520340-12	1004	7F094	520340	12	Engine temperature sensor plausibility 4: Air temperature monitoring plausibility check array 4	3	
E520341-12	1005	7F095	520341	12	Engine temperature sensor plausibility Tot: Air temperature monitoring plausibility check	3	
E520601-12	160B	7F199	520601	12	ECU hardware chip CY320 error: ECU hardware chip CY320 error	2	
E520602-12	C141	7F19A	520602	12	Hydraulic oil temperature CAN time out: Timeout error of CAN–Receive–Frame AAI	2	
E520603-12	C122	7F19B	520603	12	Timeout error of CAN receive frame DEC1V: Timeout error of CAN–Receive–Frame DEC1V	2	
E520604-12	607	7F19C	520604	12	ECU hardware chip CY146 error 1: ECU hardware chip CY146 error 1	2	
E520606-12	C10A	7F19E	520606	12	Timeout error of CAN receive frame EGR valve: Timeout error of CAN–Receive–Frame EGRerr	3	
E520607-12	D10B	7F19F	520607	12	EGR valve actuator communication error: EGR SRA error for communication loss 1	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520609-00	402	7F1A1	520609	00	Air control governor deviation error: Positive governor deviation above limit	1	
E520609-01	401	7F1A1	520609	01	Air control governor deviation error: Negative air control governor deviation below limit	2	
E520611-12	D127	7F1A3	520611	12	Timeout error of CAN receive frame vehicle cut off switch: Timeout error of CAN−Receive−Frame AUXIO1	2	
E520612-00	C124	7F1A4	520612	00	Accel pedal CAN max error: Timeout error of CAN−Receive−Frame DEC1V	2	
E520613-12	D125	7F1A5	520613	12	Vehicle cutoff switch error: DFC for error at vehicle cut−off switch	1	
E520616-00	1564	7F1A8	520616	00	ECU power stage test: Powerstage diagnosis disabled due to high battery voltage	2	
E520616-01	1565	7F1A8	520616	01	ECU power stage test: Powerstage diagnosis disabled due to low battery voltage	2	
E520618-12	60B	7F1AA	520618	12	Monitoring of ADC - 1: Diagnostic fault check to report the NTP error in ADC monitoring	2	
E520624-12	1315	7F1B0	520624	12	Monitoring of injection - 1: Number of injections is limited by charge balance of booster capacity	1	
E520625-12	A0F	7F1B1	520625	12	Detection of failed engine start: Detection of failed engine start	1	
E520626-02	162D	7F1B2	520626	02	Injection bank short circuit 0: Time out of SCG measurement of injection bank 1	2	
E520626-06	162E	7F1B2	520626	06	Injection bank short circuit 0: Short circuit to ground monitoring test in injection bank 1	2	
E520626-12	62D	7F1B2	520626	12	Injection bank short circuit 0: Short circuit of Injection bank 1	3	
E520627-12	1607	7F1B3	520627	12	ECU hardware chip CY146 error 2: ECU hardware chip CY146 error 2	2	
E520632-00	1764	7F1B8	520632	00	Diagnostic fault check for supply module: Diagnostic fault check for supply module temperature duty cycle in failure range	3	
E520632-01	1765	7F1B8	520632	01	Diagnostic fault check for supply module: Diagnostic fault check for supply module heater temperature duty cycle in invalid range	3	
E520632-03	1767	7F1B8	520632	03	Diagnostic fault check for supply module: Diagnostic fault check period outside valid range	3	
E520632-05	1768	7F1B8	520632	05	Diagnostic fault check for supply module: Diagnostic fault check to detect faulty PWM signal	3	
E520632-06	1766	7F1B8	520632	06	Diagnostic fault check for supply module: Temperature measurement module not available	3	
E520632-12	1769	7F1B8	520632	12	Diagnostic fault check for supply module: Diagnostic fault check for supply module temperature duty cycle in failure range	3	
E520632-31	176A	7F1B8	520632	31	Diagnostic fault check for supply module: Diagnostic fault check for supply module temperature duty cycle in invalid range	3	
E520633-02	161A	7F1B9	520633	02	ECU power stage module: Diagnostic fault check to report "WDA active" due to errors in query /response communication	2	
E520633-03	161C	7F1B9	520633	03	ECU power stage module: Diagnostic fault check to report "ABE active" due to overvoltage detection	2	
E520633-04	161B	7F1B9	520633	04	ECU power stage module: Diagnostic fault check to report "ABE active" due to undervoltage detection	2	
E520633-12	161D	7F1B9	520633	12	ECU power stage module: Diagnostic fault check to report "WDA/ABE active" due to unknown reason	2	
E520635-12	1306	7F1BB	520635	12	Rail PRV monitoring: Maximum rail pressure exceeded (4)	1	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520635-31	1307	7F1BB	520635	31	Rail PRV monitoring: Maximum rail pressure exceeded (5)	1	
E520637-03	659	7F1BD	520637	03	Actuator relay0 error: Short circuit to battery error at actuator relay 0	2	
E520637-05	658	7F1BD	520637	05	Actuator relay0 error: Short circuit to ground error at actuator relay 0	2	
E520638-03	2671	7F1BE	520638	03	Actuator relay1 error: Short circuit to battery error at actuator relay 1	2	
E520638-05	2670	7F1BE	520638	05	Actuator relay1 error: Short circuit to ground error at actuator relay 1	2	
E520639-03	2686	7F1BF	520639	03	Actuator relay2 error: Short circuit to battery error at actuator relay 2	2	
E520639-05	2685	7F1BF	520639	05	Actuator relay2 error: Short circuit to ground error at actuator relay 2	2	
E520640-12	1045	7F1C0	520640	12	Actuator relay3 error: Short circuit to battery error at actuator relay 3	2	
E520641-12	160F	7F1C1	520641	12	Monitoring of complete ROM test: Diagnostic fault check to report multiple error while checking the complete ROM memory	2	
E520642-12	1610	7F1C2	520642	12	ECU shut off path error 1: Loss of synchronization sending bytes to the MM from CPU	2	
E520643-12	101A	7F1C3	520643	12	Monitoring of overrun: Diagnostic fault check to report the error due to over run	2	
E520644-00	1600	7F1C4	520644	00	Monitoring of voltage supply: Reported overvoltage of VDD5	2	
E520644-01	1601	7F1C4	520644	01	Monitoring of voltage supply: Reported undervoltage of VDD5	2	
E520645-03	68B	7F1C5	520645	03	ECU main relay: DFC for stuck main relay error	2	
E520645-05	68A	7F1C5	520645	05	ECU main relay: Early opening defect of main relay	2	
E520652-03	107C	7F1CC	520652	03	Forced regeneration switch: Plausibility test of regeneration switch	2	
E520652-12	107A	7F1CC	520652	12	Forced regeneration switch: Short circuit to battery error of regeneration switch	2	
E520653-03	107B	7F1CD	520653	03	Forced regeneration inhibit switch: Short circuit to battery error of regeneration inhibit switch	2	
E520654-12	161E	7F1CE	520654	12	MSC Errors of R2S2: Reported MSC−Errors of a R2S2	2	
E520656-12	C29D	7F1D0	520656	12	Timeout error of Upstream NOx Sensor: Timeout error of CAN−Receive−Frame AT1IG1	3	
E520657-12	C29E	7F1D1	520657	12	Timeout error of downstream NOx Sensor: Timeout error of CAN−Receive−Frame AT1O1	3	
E520662-00	2201	7F1D6	520662	00	Nox sensor plausibility error: DFC for plausibility error max for upstream NOx sensor	1	
E520662-01	1201	7F1D6	520662	01	Nox sensor plausibility error: DFC for plausibility error min for upstream NOx sensor	1	
E520663-00	12FF	7F1D7	520663	00	SCR longterm adaption factor: Longterm adaption factor exceeds threshold	1	
E520663-01	1300	7F1D7	520663	01	SCR longterm adaption factor: Longterm adaption factor below threshold	1	
E520664-31	10EE	7F1D8	520664	31	ETA threshold error: DFC for SCR efficiency	3	
E520666-12	2BA8	7F1DA	520666	12	Monitoring of dosing release: Monitoring of the time until the dosing release is given	1	
E520669-06	1713	7F1DD	520669	06	Urea dosing valve: Short circuit to ground error in high side powerstage of urea dosing valve actuator	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520669-12	1712	7F1DD	520669	12	Urea dosing valve: Dosing valve is blocked	3	
E520669-31	1714	7F1DD	520669	31	Urea dosing valve: Over temperature error on powerstage of urea dosing valve actuator	3	
E520670-12	170D	7F1DE	520670	12	Plausibility of urea quantity and pump Speed: Reporting of the error for the PUQP function	3	
E520671-02	D102	7F1DF	520671	02	Diagnostic fault check for EPA emergency function: DFC for non plause error of EPA emergency function	1	
E520671-12	D101	7F1DF	520671	12	Diagnostic fault check for EPA emergency function: DFC for check sum error of EPA emergency function	1	
E520672-12	1710	7F1E0	520672	12	limitation counter when the urea fill level is in the limitation range: Maximum number restarts allowed by restriction counter is exceeded	1	
E520673-12	170E	7F1E1	520673	12	Urea tank heating plausibility error: Stuck in range check of urea tank temperature sensor	1	
E520674-12	D10A	7F1E2	520674	12	Timeout error of CAN receive frame EGR valve error message: Timeout error of CAN−Transmit−Frame EGRVlv	3	
E520675-12	C40B	7F1E3	520675	12	EGR valve actuator initializing error: EGR SRA error during initialization	2	
E520676-12	D10C	7F1E4	520676	12	EGR valve actuator communication error 2: EGR SRA error for communication loss 2	2	
E520677-12	D40B	7F1E5	520677	12	EGR valve actuator overload error: EGR SRA error for overload	2	
E520678-12	D40C	7F1E6	520678	12	EGR valve actuator position deviation: EGR SRA error in position deviation	2	
E520679-12	D40D	7F1E7	520679	12	EGR valve actuator position estimation error: EGR SRA error in position estimation	2	
E520680-12	D40E	7F1E8	520680	12	EGR valve actuator shortcut detection: EGR SRA error for short detection	2	
E520681-12	D40F	7F1E9	520681	12	EGR valve actuator temperature alert: EGR SRA error for temperature alert	2	
E520682-12	D410	7F1EA	520682	12	EGR valve actuator temperature error: EGR SRA error in measurement of temperature	2	
E520683-12	D411	7F1EB	520683	12	EGR valve actuator temperature warning: EGR SRA error for temperature warning	2	
E520684-12	D412	7F1EC	520684	12	EGR valve actuator torque limitation error: EGR SRA error for torque limitation	2	
E520685-12	1608	7F1ED	520685	12	ECU hardware chip CY146 error 3: ECU hardware chip CY146 error 3	2	
E520686-12	1609	7F1EE	520686	12	ECU hardware chip CY146 error 4: ECU hardware chip CY146 error 4	2	
E520687-12	160A	7F1EF	520687	12	ECU hardware chip CY146 error 5: ECU hardware chip CY146 error 5	2	
E520688-12	1316	7F1F0	520688	12	Monitoring of injection - 2: Number of injections is limited by quantity balance of high pressure pump	1	
E520689-12	1317	7F1F1	520689	12	Monitoring of injection - 3: Number of injections is limited by system	1	
E520690-12	1318	7F1F2	520690	12	Monitoring of injection - 4: Number of injections is limited by runtime	1	
E520691-02	1207	7F1F3	520691	02	Injection bank short circuit 1: Time out of SCG measurement of injection bank 2	2	
E520691-06	1209	7F1F3	520691	06	Injection bank short circuit 1: Short circuit to ground monitoring test in injection bank 2	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520691-12	206	7F1F3	520691	12	Injection bank short circuit 1: Short circuit of injection bank 2	3	
E520693-12	62B	7F1F5	520693	12	Injection chip error: Injection chip error	2	
E520694-03	254	7F1F6	520694	03	CP metering unit - high side circuit error: Short circuit to battery in the high side of the MeUn	2	
E520694-04	253	7F1F6	520694	04	CP metering unit - high side circuit error: Short circuit to ground in the high side of the MeUn	3	
E520695-03	1254	7F1F7	520695	03	CP metering unit - low side circuit error: Short circuit to battery of metering unit output	3	
E520695-04	1253	7F1F7	520695	04	CP metering unit - low side circuit error: Short circuit to ground of metering unit output	3	
E520696-12	160C	7F1F8	520696	12	Monitoring of ADC - 2: Diagnostic fault check to report the ADC test error	2	
E520697-12	160D	7F1F9	520697	12	Monitoring of ADC - 3: Diagnostic fault check to report the error in voltage ratio in ADC monitoring	2	
E520698-12	60C	7F1FA	520698	12	Monitoring of communication module - 1: Diagnostic fault check to report errors in query /response communication	2	
E520699-12	160E	7F1FB	520699	12	Monitoring of communication module - 2: Diagnostic fault check to report errors in SPI communication	2	
E520700-12	1611	7F1FC	520700	12	ECU shut off path error 2: DFC to set a torque limitation once an error is detected before MoCSOP's error reaction is set	3	
E520701-12	1612	7F1FD	520701	12	ECU shut off path error 3: Wrong set response time	2	
E520702-12	1613	7F1FE	520702	12	ECU shut off path error 4: Too many SPI errors during MoCSOP execution	2	
E520703-12	1615	7F1FF	520703	12	ECU shut off path error 5: Diagnostic fault check to report that WDA is not working correct	2	
E520704-12	1616	7F200	520704	12	ECU shut off path error 6: OS timeout in the shut off path test. Failure setting the alarm task period	2	
E520705-12	1617	7F201	520705	12	ECU shut off path error 7: Diagnostic fault check to report that the positive test failed	2	
E520706-12	1618	7F202	520706	12	ECU shut off path error 8: Diagnostic fault check to report the timeout in the shut off path test	2	
E520707-03	1619	7F203	520707	03	ECU shut off path error of voltage detection: Diagnostic fault check to report the error in overvoltage monitoring	2	
E520707-04	1614	7F203	520707	04	ECU shut off path error of voltage detection: Diagnostic fault check to report the error in undervoltage monitoring	2	
E520708-12	1008	7F204	520708	12	Shut-off request of the injection cut-off: Injection cut off demand (ICO) for shut off coordinator	2	
E520709-12	108C	7F205	520709	12	Monitoring of PRV -2: Pressure relief valve is forced to open; Perform pressure increase	2	
E520710-12	108D	7F206	520710	12	Monitoring of PRV -3: Pressure relief valve is forced to open; Perform pressure shock	2	
E520711-12	108E	7F207	520711	12	Monitoring of PRV -4: Pressure relief valve is open	3	
E520712-12	1036	7F208	520712	12	Monitoring of PRV -5: Quantity balance check if a successful PRV opening is ensured	2	
E520713-12	1037	7F209	520713	12	Monitoring of PRV -6: Averaged rail pressure is outside the expected tolerance range	2	
E520714-12	108F	7F20A	520714	12	Monitoring of PRV -7: Pressure relief valve reached maximum allowed open time	2	
E520715-12	1251	7F20B	520715	12	Rail pressure monitoring 2: Leakage is detected based on fuel quantity balance	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520716-12	1252	7F20C	520716	12	Rail pressure monitoring 3: Maximum negative rail pressure deviation with metering unit on lower limit is exceeded	3	
E520717-12	87	7F20D	520717	12	Rail pressure monitoring 4: Minimum rail pressure exceeded	3	
E520718-12	88	7F20E	520718	12	Rail pressure monitoring 5: Maximum rail pressure exceeded	2	
E520719-12	1090	7F20F	520719	12	Rail pressure monitoring 6: Maximum rail pressure exceeded (second stage)	2	
E520720-12	1050	7F210	520720	12	Rail pressure monitoring 7: Setpoint of metering unit in overrun mode not plausible	3	
E520721-12	1257	7F211	520721	12	Rail pressure monitoring 8: Setpoint of metering unit in idle mode not plausible	3	
E520722-12	1214	7F212	520722	12	Plausibility check for NOx sensor: DFC for stuck in range error check for downstream NOx sensor	1	
E520722-31	2214	7F212	520722	31	Plausibility check for NOx sensor: DFC for peak plausibility check for downstream NOx sensor	1	
E520723-12	12E5	7F213	520723	12	Inducement count "Blocked EGR valve" level 1: Inducement level 1 is active due to "EGR valve blocked"	3	
E520724-12	12E6	7F214	520724	12	Inducement count "Blocked EGR valve" Level 2: Inducement level 2 is active due to "EGR valve blocked"	3	
E520725-12	12E7	7F215	520725	12	Inducement count "Blocked EGR valve" Level 3: Inducement level 3 is active due to "EGR valve blocked"	3	
E520726-12	12E8	7F216	520726	12	Inducement count "Blocked EGR valve" warning: Inducement warning is active due to "EGR valve blocked"	3	
E520727-12	12E9	7F217	520727	12	Inducement count "Interruption of dosing" level 1: Inducement level 1 is active due to "Interruption of dosing"	3	
E520728-12	12EA	7F218	520728	12	Inducement count "Interruption of dosing" level 2: Inducement level 2 is active due to "Interruption of dosing"	3	
E520729-12	12EB	7F219	520729	12	Inducement count "Interruption of dosing" level 3: Inducement level 2 is active due to "Interruption of dosing"	3	
E520730-12	12EC	7F21A	520730	12	Inducement count "Interruption of dosing" warning: Inducement warning is active due to "Interruption of dosing"	3	
E520731-12	12ED	7F21B	520731	12	Inducement count DEF level: Inducement warning information for reagent level	1	
E520732-12	12EE	7F21C	520732	12	Inducement count reagent "Consumption" level 1: Inducement level 1 is active due to "Reagent consumption"	1	
E520733-12	12EF	7F21D	520733	12	Inducement count reagent "Consumption" level 2: Inducement level 2 is active due to "Reagent consumption"	1	
E520734-12	12F0	7F21E	520734	12	Inducement count reagent "Consumption" level 3: Inducement level 3 is active due to "Reagent consumption"	1	
E520735-12	12F1	7F21F	520735	12	Inducement count reagent "Consumption" warning: Inducement warning is active due to "Reagent consumption"	1	
E520736-12	12F2	7F220	520736	12	Inducement count "Reagent quality" level 1: Inducement level 1 is active due to "Reagent quality"	3	
E520737-12	12F3	7F221	520737	12	Inducement count "Reagent quality" level 2: Inducement level 2 is active due to "Reagent quality"	3	
E520738-12	12F4	7F222	520738	12	Inducement count "Reagent quality" level 3: Inducement level 3 is active due to "Reagent quality"	3	
E520739-12	12F5	7F223	520739	12	Inducement count "Reagent quality" warning: Inducement warning is active due to "Reagent quality"	3	
E520740-12	12F6	7F224	520740	12	Inducement count "Tampering" level 1: Inducement level 1 is active due to "Tampering"	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520741-12	12F7	7F225	520741	12	Inducement count "Tampering" level 2: Inducement level 2 is active due to "Tampering"	3	
E520742-12	12F8	7F226	520742	12	Inducement count "Tampering" level 3: Inducement level 3 is active due to "Tampering"	3	
E520743-12	12F9	7F227	520743	12	Inducement count "Tampering" level warning: Inducement warning is active due to "Tampering"	3	
E520744-05	2E0	7F228	520744	05	Throttle valve H-bridge: Open load error for throttle valve powerstage	2	
E520744-12	2EB	7F228	520744	12	Throttle valve H-bridge: Over temperature error for throttle valve H–bridge	2	
E520745-03	2E3	7F229	520745	03	Throttle valve H-bridge short circuit 1: Short circuit to battery on out1 error for throttle valve H–bridge	2	
E520745-04	2E2	7F229	520745	04	Throttle valve H-bridge short circuit 1: Short circuit to ground on out1 error for throttle valve H–bridge	2	
E520746-03	12E3	7F22A	520746	03	Throttle valve H-bridge short circuit 2: Short circuit to battery on out2 error for throttle valve H–bridge	2	
E520746-04	12E4	7F22A	520746	04	Throttle valve H-bridge short circuit 2: Short circuit to ground on out2 error for throttle valve H–bridge	2	
E520747-00	2E4	7F22B	520747	00	Throttle valve control jammed: Jammed valve of throttle valve (open)	2	
E520747-01	2E5	7F22B	520747	01	Throttle valve control jammed: Jammed valve of throttle valve (close)	2	
E520750-12	12FC	7F22E	520750	12	Overheating protection: Diagnostic fault check to report the error due to cooling injection in over run	2	
E520751-12	1700	7F22F	520751	12	Supply module monitoring error (backflow line plausibility error): General backflow line plausibility error (supply module monitoring)	3	
E520752-12	1701	7F230	520752	12	Supply module monitoring (pressure check error): General pressure check error (supply module monitoring)	3	
E520753-12	1702	7F231	520753	12	Supply module monitoring (pressure stabilization error): Pressure stabilization error (supply module monitoring)	3	
E520754-12	1703	7F232	520754	12	Supply module monitoring 1: Monitoring of ECU over temperature regardless of the state (supply module monitoring)	2	
E520755-12	20E9	7F233	520755	12	Supply module monitoring (over pressure error 1): Monitoring of metering control malfunction max (supply module monitoring)	3	
E520757-12	20E8	7F235	520757	12	Supply module monitoring (under pressure error): Monitoring of metering control malfunction min (supply module monitoring)	3	
E520758-12	1706	7F236	520758	12	Supply module monitoring (over pressure error 2): Monitoring of over pressure (supply module monitoring)	3	
E520759-12	124A	7F237	520759	12	Supply module monitoring (pressure build-up error): Monitoring of pressure build up error asymmetric (supply module monitoring)	3	
E520759-31	124B	7F237	520759	31	Supply module monitoring (pressure build-up error): Monitoring of pressure build up error symmetric (supply module monitoring)	3	
E520760-12	1708	7F238	520760	12	Supply module monitoring (pressure drop error): General pressure drop check error (supply module monitoring)	3	
E520761-12	1709	7F239	520761	12	Supply module monitoring (pressure reduction error): Monitoring of pressure reduction malfunction max (supply module monitoring)	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520761-31	1708	7F239	520761	31	Supply module monitoring (pressure reduction error): Monitoring of underpressure error in afterrun state (supply module monitoring)	3	
E520762-12	170A	7F23A	520762	12	SCR catalyst downstream temperature sensor static plausibility: Error for SCR catalyst downstream temperature sensor static plausibility	1	
E520763-00	170B	7F23B	520763	00	Urea tank level plausibility error: Urea tank sensor indicates too high fill level	1	
E520763-01	170C	7F23B	520763	01	Urea tank level plausibility error: Urea tank sensor indicates too low fill level	1	
E520764-12	1711	7F23C	520764	12	Detection of SCR wrong temperature value: Detection of SCR wrong temperature value	1	
E520765-03	1715	7F23D	520765	03	Low side switch error of urea dosing valve: Short circuit to battery error in powerstage of urea dosing valve actuator	3	
E520765-06	1716	7F23D	520765	06	Low side switch error of urea dosing valve: Short circuit to ground error in powerstage of urea dosing valve actuator	3	
E520766-03	1717	7F23E	520766	03	High side switch error of urea dosing valve: Short circuit to battery error in high side powerstage of urea dosing valve actuator	3	
E520766-06	1718	7F23E	520766	06	High side switch error of urea dosing valve: Short circuit error in high side powerstage of urea dosing valve actuator	3	
E520767-12	1719	7F23F	520767	12	Supply module heater plausibility error 1: Error supply module heater plausibility	3	
E520768-12	171A	7F240	520768	12	Supply module heater plausibility error 2: Error urea supply module heater temperature sensor dynamic plausibility	3	
E520768-31	171B	7F240	520768	31	Supply module heater plausibility error 2: Error urea supply module heater temperature sensor cold start plausibility	1	
E520769-12	171C	7F241	520769	12	Supply module temperature sensor plausibility error: Error urea supply module temperature sensor dynamic plausibility	3	
E520769-31	171D	7F241	520769	31	Supply module temperature sensor plausibility error: Error urea supply module temperature sensor cold start plausibility	1	
E520770-12	171E	7F242	520770	12	Urea catalyst upstream temperature plausibility error: Error for SCR catalyst upstream temperature sensor plausibility max threshold	3	
E520770-31	1720	7F242	520770	31	Urea catalyst upstream temperature plausibility error: Error for SCR catalyst upstream temperature sensor plausibility min threshold	1	
E520771-12	1723	7F243	520771	12	Urea pump motor 2: Pump motor not available for actuation	1	
E520772-03	208D	7F244	520772	03	Urea pump motor 3: Short circuit to battery error on powerstage for urea pump motor	3	
E520772-05	208A	7F244	520772	05	Urea pump motor 3: No load error on powerstage for urea pump motor	3	
E520772-06	208C	7F244	520772	06	Urea pump motor 3: Short circuit to ground error on powerstage for urea pump motor	3	
E520772-12	1724	7F244	520772	12	Urea pump motor 3: Over temperature error on powerstage for urea pump motor	3	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520780-12	D126	7F24C	520780	12	SAE J1939 error for catalyst reagent concentration: SAE J1939 error for catalyst reagent concentration message	1	
E520781-12	D5A3	7F24D	520781	12	SAE J1939 error for urea tank: SAE J1939 error for urea tank level message	1	
E520781-31	D5A4	7F24D	520781	31	SAE J1939 error for urea tank: SAE J1939 error for urea tank temperature message	1	
E520782-12	D5AA	7F24E	520782	12	Timeout error of catalyst reagent concentration: Timeout error of CAN−Receive−Frame A1DEFI	3	
E520783-12	D5AB	7F24F	520783	12	Timeout error of catalyst tank level and temperature: Timeout error of CAN−Receive−Frame AT1T1I	3	
E520784-12	D128	7F250	520784	12	SAE J1939 error for urea catalyst tank level indicator: SAE J1939 error for urea catalyst tank level indicator	1	
E520785-12	D146	7F251	520785	12	SAE J1939 error for catalyst reagent temperature2: SAE J1939 error for urea catalyst temperature2	1	
E520787-12	D148	7F253	520787	12	SAE J1939 error for catalyst tank level 2: SAE J1939 error for urea catalyst tank level 2	1	
E520788-12	107C	7F254	520788	12	Plausibility check for hardware switch interface of regeneration inhibition and regeneration demand switch: DFC for regeneration inhibition hardware switch and forced regeneration hardware switch plausibility test	2	
E520789-12	1302	7F255	520789	12	Diagnostic fault check to represent inducement override is active: Shows if inducement override is active	1	
E520790-12	1303	7F256	520790	12	Diagnostic fault check to represent level 1 is active due to repeat offense error: Repeat offense level 1 error	3	
E520791-12	1304	7F257	520791	12	Diagnostic fault check to represent level 2 is active due to repeat offense error: Repeat offense level 2 error	3	
E520792-12	1305	7F258	520792	12	Diagnostic fault check to represent level 3 is active due to repeat offense error: Repeat offense level 3 error	3	
E520794-05	2203	7F25A	520794	05	Monitoring of upstream Nox sensor: Open circuit monitoring for upstream Nox sensor	3	
E520794-06	2202	7F25A	520794	06	Monitoring of upstream Nox sensor: Short circuit monitoring for upstream Nox sensor	3	
E520795-05	2216	7F25B	520795	05	Monitoring of downstream Nox sensor: Open circuit monitoring for downstream Nox sensor	3	
E520795-06	2215	7F25B	520795	06	Monitoring of downstream Nox sensor: Short circuit monitoring for downstream Nox sensor	3	
E520796-12	1012	7F25C	520796	12	Diagnostic fault check to report the accelerator pedal position error: Diagnostic fault check to report the accelerator pedal position error	2	
E520797-12	1013	7F25D	520797	12	Diagnostic fault check to report the engine speed error: Diagnostic fault check to report the engine speed error	2	
E520798-12	1014	7F25E	520798	12	Diagnostic fault check to report the plausibility error between level 1 energizing time and level 2 information: Diagnostic fault check to report the plausibility error between level 1 energizing time and level 2 information	2	
E520799-12	1015	7F25F	520799	12	Error in the plausibility of the start of energizing angles: Diagnostic fault check to report the error due to plausibility between the injection begin v/s injection type	2	
E520800-12	1016	7F260	520800	12	Error in the plausibility check of the ZFC energizing times: Diagnostic fault check to report the error due to non plausibility in ZFC	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520801-12	1017	7F261	520801	12	Diagnosis fault check to report the demand for normal mode due to an error in the PoI2 quantity: Diagnosis fault check to report the demand for normal mode due to an error in the PoI2 quantity	2	
E520802-12	1018	7F262	520802	12	Diagnosis fault check to report the error to demand for an ICO due to an error in the PoI2 shut−off: Diagnosis fault check to report the error to demand for an ICO due to an error in the PoI2 shut−off	2	
E520803-12	1019	7F263	520803	12	Diagnosis fault check to report the error to demand for an ICO due to an error in the PoI3 efficiency factor: Diagnosis fault check to report the error to demand for an ICO due to an error in the PoI3 efficiency factor	2	
E520804-12	101B	7F264	520804	12	Diagnostic fault check to report the error due to injection quantity correction: Diagnostic fault check to report the error due to injection quantity correction	2	
E520805-12	101C	7F265	520805	12	Diagnostic fault check to report the plausibility error in rail pressure monitoring: Diagnostic fault check to report the plausibility error in rail pressure monitoring	2	
E520806-12	101D	7F266	520806	12	Diagnostic fault check to report the error due to torque comparison: Diagnostic fault check to report the error due to torque comparison	2	
E520807-02	1020	7F267	520807	02	Diagnosis of curr path limitation forced by ECU monitoring level 2: Diagnosis of set path limitation forced by ECU monitoring level 2	2	
E520807-12	101E	7F267	520807	12	Diagnosis of curr path limitation forced by ECU monitoring level 2: Diagnosis of curr path limitation forced by ECU monitoring level 2	2	
E520807-31	101F	7F267	520807	31	Diagnosis of curr path limitation forced by ECU monitoring level 2: Diagnosis of lead path limitation forced by ECU monitoring level 2	2	
E520808-12	1763	7F268	520808	12	Error dosing valve plausibility: Error dosing valve plausibility	3	
E520809-12	1038	7F269	520809	12	Monitoring of SCR DeSox: The demand for a desulphurization of the SCR catalyst is not fulfilled	2	
E520809-31	1039	7F269	520809	31	Monitoring of SCR DeSox: The engine operation mode was changed for a desulphurization of the SCR catalyst without being able to finish it successfuly	2	
E520810-12	170F	7F26A	520810	12	Deviation from the dosing quantity detected during test injection: Deviation from the urea dosing quantity detected during test injection	1	
E520811-12	1130	7F26B	520811	12	Inducement emergency state: Shows if inducement emergency state is active	1	
E520812-00	1131	7F26C	520812	00	Diagnostic fault check for urea quality temperature sensor: Diagnostic fault check for urea quality sensor temperature whether physical signal above the maximum limit	1	
E520812-01	1132	7F26C	520812	01	Diagnostic fault check for urea quality temperature sensor: Diagnostic fault check for urea quality sensor temperature whether physical signal below the minimum limit	1	
E520813-02	268C	7F26D	520813	02	Injector adjustment value error 1 (cylinder 1): Check of missing injector adjustment value programming 1	2	
E520814-02	2690	7F26E	520814	02	Injector adjustment value error 2 (cylinder 5): Check of missing injector adjustment value programming 2	2	
E520815-02	268E	7F26F	520815	02	Injector adjustment value error 3 (cylinder 3): Check of missing injector adjustment value programming 3	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520816-02	2691	7F270	520816	02	Injector adjustment value error 4 (cylinder 6): Check of missing injector adjustment value programming 4	2	
E520817-02	268D	7F271	520817	02	Injector adjustment value error 5 |(cylinder 2): Check of missing injector adjustment value programming 5	2	
E520818-02	268F	7F272	520818	02	Injector adjustment value error 6 (cylinder 4): Check of missing injector adjustment value programming 6	2	
E520819-12	1620	7F273	520819	12	ECU reset 0: Visibility of softwareresets 1	1	
E520820-12	1621	7F274	520820	12	ECU reset 1: Visibility of softwareresets 2	1	
E520821-12	1622	7F275	520821	12	ECU reset 2: Visibility of softwareresets 3	1	
E520822-12	1730	7F276	520822	12	Without empty pressure reduction: Pressure line heater error and temperature condition to perform an afterrun	2	
E520619-03	1047	7F1AB	520619	03	External actuator relay: Open load error at low side of external actuator relay	3	
E520619-04	1046	7F1AB	520619	04	External actuator relay: Short circuit to battery error at low side of external actuator relay	3	
E520619-05	1048	7F1AB	520619	05	External actuator relay: Short circuit to battery error at low side of external actuator relay	3	
E000970-31	1102	3CA	970	31	Engine emergency stop switch: DFC for engine emergency stop switch	1	
E003217-12	134	C91	3217	12	Dynamic monitoring of upstream Nox sensor O2 signal: DFC for dynamic monitoring of upstream Nox sensor O2 signal	1	
E003219-31	1203	C93	3219	31	Upstream Nox sensor heater temperature monitoring: Fault detection of heater availability for upstream Nox sensor	1	
E003227-12	140	C9B	3227	12	Dynamic monitoring of downstream Nox sensor O2 signal: DFC for dynamic monitoring of downstream Nox sensor O2 signal	1	
E003229-31	1204	C9D	3229	31	Downstream Nox sensor heater temperature monitoring: Fault detection of heater availability for downstream Nox sensor	1	
E520773-12	1727	7F245	520773	12	VGT actuator temperature fault: Temperature fault for VGT SRA	3	
E520774-12	1728	7F246	520774	12	VGT actuator OBSTRUCTION: Obstruction error for VGT SRA	3	
E520775-12	1729	7F247	520775	12	VGT actuator SPAN_LEARN_FAILURE: Learn failure error reported from VGT SRA	3	
E520776-12	172A	7F248	520776	12	VGT actuator IGNITION_VOLTAGE_FAULT: Ignition voltage fault of VGT SRA	3	
E520777-12	172B	7F249	520777	12	VGT actuator CAN_ERROR: CAN error of VGT SRA	3	
E520778-12	172C	7F24A	520778	12	VGT actuator INTERNAL_ELECTRICAL_FAULT: Internal electrical fault of VGT SRA	3	
E520779-12	172D	7F24B	520779	12	VGT actuator END_OF_LINE_LEARN_FAILURE: EOL learn failure of VGT SRA	3	
E520793-12	172E	7F259	520793	12	VGT actuator temperature warning: Temperature warning for VGT SRA	3	
E520614-12	C10C	7F1A6	520614	12	Timeout error of CAN−Receive−Frame VGTB2EDC	2	
E004339-12	1301	10F3	4339	12	NOx feedback controller reset: Monitoring of the SCR NOx governor	2	
E520823-03	1752	7F277	520823	03	Power stage for turbocharger: Short circuit to battery error for turbocharger powerstage	2	
E520823-12	1750	7F277	520823	12	Power stage for turbocharger: No load error for turbocharger powerstage	2	

GP Display Code	P Code DTC	DTC Code		FMI	GP Display Description	Severity	Remarks
		HEX	DEC				
E520823-31	1751	7F277	520823	31	Power stage for turbocharger: Over temperature error for turbocharger powerstage	2	
E520824-12	1754	7F278	520824	12	SAE J1939 error for upstream NOx sensor self-diagnosis: SAE J1939 error for upstream NOx sensor Self−diagnosis Status	2	
E520824-31	1755	7F278	520824	31	SAE J1939 error for upstream NOx sensor self-diagnosis: SAE J1939 error for upstream NOx sensor Self−diagnosis final result	2	
E520825-12	1756	7F279	520825	12	SAE J1939 error for downstream NOx sensor self-diagnosis: SAE J1939 error for downstream NOx sensor self−diagnosis status	2	
E520825-31	1757	7F279	520825	31	SAE J1939 error for downstream NOx sensor self-diagnosis: SAE J1939 error for downstream NOx sensor self−diagnosis final result	2	
E520826-12	1758	7F27A	520826	12	Urea reverting valve plausibility: Diagnostic fault check for plausibility errors in urea reverting valve	2	
E000518-12	D122	206	518	12	Timeout error of CAN receive frame machine controller: Timeout error of CAN−Receive−Frame TSC1VE	2	

FMIs (Failure Mode Identifier)

FMI	Description
0	Data Valid but Above Normal Operational Range - Most Severe Level
1	Data Valid but Below Normal Operational Range - Most Severe Level
2	Data Erratic, Intermittent or Incorrect
3	Voltage Above Normal, or Shorted to High Source
4	Voltage Below Normal, or Shorted to Low Source
5	Current Below Normal or Open Circuit
6	Current Above Normal or Grounded Circuit
7	Mechanical System Not Responding or Out of Adjustment
8	Abnormal Frequency or Pulse Width or Period
9	Abnormal Update Rate
10	Abnormal Rate of Change
11	Root Cause Not Known
12	Bad Intelligent Device or Component
13	Out of Calibration
14	Special Instructions
15	Data Valid but Above Normal Operating Range - Least Severe Level
16	Data Valid but Above Normal Operating Range - Moderately Severe Level
17	Data Valid but Below Normal Operating Range - Least Severe Level
18	Data Valid but Below Normal Operating Range - Moderately Severe Level
19	Received Network Data in Error
20	Data Drifted High
21	Data Drifted Low
31	Condition Exists

ELECTRONIC HYDRAULIC CONTROL SYSTEM (EPOS)

Control System Schematic

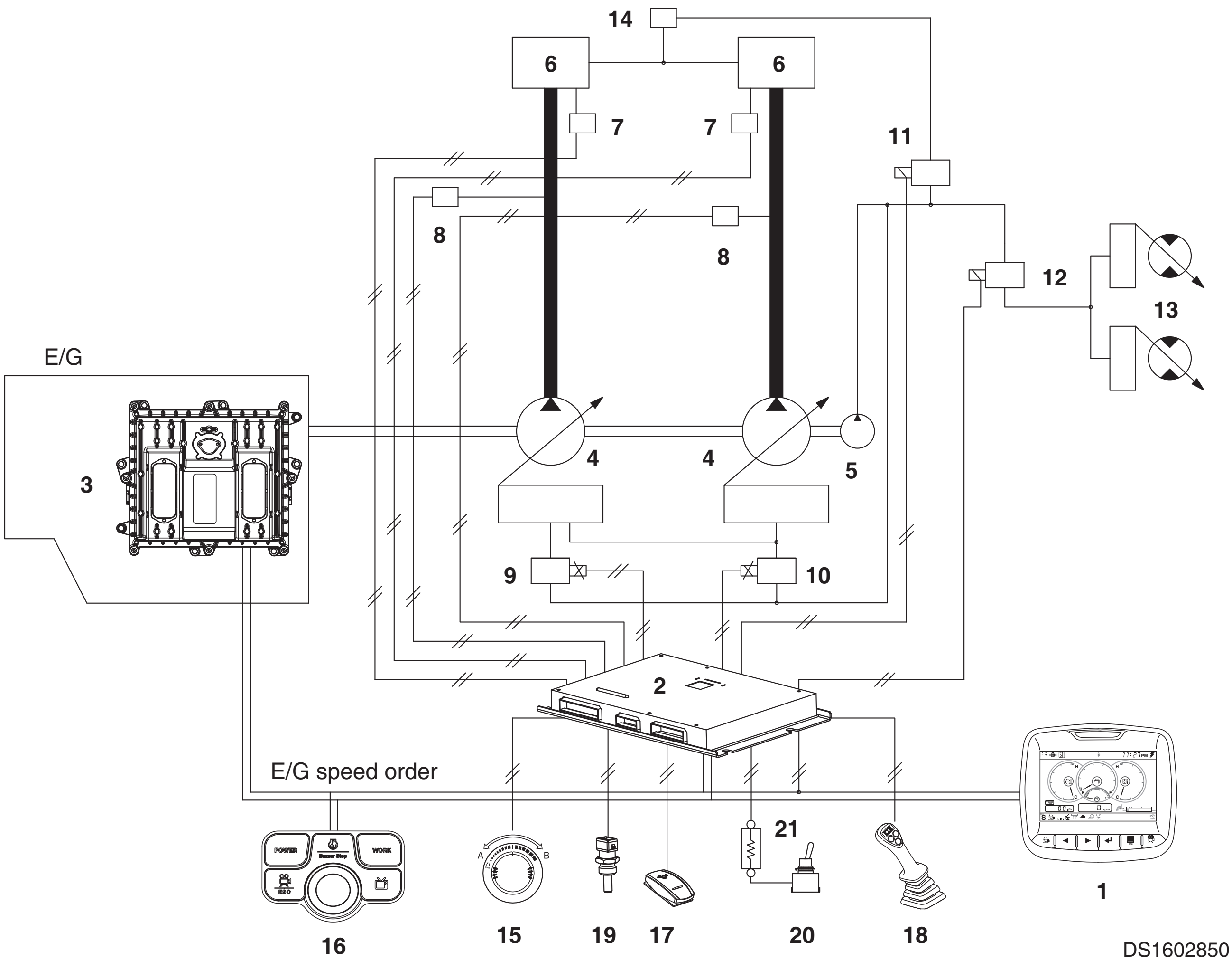


Figure 151

Reference Number	Description
1	Instrument Panel
2	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	Travel Motor
14	Main Relief Valve
15	Engine Control Dial
16	Jog Switch Control Panel
17	Auto Travel Selector Switch
18	Boost Switch (Right Work Lever)
19	Sensor
20	Aux Mode Switch
21	Aux Mode Resistor

POWER PLUS MODE CONTROL

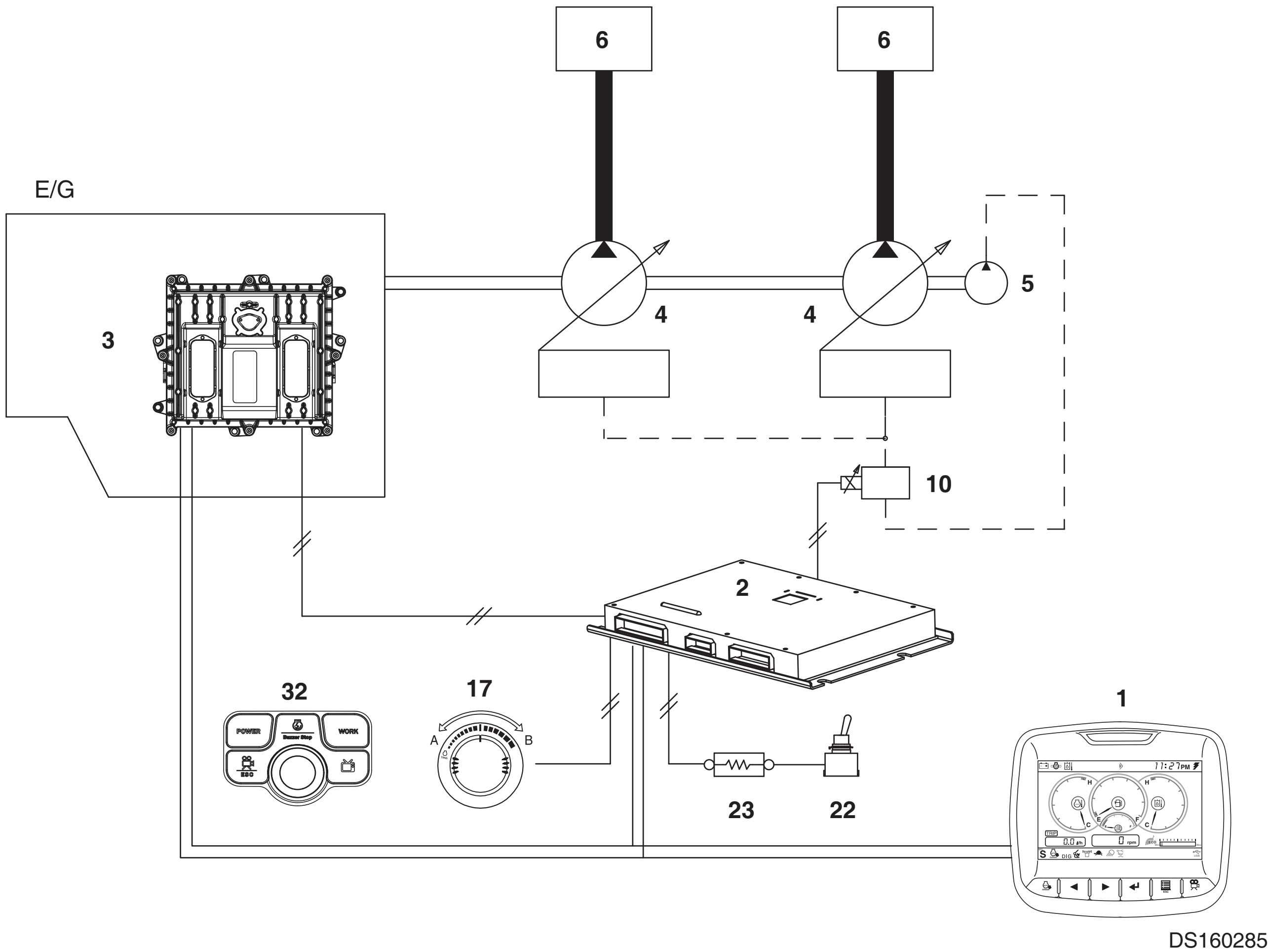


Figure 152

Reference Number	Description
1	Instrument Panel (Power Mode Selector Switch)
2	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
32	Jog Switch Control Panel

The Jog Switch Control Panel permits the selection of the appropriate engine power depending on the working condition. One of the four. Power Plus Mode, Power Mode, Standard Mode or Economy 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 jog switch on the jog switch control 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

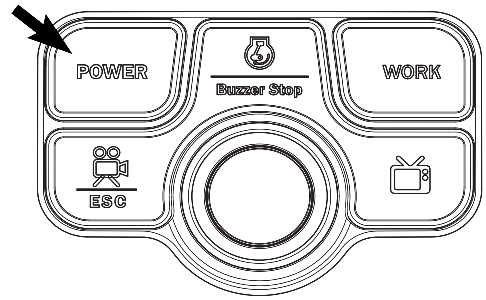
Mode	**Power Plus Mode**	**Power Mode**	**Standard Mode**	**Economy Mode**
Output (%)	100%	Approximately 90%	Approximately 80%	Approximately 75%

Operation

1. Power Plus Mode

This mode must be selected for high-speed work. In this mode the engine output is most efficiently utilized because of the discharged oil volume being controlled based on the equivalent horsepower curve at various loaded pressures. The EPOS controller compares the target engine speed with the actual engine speed and controls the signal to the EPPR (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.



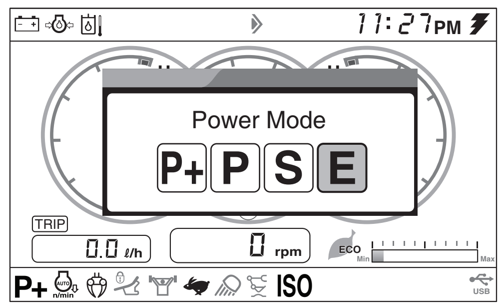
FG018900

Figure 153

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.

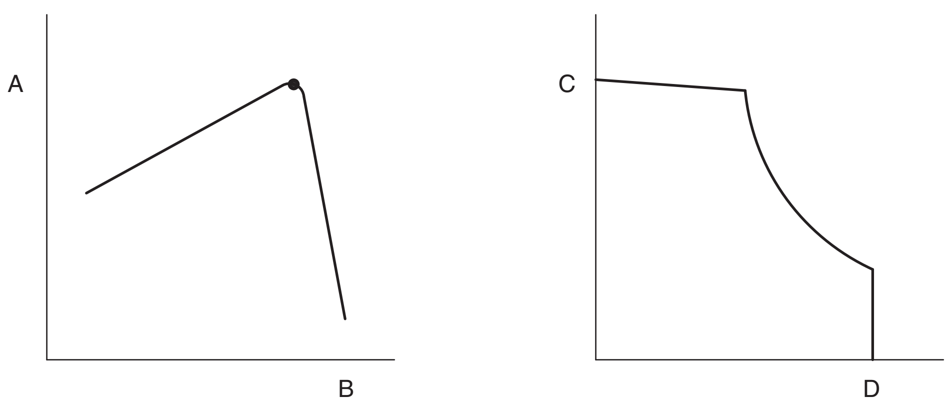
By repeating these control operations, the engine speed is maintained at the rated speed so maximum power can be generated.

In Power Mode, the 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 EPPR valve. Now the EPPR 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.



DS1601534

Figure 154



FG000580

Figure 155

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. Power Mode, Standard Mode, Economy Mode

Power Mode, Standard Mode or Economy Mode is selected on the work type. When the standard/economy mode is selected it will reduce noise and fuel consumption in comparison with Power Plus Mode. The EPOS controller compares the target engine speed with the actual engine speed and controls the signal to the EPPR valve which in turn varies the pump output quantity and it is the same method with power volume.

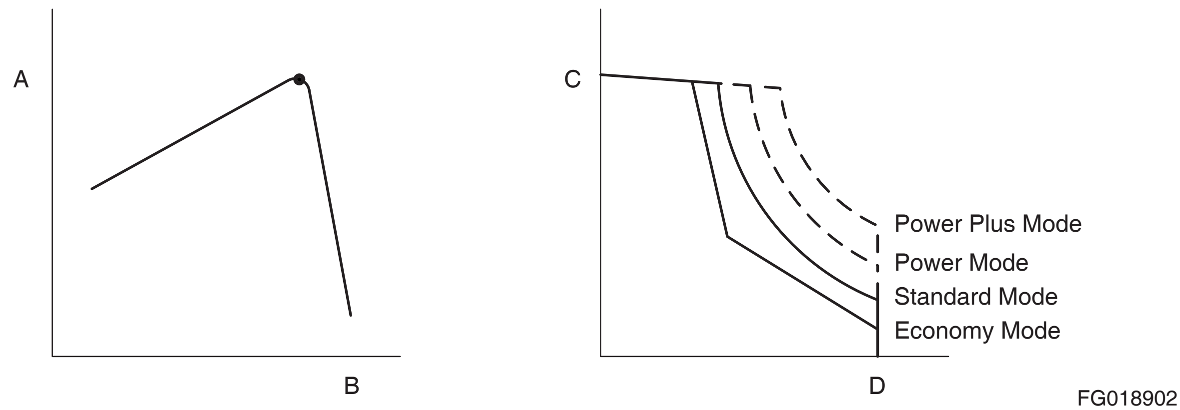


Figure 156

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)

POWER MODE CONTROL

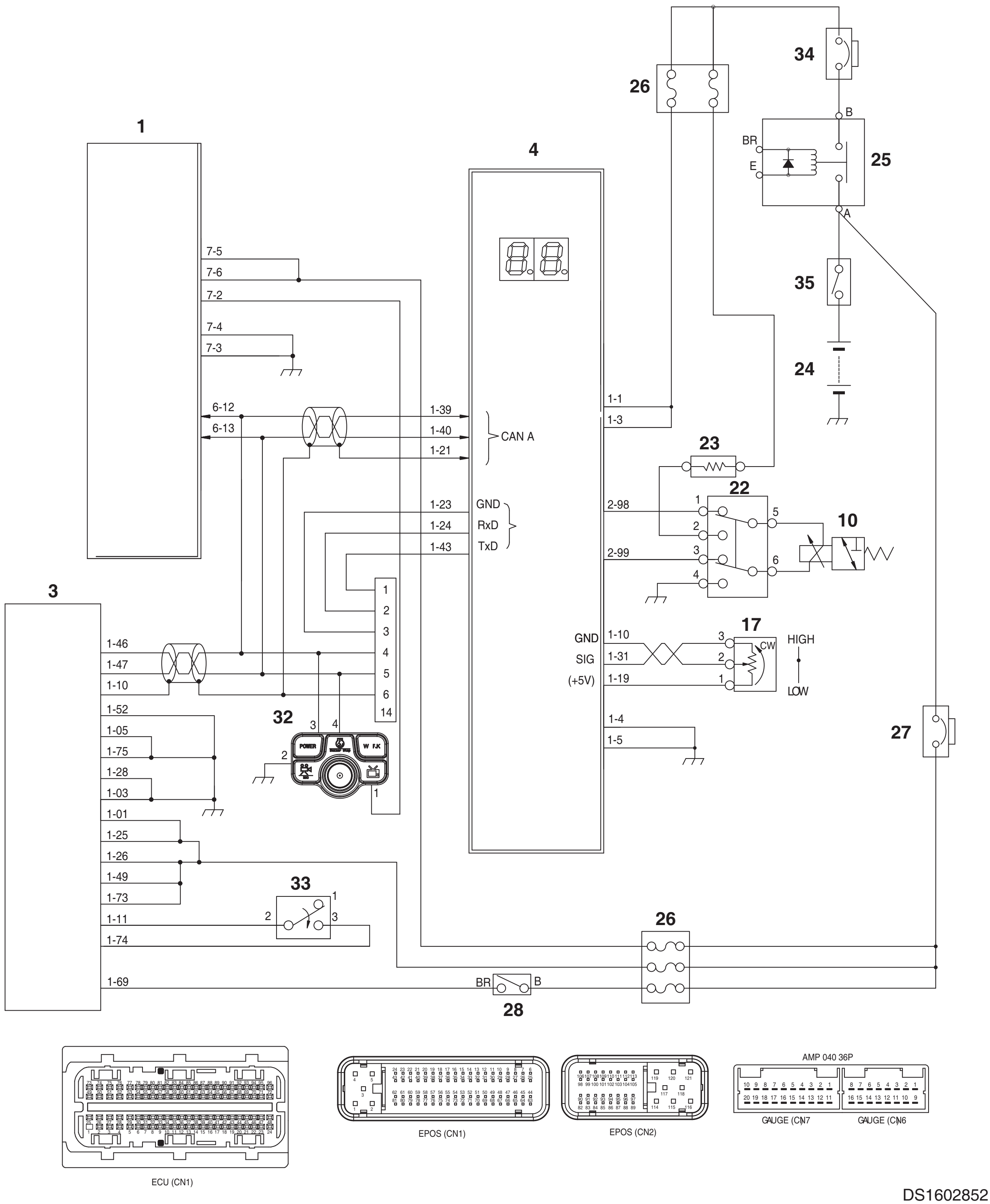


Figure 157

Reference Number	Description
1	Instrument Panel
3	Engine Controller
4	EPOS Controller
10	EPPR Valve (Electromagnetic Proportional Pressure Reducing)
17	Engine Control Dial
22	Aux Mode Switch
23	Aux Mode Resistor
24	Battery

Reference Number	Description
25	Battery Relay
26	Fuse
27	Circuit Breaker 1
28	Starter Switch
32	Jog Switch Control Panel
33	Engine Emergency Stop Switch
34	Circuit Breaker 2
35	Master Switch

SMART POWER CONTROL (SPC)

The SPC (Smart Power Control) function controls engine speed to reduce fuel consumption by determining high and low load during excavation operation.

When SPC mode is selected, the engine rpm is reduced by 100 rpm from the working mode. In excavation work, the load at boom-up and arm-in is detected to increase engine power to operate the equipment at high power.

The selection and release of the SPC function can be made with the SPC switch on the R.H stand.

When the start-up switch is turned on, the power mode is automatically set to SPC Standard of SPC Mode. In this status, use the button switch on the instrument panel or jog switch to select SPC Power Plus Mode, SPC Power Mode, SPC Standard Mode, or SPC Economy Mode. When a mode is selected, the corresponding symbol appears at the bottom left of the instrument panel.

Operation

1. **Smart Engine Speed Control**

   This function controls engine speed according to the workload which is determined with the actual torque of the engine and high load (boom-up, arm crowd) pilot pressure.

   The engine speed is classified into Heavy load mode and Light load mode and matched automatically according to the workload. The variable range of the engine speed is set by 100 rpm that does not cause any problem in operation sequence. The workload is determined with the actual torque information of the engine and the joystick information.

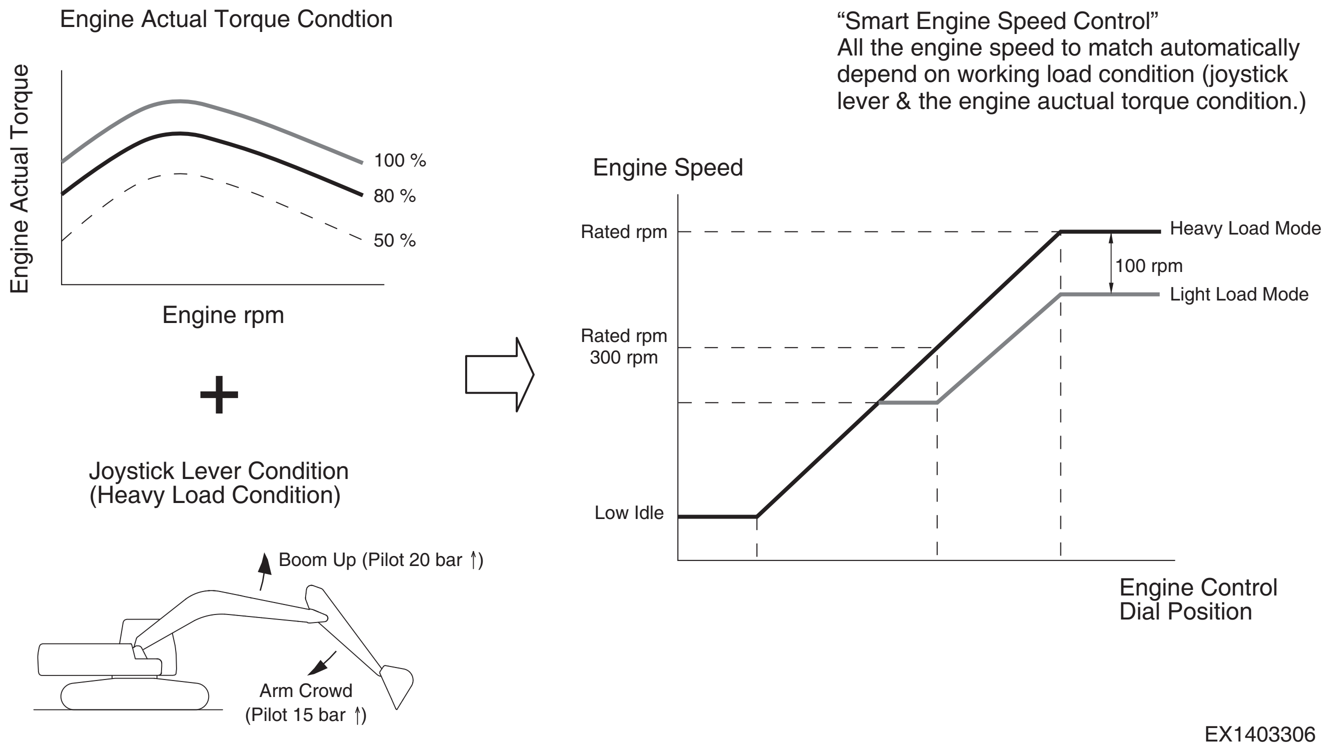


Figure 158

Heavy Load Condition	Entering Condition	If the joystick lever condition meets the heavy load condition and the actual torque of the engine meets the heavy load area condition, the engine speed is shifted from light load mode to heavy load mode to set the hydraulic power to the maximum working performance level.
	Maintenance Condition	If the joystick lever condition meets any one of the heavy load condition and 50 % or above of the engine actual torque, the engine speed is maintained at heavy load mode.
Light Load Condition	Entering Condition	When the engine actual torque is reduced to less than 50% and the joystick lover condition meets all the conditions other than the heavy load condition, the engine speed is shifted to light load mode to improve fuel efficiency.
	Maintenance Condition	If the joystick lever condition meets any condition other than the heavy load condition or the engine actual torque is in the light load area (0 - 80 %), the engine speed is maintained at light load mode.

2. **Smart Pump Torque Control**

This function controls the pump torque according to the limitation applied to the engine by turbocharger lag time and smoke limit. The engine limitation information is obtained from the engine actual torque. In the fuel economy mode, the pump responsibility is lowered than that of the engine torque slightly for smooth operation of the equipment.

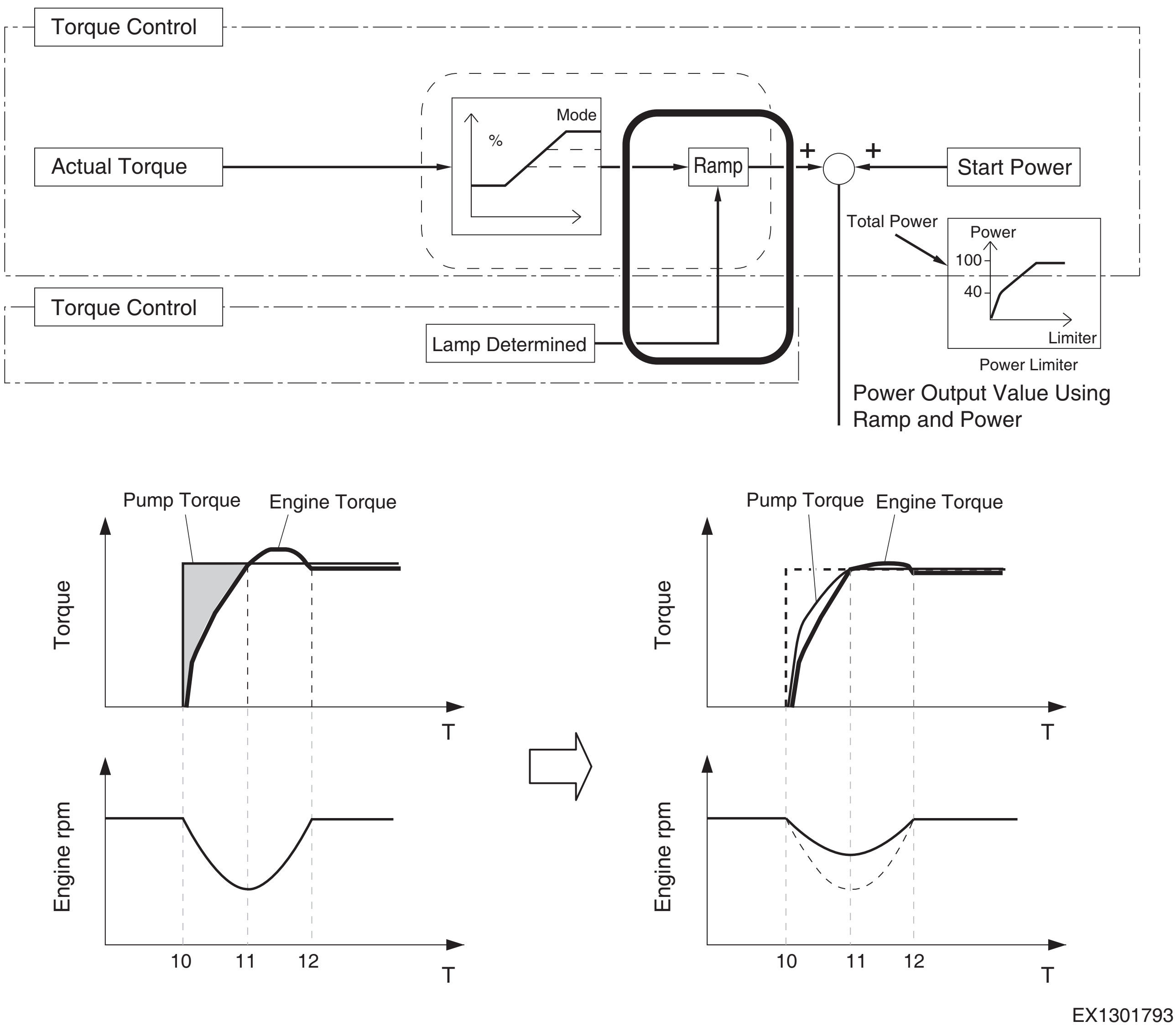


Figure 159

ENGINE CONTROL SYSTEM

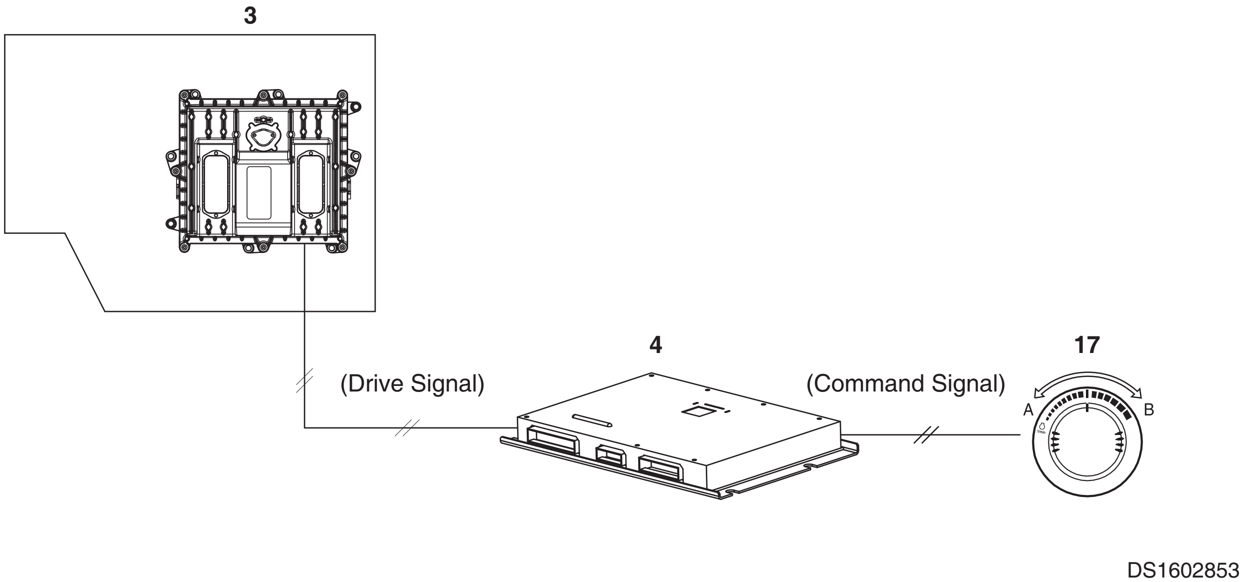


Figure 160

Reference Number	Description
3	Engine Controller
4	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 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.

Power Output Value Using Ramp and Power

Engine Control Dial

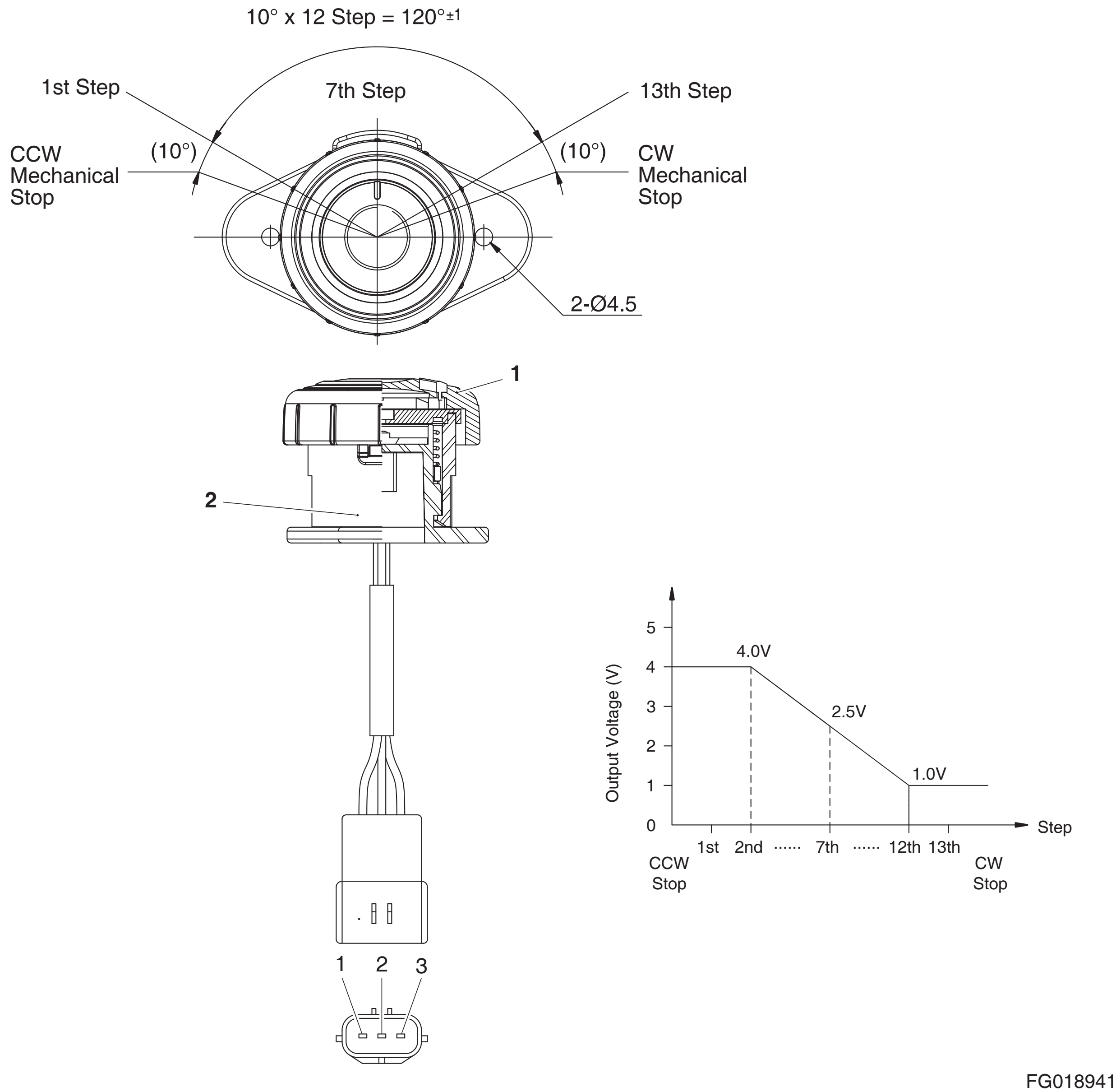


Figure 161

Reference Number	Description
1	Knob

Reference Number	Description
2	Hall Effect Sensor

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 EPOS controller as shown in the graph.

Engine Control

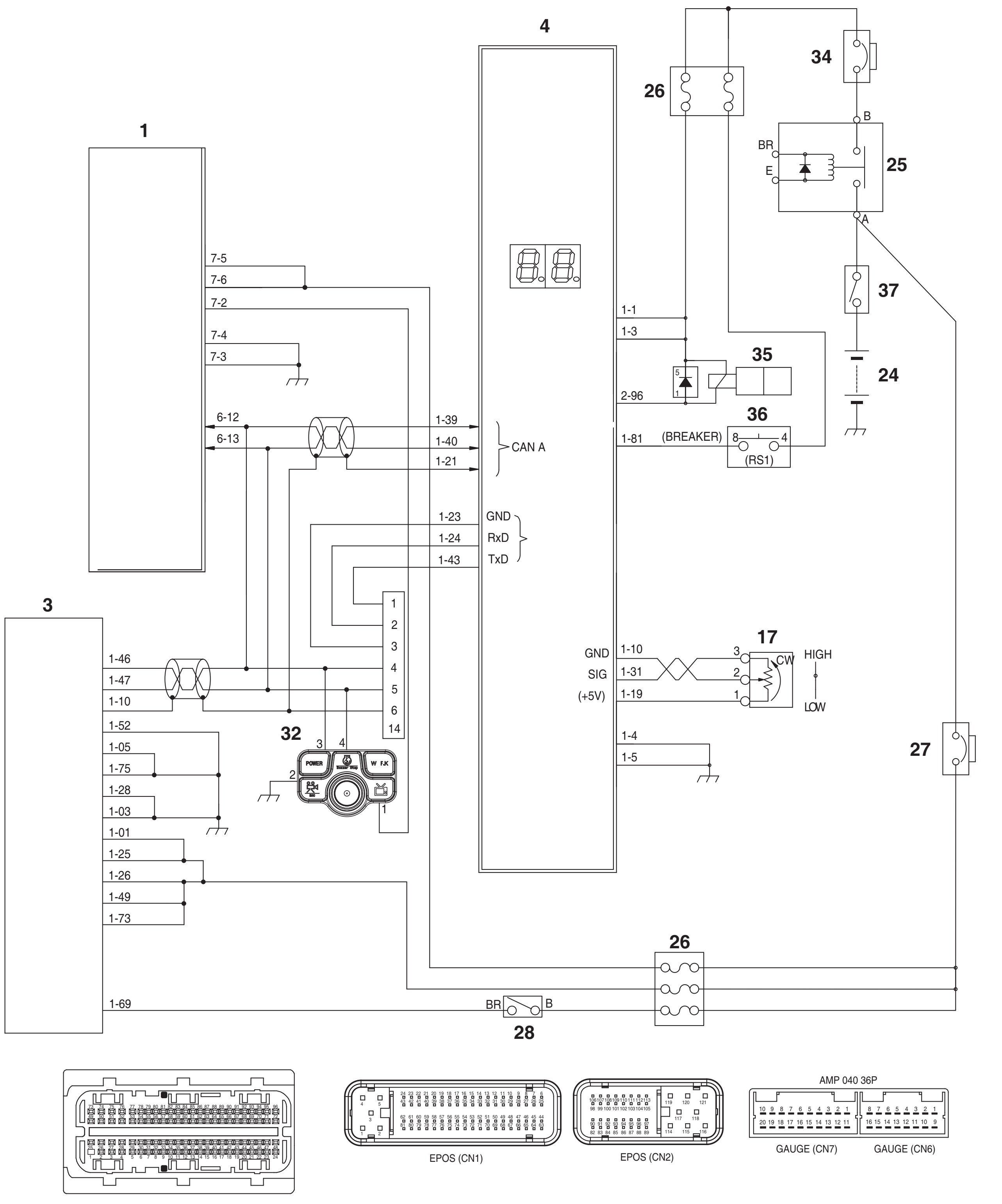


Figure 162

Reference Number	Description
1	Instrument Panel
3	Engine Controller
4	EPOS Controller
17	Engine Control Dial
24	Battery
25	Battery Relay
26	Fuse
27	Circuit Breaker 1

Reference Number	Description
28	Starter Switch
32	Jog Switch Control Panel
33	Engine Emergency Stop Switch
34	Circuit Breaker 2
35	Solenoid Valve (Pressure Up)
36	Power Boost Switch
37	Master Switch

AUTOMATIC DECELERATION CONTROL (AUTO IDLE CONTROL)

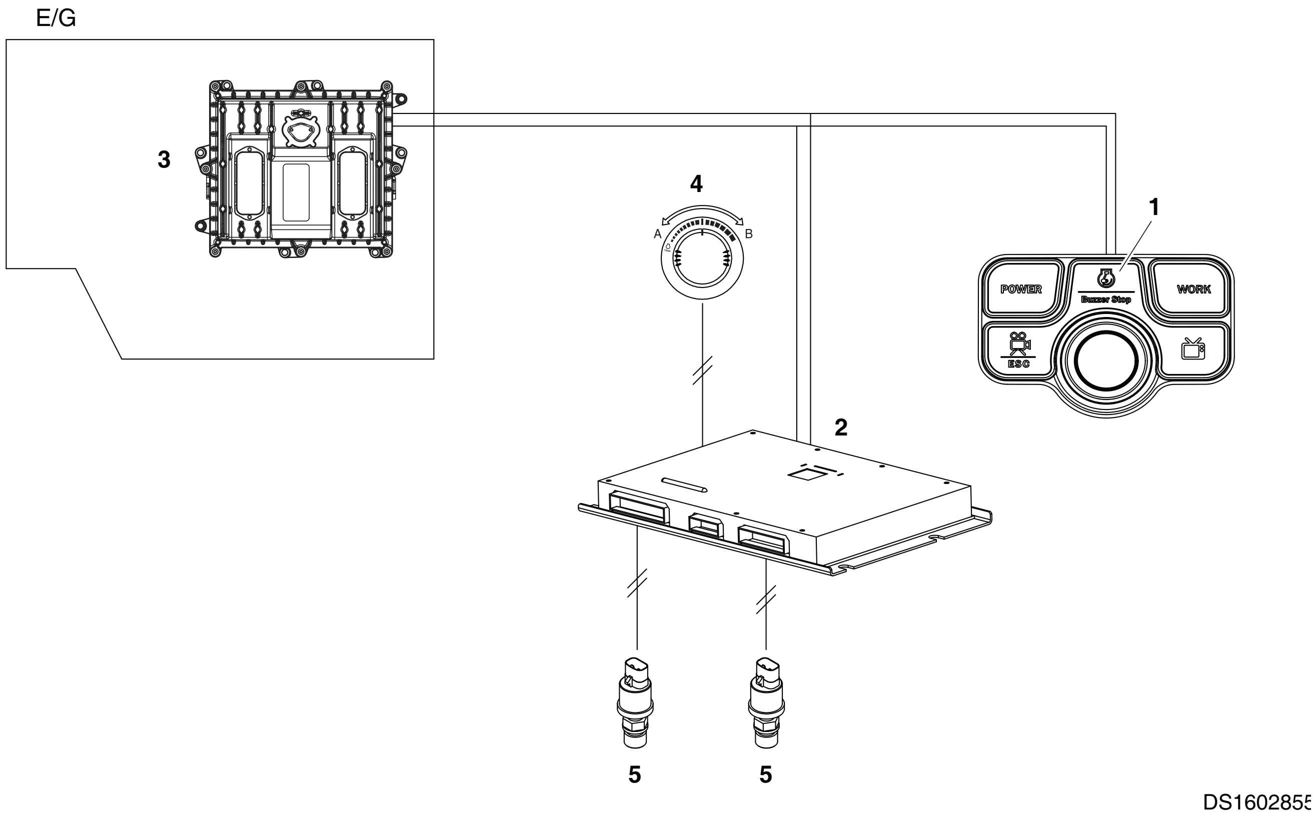


Figure 163

Reference Number	Description
1	Jog Switch Control Panel (Auto Idle Switch)
2	EPOS Controller

Reference Number	Description
3	Engine Controller
4	Engine Control Dial
5	Pressure Sensor

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 canceled 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 EPOS controller compares the automatic reduction signal with the signal set by engine control dial. The lower of the two signals is selected, the 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 sensors.

Auto idle logic is as below table.

Location	Auto Idle Release pressure	Auto Idle Operating Pressure	Remark
SH (Swing Motor)	15.5 bar (15.8 kg/cm^2, 224 psi) over	11 bar (11 kg/cm^2, 160 psi) below	Joystick Signal
PT (Control Valve)	23 bar (23.5 kg/cm^2, 334 psi) over	14 bar (14.2 kg/cm^2, 203 psi) below	Travel Signal

ENGINE OVERHEAT PROTECTION SYSTEM

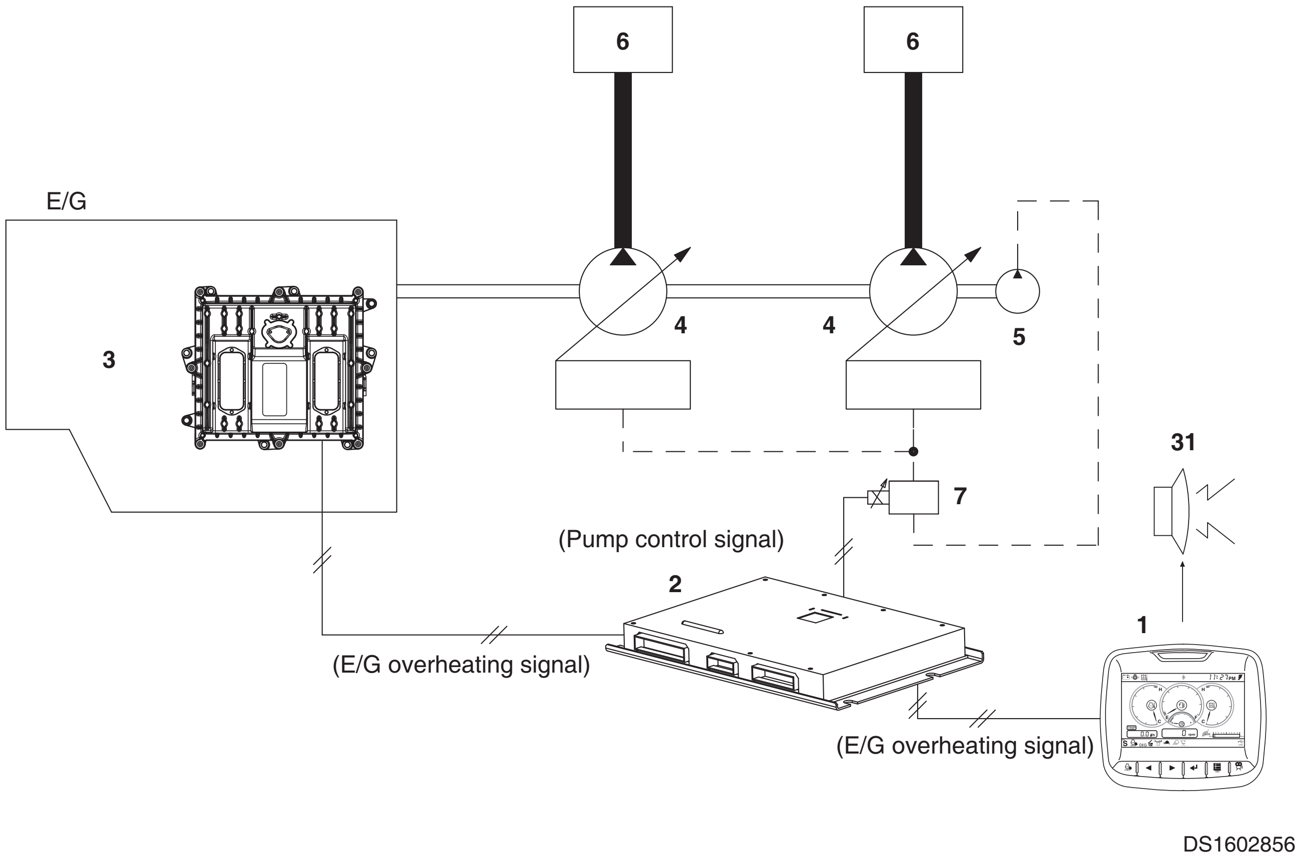


Figure 164

Reference Number	Description
1	Instrument Panel
2	EPOS Controller
3	Engine Controller
4	Main Pump
5	Aux Pump

Reference Number	Description
6	Control Valve
7	EPPR 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 EPOS controller. The EPOS controller sends a overheat signal to the instrument panel turning "ON" the warning light and buzzer simultaneously.

When coolant temperature falls below 95°C (203°F), normal operation will resume.

1. Coolant Overheat Prevention System

The engine controller detects the engine coolant temperature with the temperature sensor in the coolant line. If the coolant is overheated, the engine controller send the overheat signal to the EPOS controller which conveys the signal to the instrument panel.

If the coolant is overheated, the pump output is reduced to prevent engine overheat.

When the coolant temperature reaches about 107°C (225°F), the pump output is reduced to 85 % into the Tropical mode. A pop-up screen appears on the instrument panel to inform the operator of the mode shift.

If the coolant temperature exceeds 107°C (225°F), the engine controller sends coolant overheat signal to the EPOS controller which conveys the signal to the instrument panel.

Receiving the engine overheat signal, the instrument panel turns on the warning light and triggers the buzzer for warning.

The engine controller controls the engine speed to low speed range.

In summary, in case of engine coolant overheat, the system selects tropical mode, triggers warning buzzer, shifts to standard power mode, reduce engine speed, and reduces pump output.

When the coolant temperature is lowered to 95°C (203°F) or below, the system resumes normal operating condition.

2. Hydraulic Oil Overheat Prevention System

During operation, the EPOS controller monitors the hydraulic oil temperature with the hydraulic oil temperature sensor. If the hydraulic oil is overheated, the EPOS controller sends the overheat signal to the instrument panel.

When the hydraulic oil is overheated, the pump output is reduced to prevent engine overheat.

When the hydraulic oil temperature reaches about 97 °C (206.6 °F), the pump output is reduced to 85 % into the Tropical mode. A pop-up screen appears on the instrument panel to inform the operator of the mode shift.

If the hydraulic oil temperature exceeds 99 °C (210.2 °F), the EPOS controller sends hydraulic oil overheat signal to the instrument panel.

Receiving the hydraulic oil overheat signal, the instrument panel turns on the warning light and triggers the buzzer for warning.

In addition, the EPOS controller sends a signal back to the engine controller and shifts the power mode to the standard mode.

The engine controller controls the engine speed to low speed range.

In summary, in case of hydraulic oil overheat, the system selects tropical mode, triggers warning buzzer, shifts to standard power mode, reduce engine speed, and reduces pump output.

When the hydraulic oil temperature is lowered to 91 °C (196 °F) or below, the system resumes normal operating condition

POWER BOOST MODE

Operation

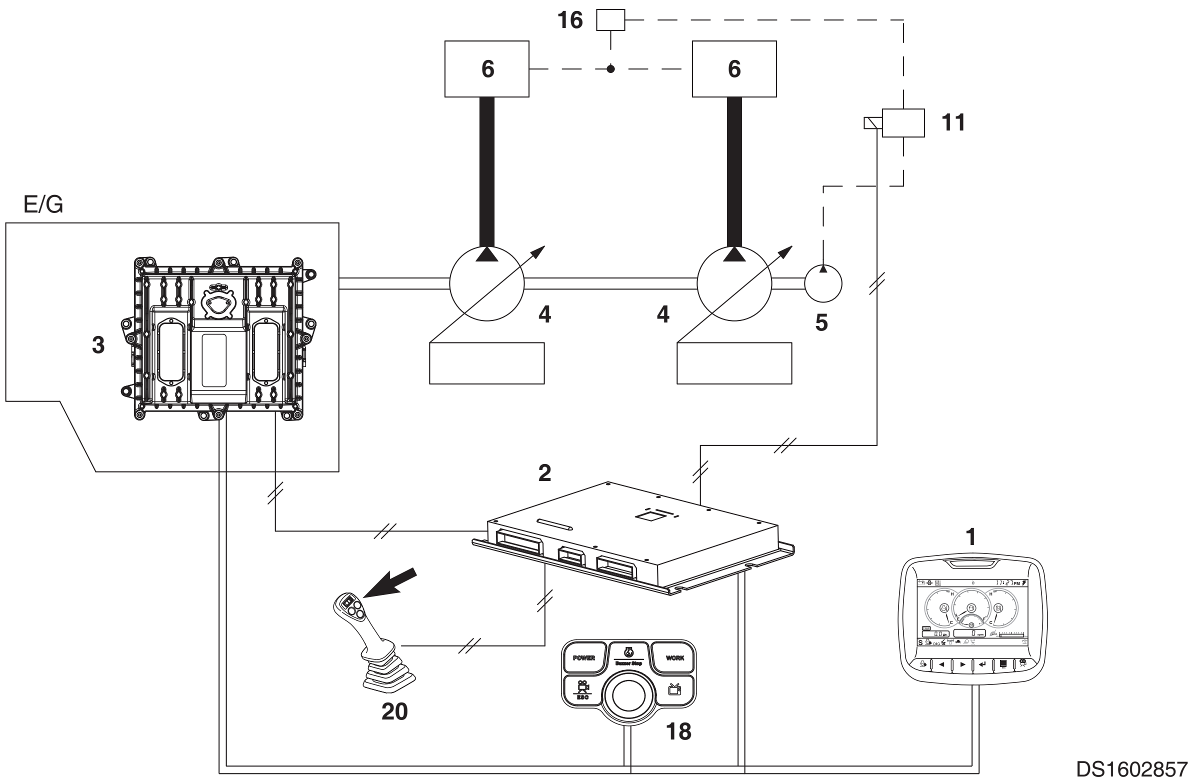


Figure 165

Reference Number	Description
1	Instrument Panel
2	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	Jog Switch Control Panel
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 Work Mode is set to "BOOST" by the jog switch control panel and the power boost button on the right-hand work lever (joystick) is pressed during work, the EPOS controller will activate the power boost solenoid valve and increase the relief valve pressure from 323 ~ 343 bar (4,684 ~ 4,974 psi) for 7 seconds. 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

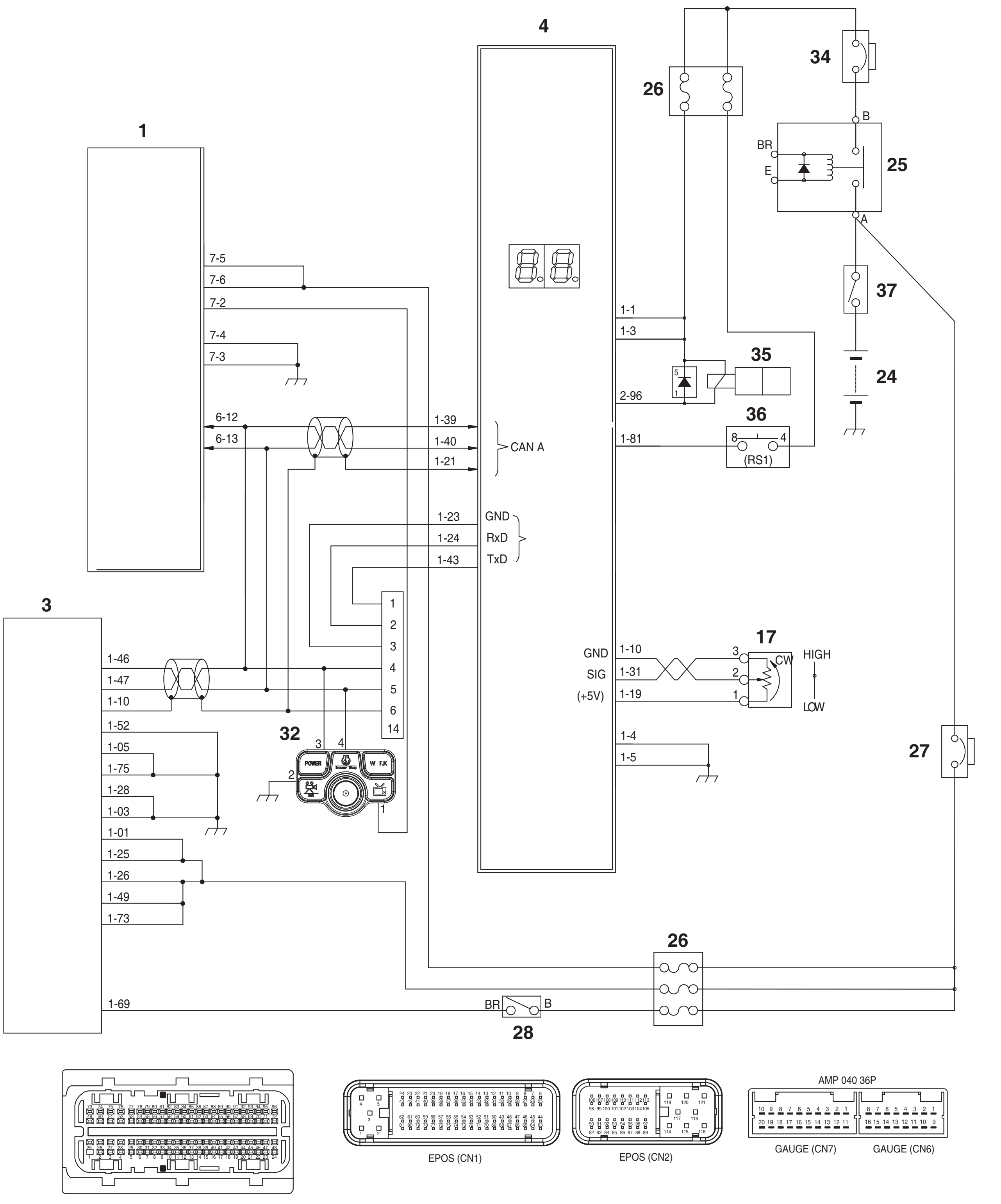


Figure 166

Reference Number	Description
1	Instrument Panel
3	Engine Controller
4	EPOS Controller
17	Engine Control Dial
24	Battery
25	Battery Relay
26	Fuse
27	Circuit Breaker 1

Reference Number	Description
28	Starter Switch
32	Jog Switch Control Panel
33	Engine Emergency Stop Switch
34	Circuit Breaker 2
35	Solenoid Valve (Pressure Up)
36	Power Boost Switch
37	Master Switch

AUTOMATIC TRAVEL SPEED CONTROL

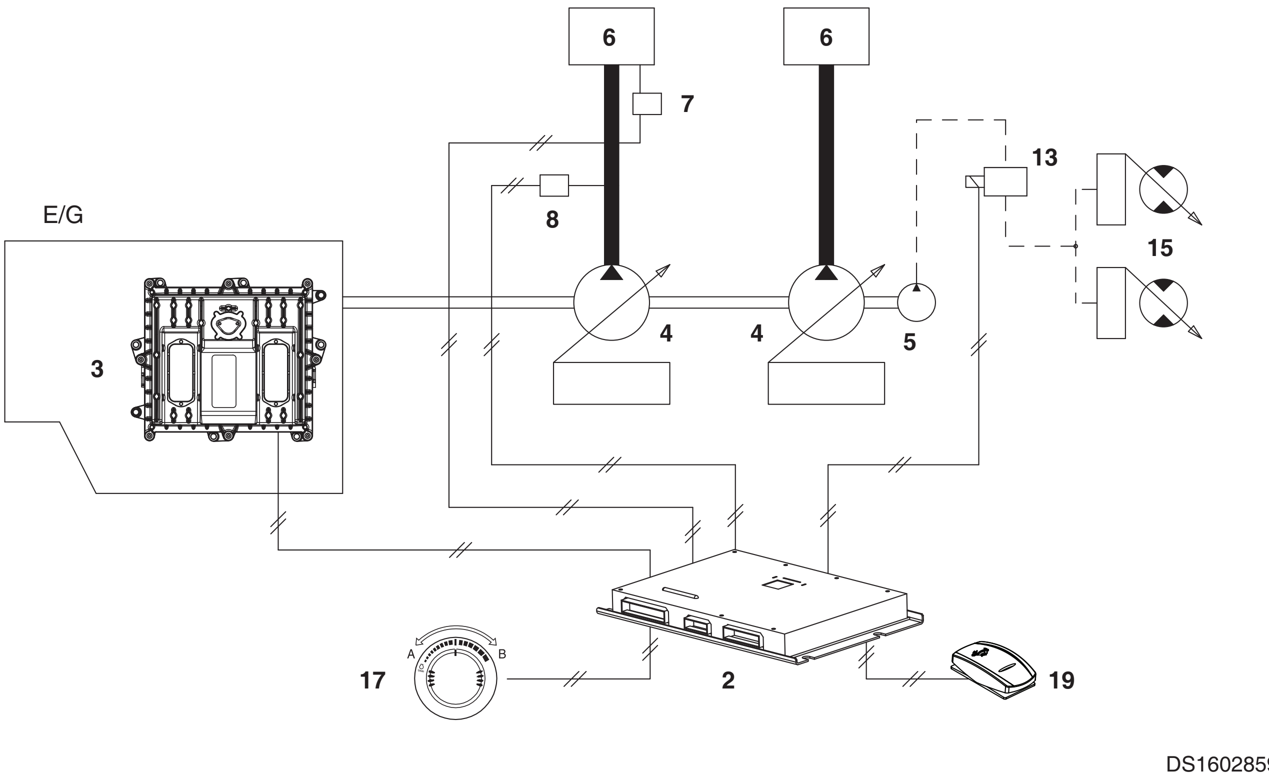


Figure 167

Reference Number	Description
2	EPOS Controller
3	Engine Controller
4	Main Pump
5	Aux Pump
6	Control Valve
7	Pressure Switch

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 "OFF" position, the travel motor will run in the I-speed (low speed) range. If the selector switch is set to "I" position, the travel motor will run in the II-speed (high-speed) range. If the selector switch is set to "II" position, the 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 294 bar (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 156 bar (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 1,400 rpm, the travel speed will be set to I-speed mode.

Automatic Travel Speed Control

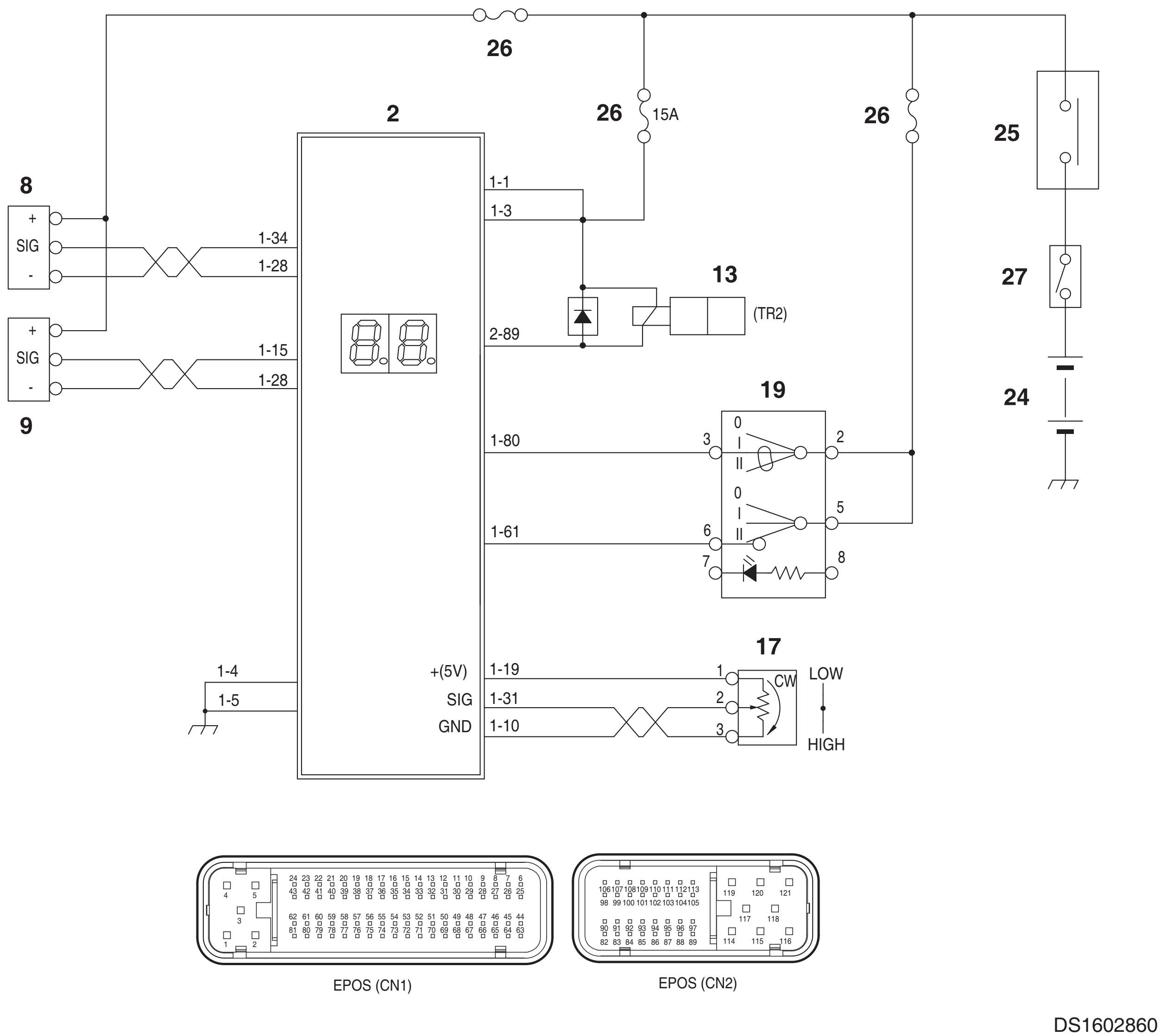


Figure 168

Reference Number	Description
2	EPOS Controller
8	Pressure Sensor (Front Pump)
9	Pressure Sensor (Rear Pump)
13	Solenoid Valve (High-speed)
17	Engine Control Dial
19	Selector Switch For Automatic Travel

Reference Number	Description
24	Battery
25	Battery Relay
26	Fuse
27	Master Switch

WATER IN FUEL WARNING SYSTEM

Operation

If the fuel contains a significant concentration of water, it can cause engine performance deterioration and shorten the service life of the engine, after a long time operation.

To protect the engine in case that operator ignores "Water In Fuel (WIF)" warning and keeps operating the equipment, which can deteriorate the engine, a sound warning system is added to induce the operator to remove water in the fuel.

1. Buzzer Sound at WIF Warning

If the fuel contains significant ratio of water, the WIF sensor of the water-oil separator sends a signal to the EPOS controller which relays the signal to the instrument panel. The instrument panel turns on the warning light and pop-up window on the screen, and triggers the buzzer so operator can remove water from the fuel.

If the operator resets the warning pop-up and buzzer without removing the water from the fuel, the warning pop-up window reappears on the instrument panel screen and the buzzer sounds again after 30 seconds from the reset.

2. Power Output Reduction by Water in Fuel

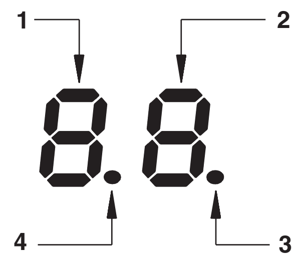
If the operator fails to remove water from the fuel for one hour from the first WIF warning, the power of the equipment is reduced so operator remove water from the fuel.

Restricted Function	Engine Speed	Pump Output
Limited	1,200 rpm	70%

SELF-DIAGNOSTIC FUNCTION

EPOS Controller

The system operation status and malfunction codes can be checked through the display on top of the EPOS controller box the rear cover behind the operator's seat.



FG000588

Figure 169

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 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		Display		System Condition
		Higher Digit	Lower Digit	
Power Mode	P+, P	9 HAOH340L	- FG018940	Normal Operation Power Mode
	S	8 FG018938	- FG018940	Normal Operation Standard Mode
	E	7 HAOH350L	- FG018940	Normal Operation Economy Mode
Work Mode	Digging	- FG018940	0 HAOH370L	Normal Operation Digging Mode
	Lift	- FG018940	3 FG018939	Normal Operation Lift Mode

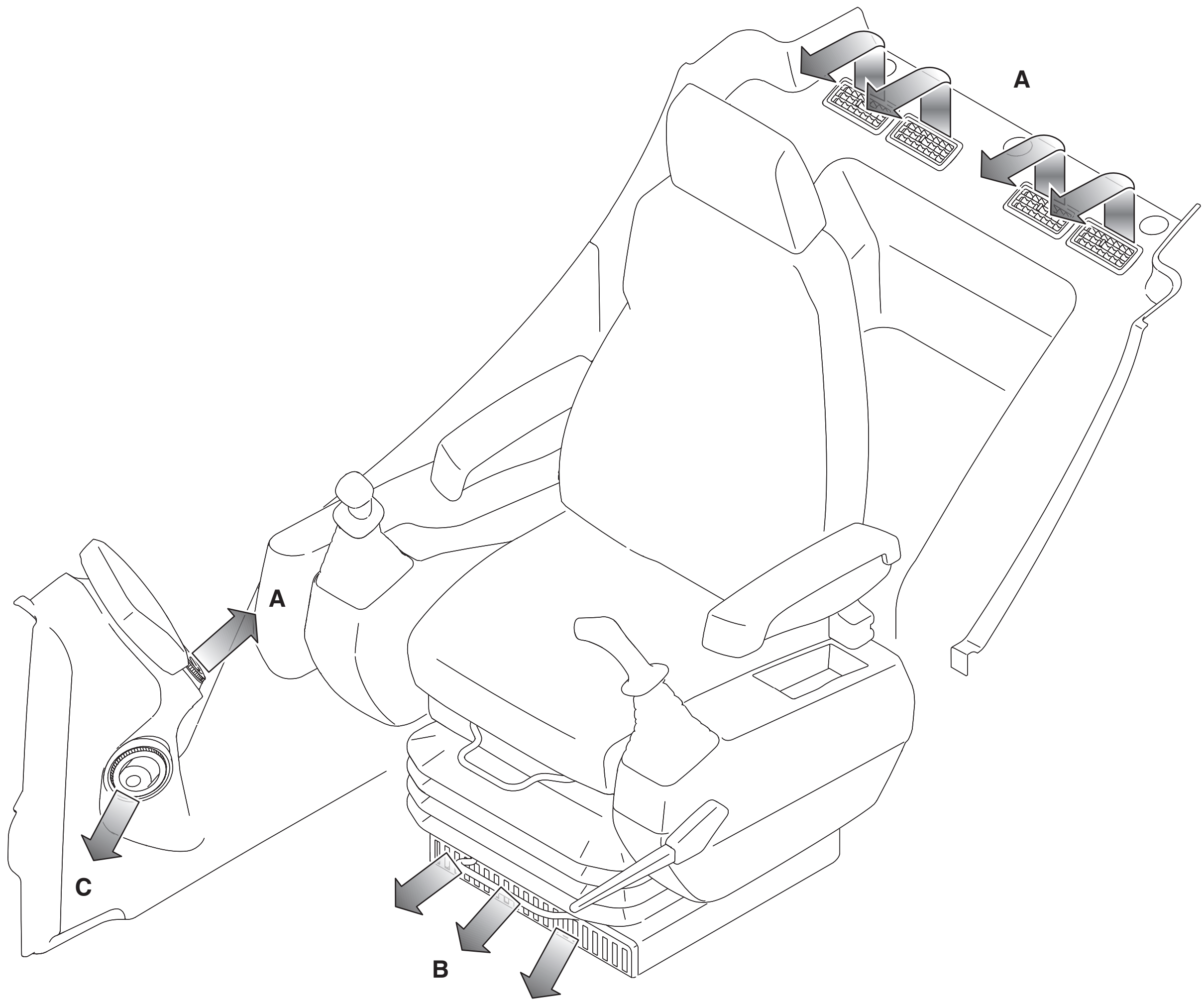
4. **Communication Monitor**

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



EX1301100

Figure 170

Solid-type heater and air conditioner are installed in the cover behind the operator's seat.

Temperature of the operator's cabin is adjusted automatically to the temperature set by operator.

(Please refer to the Operation & Maintenance Manual for detailed full automatic control.

Vent mode selects the direction of discharged air.

<u>Outlets by vent modes</u>

Modes					
Outlets	A	A+B	B	B+C	C

Internal and External Filters

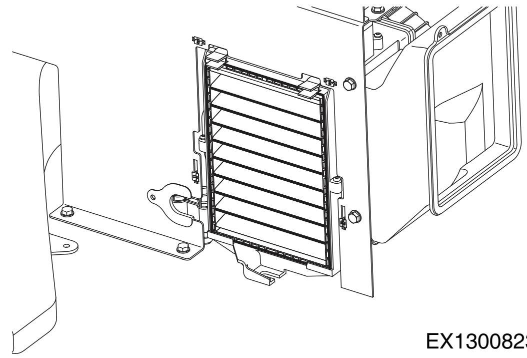
Internal and external air purification filters are installed for the operator's room.

Filters must be cleaned every 500 hours.

If machine operates in an excessively contaminated environment, filters must be cleaned more frequently and if necessary, replaced with new ones.

How to Check Internal Air Filter

1. Remove cover by pulling knob outward on top of the left and right of the filter which is inside the left rear part of the cabin.
2. Remove inner filter by pulling knob outward while pressing the upperpart and lower part of the filter handle.
3. Replace with new one.
4. Reassemble filter in reverse order.



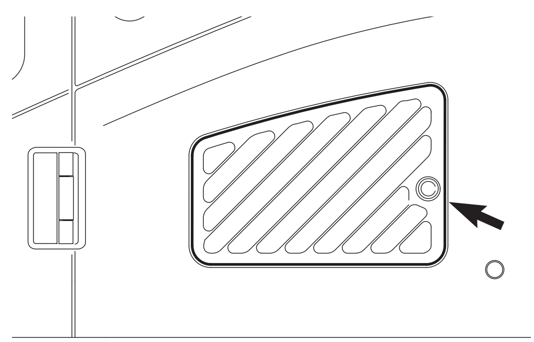
EX1300823

Figure 171

How to Check External Air Filter

NOTE: *All right and left call outs are based on the operator being seated in the operator's seat facing the front.*

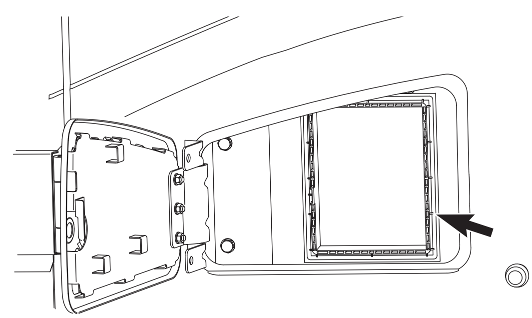
1. Open the cover by using the starter KEY in the left side of the cabin.



EX1300825

Figure 172

2. Remove filter (Figure 173) and replace with new one.
3. Reassemble in reverse order.



EX1403389

Figure 173

Air-Conditioning System Layout

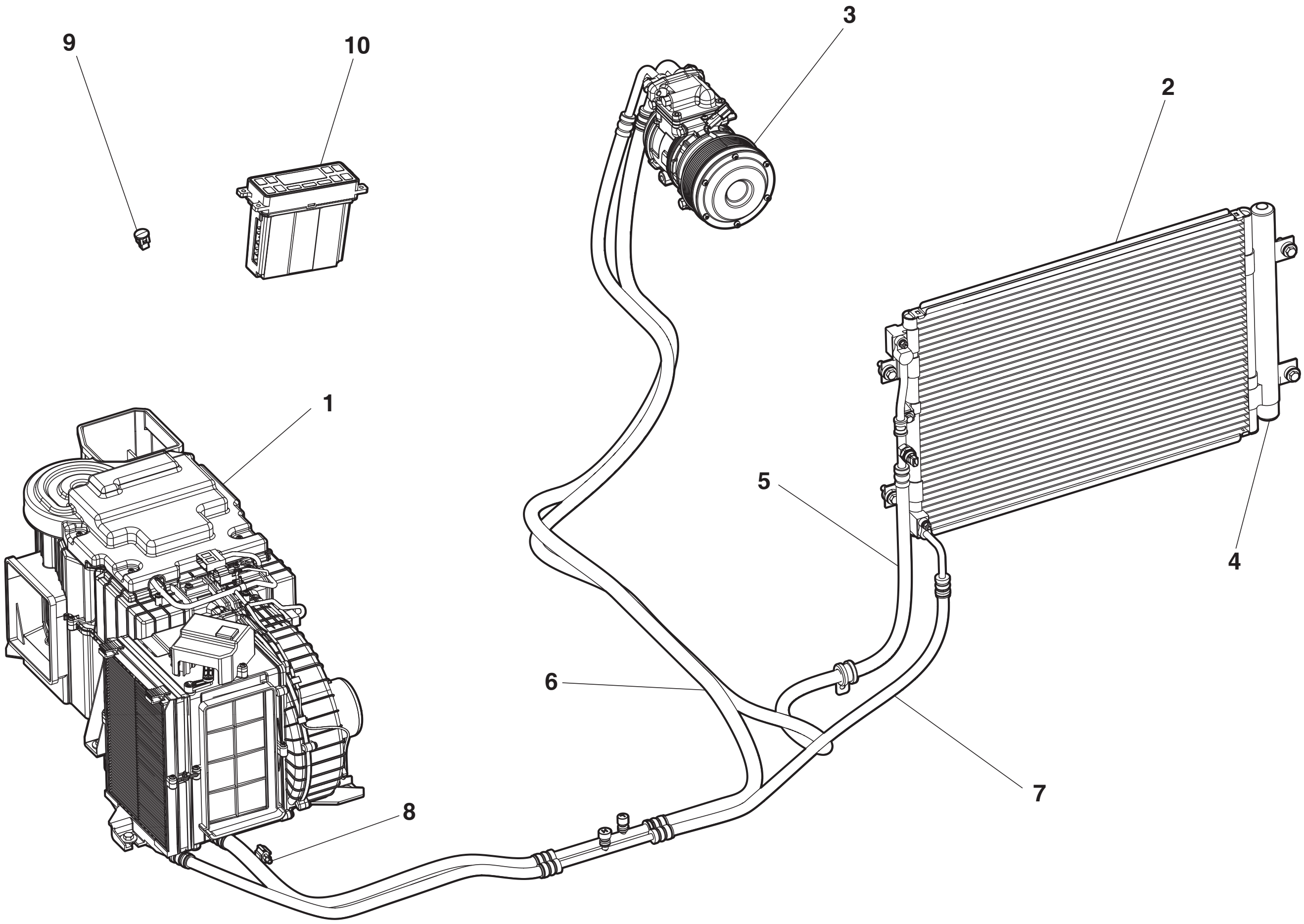


Figure 174

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
8	Ambient Temperature Sensor
9	Sun Sensor
10	Control Panel

Air Conditioner/Heater Circuit Diagram

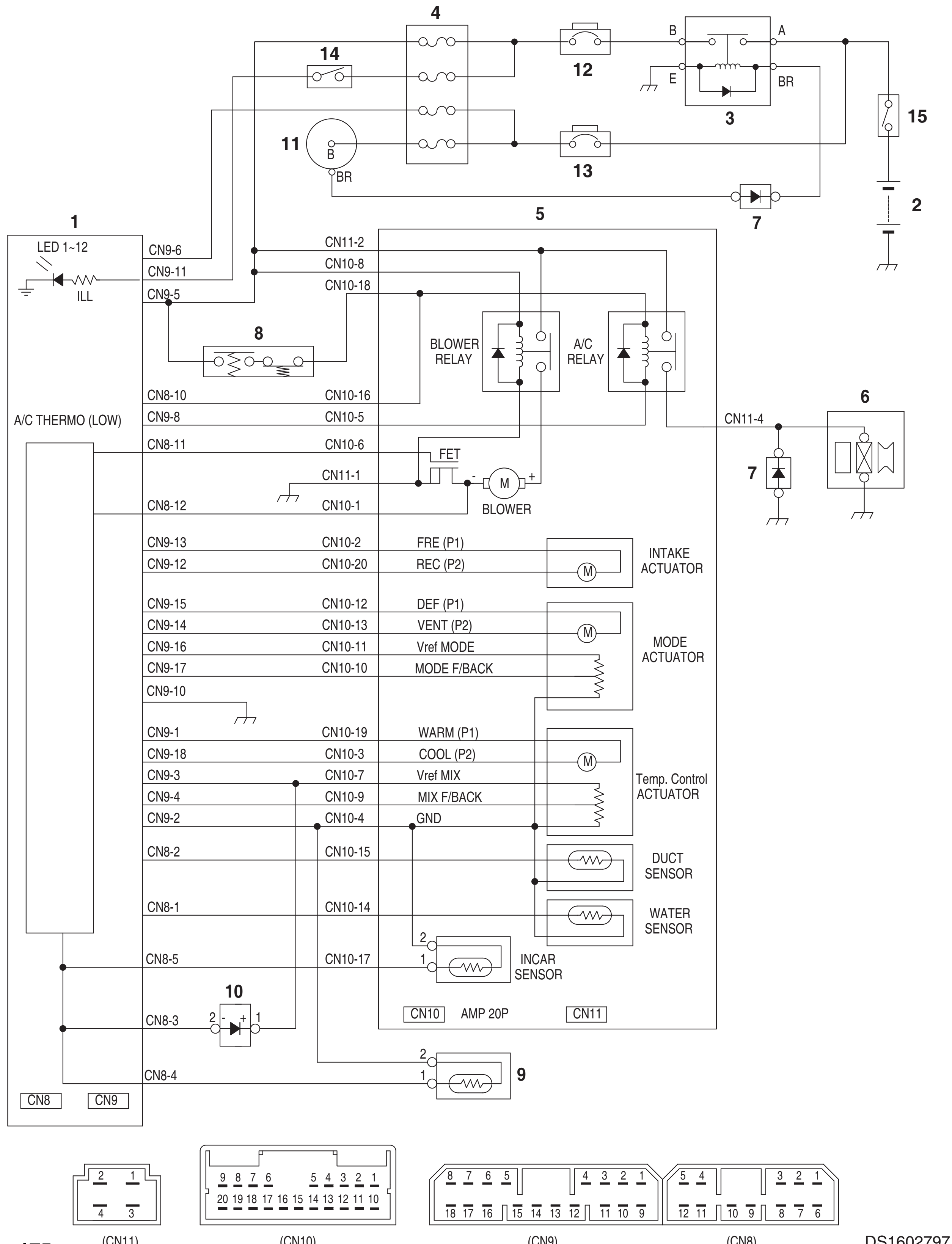


Figure 175

Reference Number	Description
1	A/C Control Panel
2	Battery
3	Battery Relay
4	Fuse Box
5	Aircon Unit
6	Compressor
7	Diode
8	DPS

Reference Number	Description
9	Ambient Temp Sensor
10	Photo Sensor
11	Starter Switch
12	Circuit Breaker 1
13	Circuit Breaker 2
14	Lamp Switch
15	Master Switch

Air Conditioner/Heater Unit

Airflow Diagram

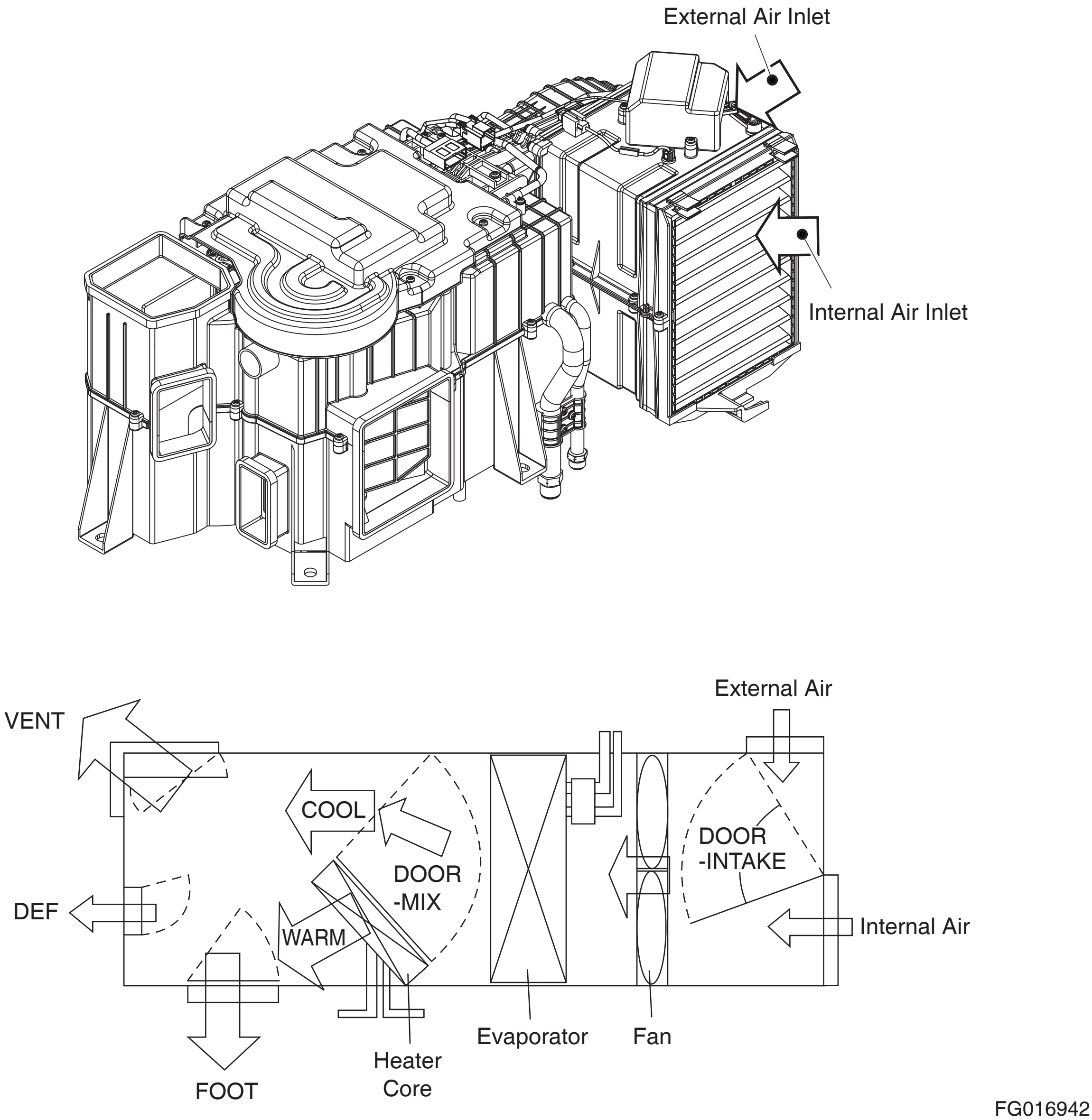


Figure 176

Door Open by Vent Modes

Door	Mode				
	Vent	Bi-level	Foot	Def/foot	Def
Vent	100	60	0	0	0
Foot	0	40	100	80	60
Def	0	0	0	20	40

Main Components

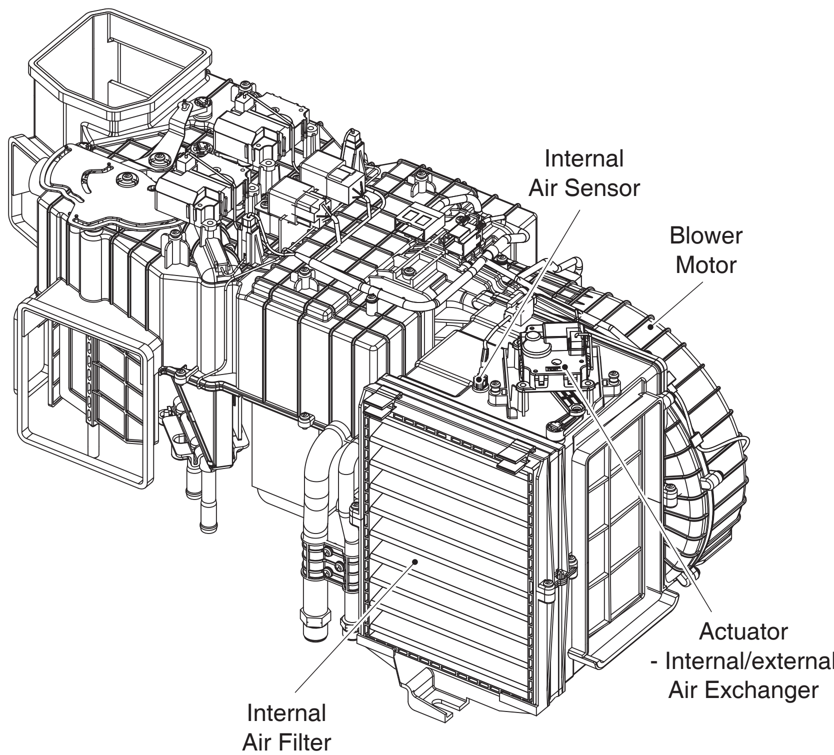


Figure 177

Actuator - Airflow Direction Control

Change of discharged airflow according to selected airflow direction mode

Change of airflow direction: Direction changes in the order of VENT→ BI-LEVEL → FOOT → FOOT/DEF → VENT.

Actuator - Temperature Control

Change of discharged air temperature by controlling the position of temperature control door.

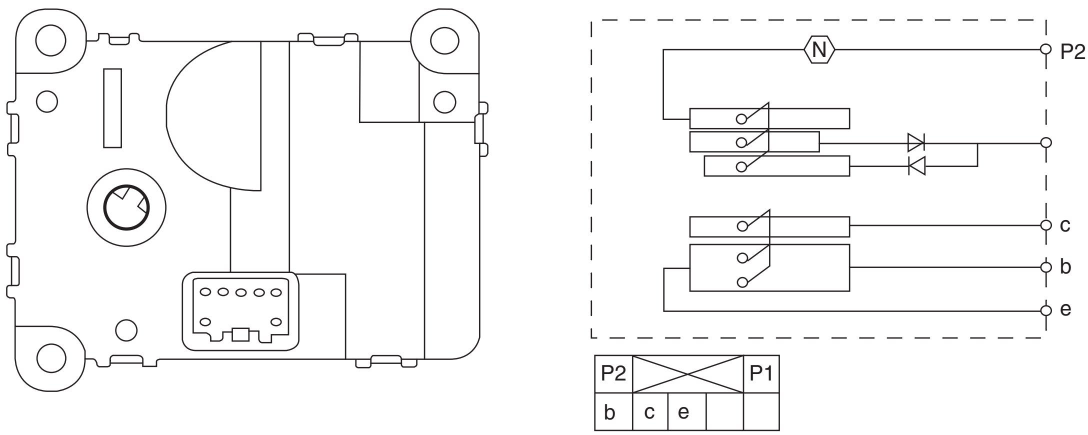


Figure 178

Actuator - Airflow Direction Control

Airflow Direction Mode	Output Terminal	Voltage
Vent	c (+): CN10-10 b (-): CN10-4	0.5 ±0.2V
Bi-level		1.3 ±0.2V
Foot		2.45 ±0.2V
Foot/def		3.5 ±0.2V
Def		4.5 ±0.2V

Actuator - Temperature Control

Set Temperature	Output Terminal	Voltage
Max cooling	c (+): CN10-9	Below 0.4V
Max heating	b (-): CN10-4	Above 4.5V

Actuator - Internal/External Air Exchange

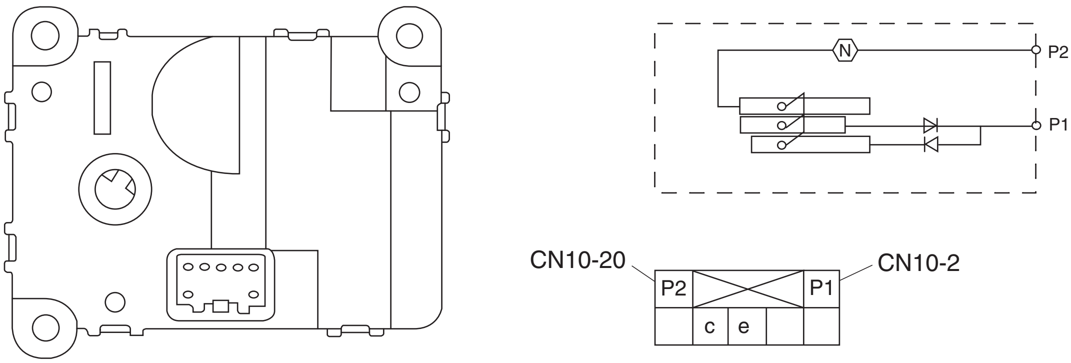


Figure 179

Mode	Output Terminal	Output
Intake	P1 (+), P2 (-)	Moving of exchange door by selecting intake.
Recirculate	P1 (-), P2 (+)	Moving of exchange door by selecting recirculate.

Airflow Control Module

Airflow is controlled through the control of voltage between GATE and SOURCE.

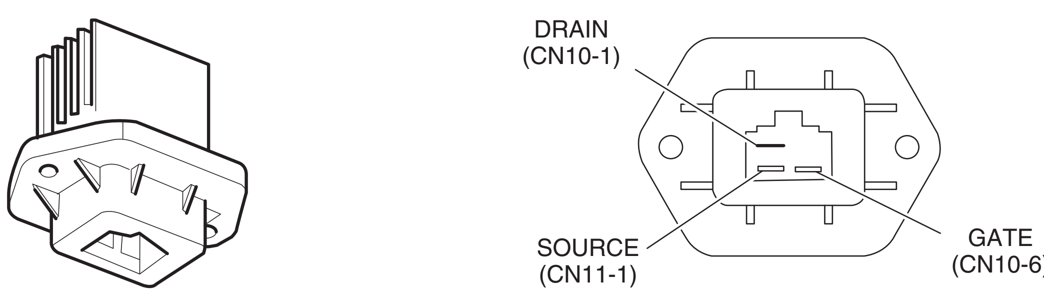


Figure 180

Airflow	Output Terminal		Output
1st	CN11-2	CN10-1	10 ±0.5V
2nd			12.5 ±0.5V
3rd			15 ±0.5V
4th			17.5 ±0.5V
5th			20.0 ±0.5V
6th			22.0 ±0.5V
7th			More than 25V

Input voltage is 27.5V.

The airflow is based on manual set.

Relay - Blower: Power is supplied to the blower motor when the system is turned "ON".

Specifications	
Rated voltage	24V
Rated current	20A

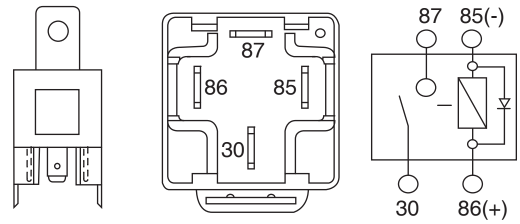


Figure 181

Relay - A/C: Power is supplied to the magnetic clutch of the compressor.

Specifications	
Rated voltage	24V
Rated current	10A

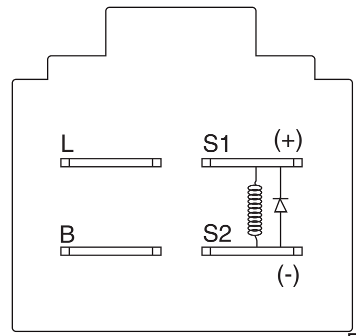


Figure 182

Duct Sensor: It is inserted in the core of the evaporator to prevent freezing of the evaporator.

The sensor consist of negative characteristic thermistor that resistant value increases and decreases when the temperature rises and falls, respectively.

Temperature (°C)	Resistance (KΩ)
0	11.36 ±0.1
2	10.39 ±0.2
2.5	10.17 ±0.2
3	9.95 ±0.2
3.5	9.73 ±0.2
4	9.52 ±0.2
5	9.12 ±0.2
10	7.36 ±0.15
25	4.02 ±0.08
30	3.33 ±0.07

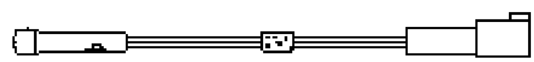


Figure 183

Internal Air Temperature Sensor: Built in the internal air filter, it senses the internal temperature.

Temperature (°C)	Resistance (KΩ)
-15	218.2 ±7.5
0	97.83 ±0.9
15	47.12 ±0.7
25	30.0 ±0.36
35	19.60 ±0.3

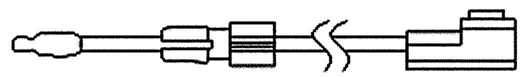


Figure 184

Ambient Air Temperature Sensor

Built at the bottom of the cockpit, it senses the temperature of external air.

Temperature (°C)	Resistance (KΩ)
-10	163 ±4.9
0	96.9 ±2.9
10	59.4 ± 1.8
20	37.4 ±1.1
25	30 ±0.9
30	24.2 ±0.7

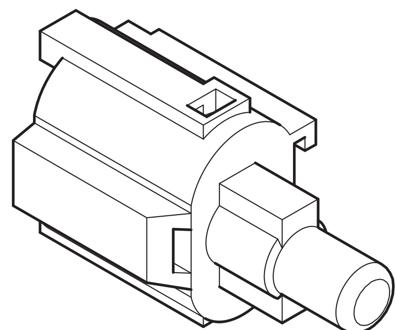
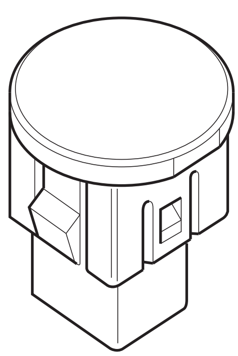


Figure 185

Sun Sensor

Built beside the socket of spare power, it senses the quantity of the sun radiation to regulate discharge temperature and airflow as set by operator.



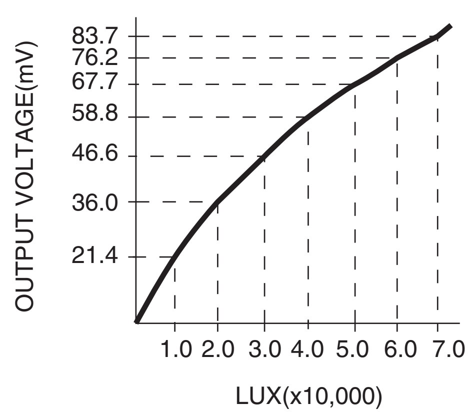
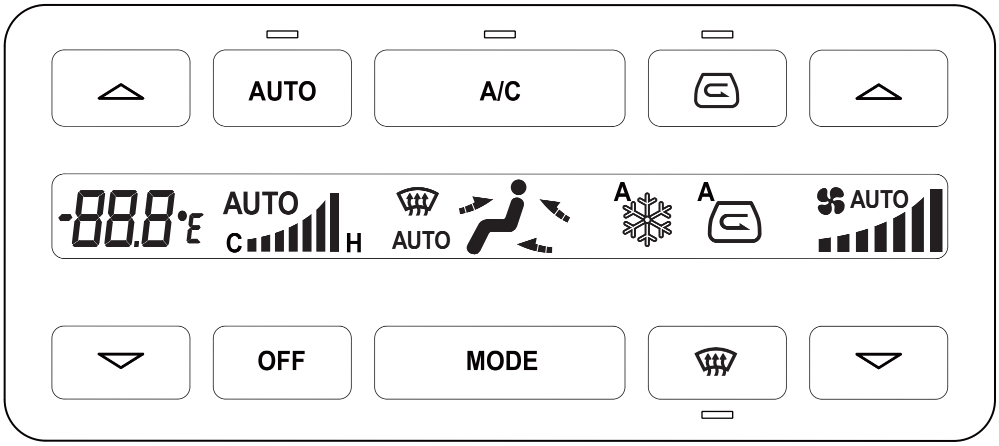


Figure 186

Control Panel

Appearance and Terminal Arrangement



DS2100298

Figure 187

Refer to "Air Conditioner and Heater" of operation manual.

Terminal Terms

CN	Term No.	Terms
CN9	1	Temperature control (warm)
	2	Sensor ground
	3	Temperature control Power (5V)
	4	Mix feedback
	5	Power (KEY "ON")
	6	Backup
	7	-
	8	A/C output (LOW)
	9	-
	10	Ground
	11	Illumination
	12	Intake/Recirculate (Recirculate)
	13	Intake/Recirculate (Intake)
	14	Airflow direction control (VENT)
	15	Airflow direction control (DEF.)
	16	Airflow direction control Power (5V)
	17	Airflow direction control (feedback)
	18	Temperature control (cool)

CN	Term No.	Terms
CN8	1	Coolant temperature gauge sensor
	2	Duct sensor
	3	Sun sensor
	4	Ambient air temperature sensor
	5	Internal air temperature sensor
	6	-
	7	-
	8	-
	9	-
	10	D.P.S CHECK
	11	Airflow module (gate)
	12	Blower motor (feedback)

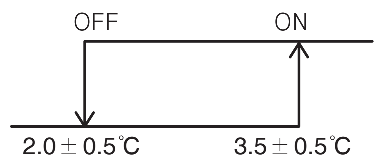
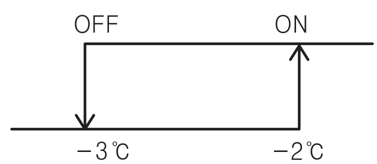
Control Logic

Categories	Inputs	System Operation
AUTO	Set temperature Internal air temperature sensor Ambient air temperature sensor Sun sensor	1. Automatically adjust room temperature as set and then next items. Temperature, airflow direction, Recirculate/Intake, Airflow, Compressor 2. Auto mode is released when manually setting any switch except, Temperature Control switch in Auto mode. 3. Upon the releasing of Auto mode, all of functions except selected switch are controlled automatically.
Sensor compensation	Set temperature Internal air temperature sensor Ambient air temperature sensor	1. In case of sensor fault, the following defaults are applied: Internal air temperature sensor: 25°C, Ambient air temperature sensor: 25°C, Duct sensor: -2°C Temperature control actuator: - Set Temperature 17 - 24.5°C: Max cooling, Set Temperature 25 - 32°C: Max heating Airflow direction mode actuator - VENT: VENT fix, modes other than VENT: Fixed to DEF * Sun sensor is not compensated.
Max cooling/ heating control	Auto Setting	1. Set Temperature 32°C: Max heating 2. Set Temperature 17°C: Max cooling

	Max Cooling (17 °C)	Max Heating (32 °C)
Temp Control Actuator	FULL COOL	FULL HOT
Air Flow	MAX HI	AUTO HI
Compressor	Forced ON	OFF
Intake/Recircle	Recircle	Intake
Wind Direction Mode	VENT	FOOT

* Max cooling/heating control is possible only in Auto mode.

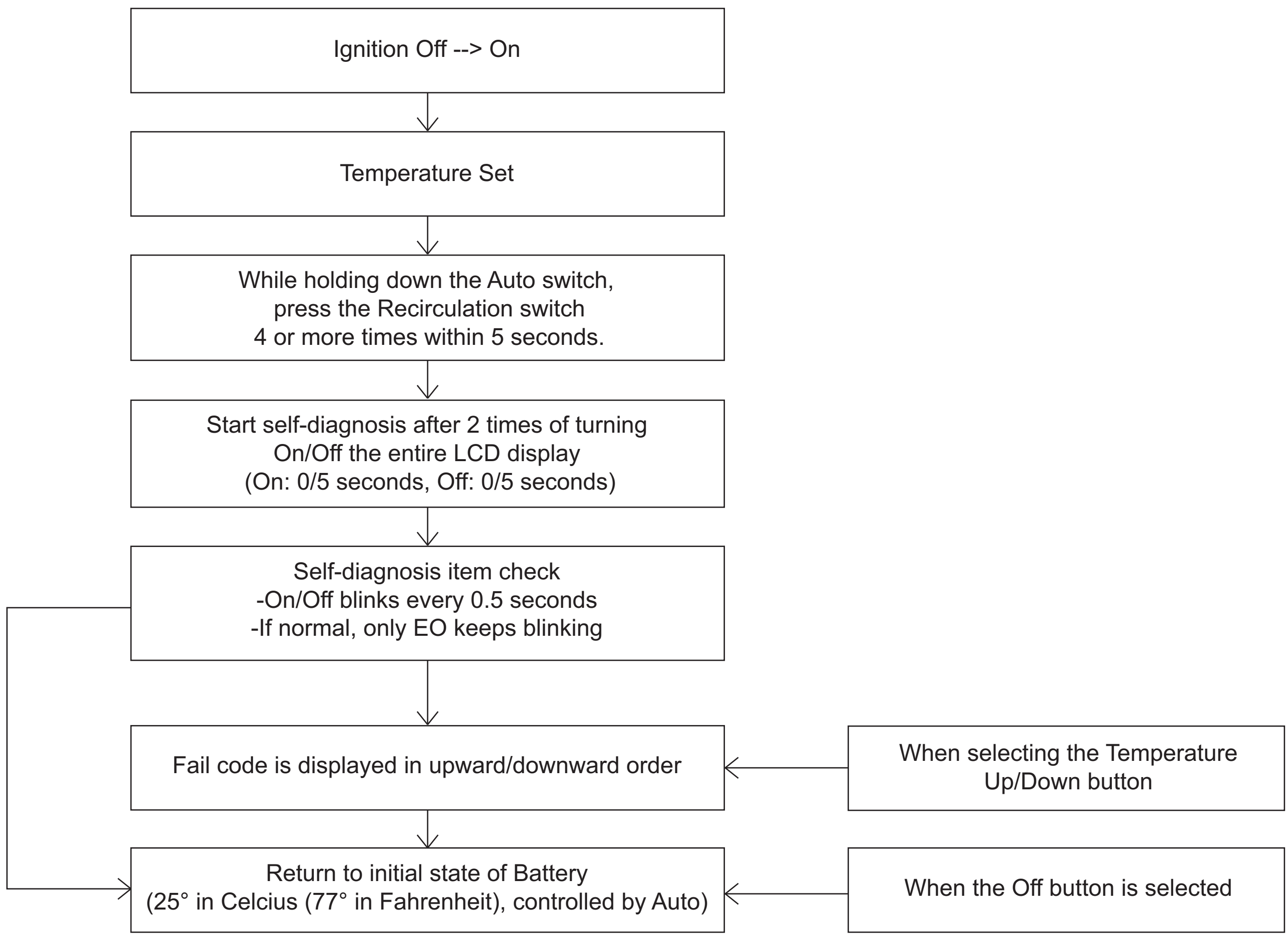
Categories	Inputs	System Operation
Starting Control of Cooling	Auto mode Duct sensor	1. Prevention of discharge of hot air before discharge temperature drops enough in hot summer weather 2. Start conditions (AND condition) A. A/C on (AUTO or manual) B. Temperature sensed by the duct sensor is above 30°C C. Airflow: Auto mode 3. One time control in the cycle of engine OFF → engine run 4. Initial cooling control is executed when the Auto switch is "ON" in the manual status (A/C "OFF" and manual control of airflow) in 5 seconds after engine run. 5. Initial cooling control must be before max cooling. 6. Release condition (OR condition) A. A/C "OFF" B. Airflow: Manual control C. Release is possible with the "OFF" switch but not allowed within 12 seconds (after Start "ON") while the system is off using the "OFF" switch and during the time of initial cooling control.
Starting control of heating (1)	Internal air temperature sensor Auto mode Set Temperature	1. Start condition (AND condition) A. When airflow direction mode is one of the following modes in the Auto or manual control mode - BI-LEVEL, FOOT or FOOT/DEF B. The ambient air temperature sensor measures the ambient air temperature and determines that the appropriate engine temperature has been reached after a certain period of time. C. Airflow: Auto mode D. Set temperature > Internal air temperature + 3°C * Airflow falls gradually up to 12 seconds when operation released. 2. One time control in the cycle of engine OFF → engine run 3. Initial heating control must be before max heating. 4. Airflow is controlled only when the airflow direction is in the manual mode and BI-LEVEL, FOOT, or FOOT/DEF is set. 5. Operation release (OR condition) A. Only airflow is released if it is selected manually. B. When handling the airflow direction mode switch, only airflow direction is released but the airflow control is performed only for the remaining period of the starting control of heater. C. When Max Cooling (17°C) is selected.

<table>
<tr><th>Categories</th><th>Inputs</th><th>System Operation</th></tr>
<tr><td rowspan="2">Compressor control</td><td>Duct sensor</td><td>1. Function: Magnetic clutch of compressor is turned "ON/OFF" depending on temperature of the duct sensor to prevent the freezing of the evaporator with A/C being "ON".
2. Control pattern.

</td></tr>
<tr><td>External temperature sensor</td><td>1. Function: Prevention of compressor in winter.
2. Control pattern.


*Only for Auto mode.</td></tr>
</table>

Self-diagnosis

How to start self-diagnosis



DS2100299

Figure 188

Error codes

Code	Description
E0	Normal
E1	Internal air temperature sensor short
E2	Internal air temperature sensor open
E3	Ambient air temperature sensor short
E4	Ambient air temperature sensor open
E5	Duct sensor short
E6	Duct sensor open
E7	Sun sensor short
E8	Sun sensor open
E9	Coolant temperature gauge sensor short
E10	Coolant temperature gauge sensor open
E11	D.P.S open
E12	Position error of airflow direction actuator
E13	Position error of temperature control actuator

NOTE: *The position error means that it fails to move to designated place in 40 seconds.*

Sun sensor displays E8 in case of no sunlight.

2 and more fails: Codes concerned blinks twice at a time.

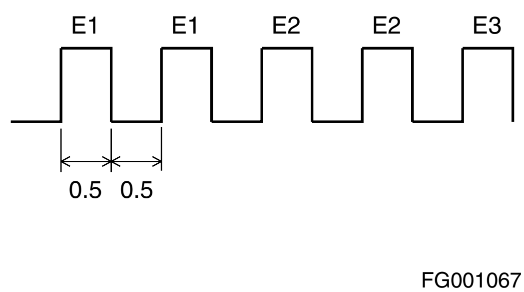


Figure 189

Ambient Temperature Display

Selection of both the SEL and MODE switch for more than 3 seconds indicates the ambient temperature in the set temperature display department.

- Range of temperature display: -40 - +60°C

NOTE: *Display of ambient temperature may be released in the same way for its entry way.*

It returns automatically to default mode 5 seconds after entering the ambient air temperature display mode.

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.

- Volume of refrigerant: 800 ±20 grams

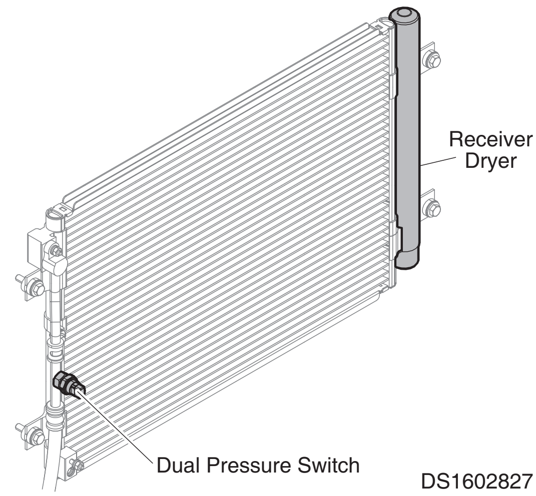


Figure 190

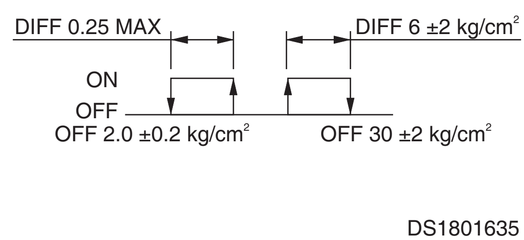


Figure 191

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.

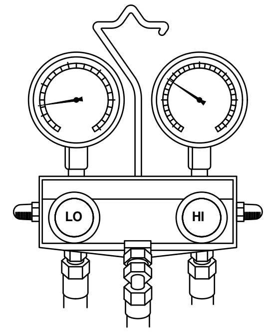


Figure 192

4. Check high/low-pressure of refrigerant.

1	**High-pressure: 8.0 - 10.0 bar (114 - 142 psi)** **Low-pressure: Approximately 1.0 bar (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 bar (327 psi)** **Low-pressure: Approximately 2.5 - 3.0 bar (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 bar (285 - 356 psi)** **Low-pressure: Approximately 2.5 - 3.5 bar (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 time, replace the receiver dryer.*	

<table>
<tr><th>4</th><th colspan="3">High-pressure: Over 6 bar (85 psi)
Low-pressure: Approximately 760 mmHg (Negative Pressure)</th></tr>
<tr><td colspan="4">Possible Cause: Refrigerant does not circulate</td></tr>
<tr><td>Step</td><td colspan="2">Inspection Item</td><td>Remedy</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">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.
5. Recheck high/low-pressure readings.
High-pressure: 13.0 - 19.0 bar (185 - 270 psi)
Low-pressure: 1.5 - 3.3 bar (21.3 - 46.9 psi)</td><td>Yes</td><td>Moisture in system, replace receiver dryer.</td></tr>
<tr><td>No</td><td>Contaminated system, replace expansion valve.
(Replace evaporator core assembly.)</td></tr>
</table>

<table>
<tr><th>5</th><th>High-pressure: Over 6 - 18 bar (85 - 256 psi)
Low-pressure: 500 mmHg (Negative Pressure) - Dial indicator needle unstable.</th></tr>
<tr><td colspan="2">Possible Cause: Moisture in system has iced up the expansion valve.
NOTE: When the absorbed moisture freezes the pressure readings may look normal. Careful readings must be made to determine whether pressure is in normal range.</td></tr>
<tr><td colspan="2">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 time, replace the receiver dryer.</td></tr>
</table>

<table>
<tr><th>6</th><th colspan="3">High-pressure: Over 22.0 - 23 bar (313 - 327 psi)
Low-pressure: 2.5 bar (36 psi)</th></tr>
<tr><td colspan="4">Possible Cause: Refrigerant pressure problem because of defective expansion valve or temperature sensor.</td></tr>
<tr><td>Step</td><td colspan="2">Inspection Item</td><td>Remedy</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Inspect whether the temperature sensor is installed properly.</td><td>Yes</td><td>Replace expansion valve.</td></tr>
<tr><td>No</td><td>Exchange duct sensor.</td></tr>
</table>

<table>
<tr><th>7</th><th>High-pressure: Over 7.0 - 11.0 bar (100 - 156 psi)
Low-pressure: 4.0 - 6.0 bar (57 - 85 psi)</th></tr>
<tr><td colspan="2">Possible Cause: Low refrigerant pressure because of poor compressor compression.</td></tr>
<tr><td colspan="2">Inspect and replace compressor if necessary.</td></tr>
</table>

REFRIGERANT SYSTEM REPAIRS

WARNING

AVOID DEATH OR SERIOUS INJURY

Always wear safety goggles 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 must be stored below 40°C (104°F). Be careful not to drop the container from a high location.

The contents are under high-pressure and should not be used with compressed air or near an open flame.

Refrigerant Safe Handling Procedures

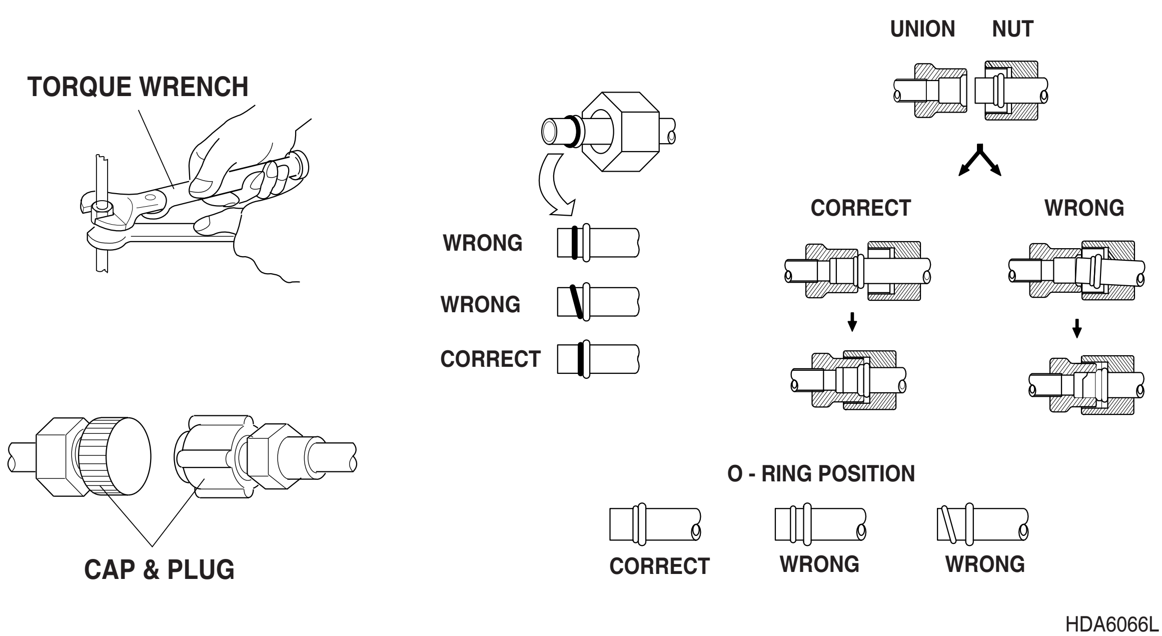


Figure 193

The following procedures must 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 must 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 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.*

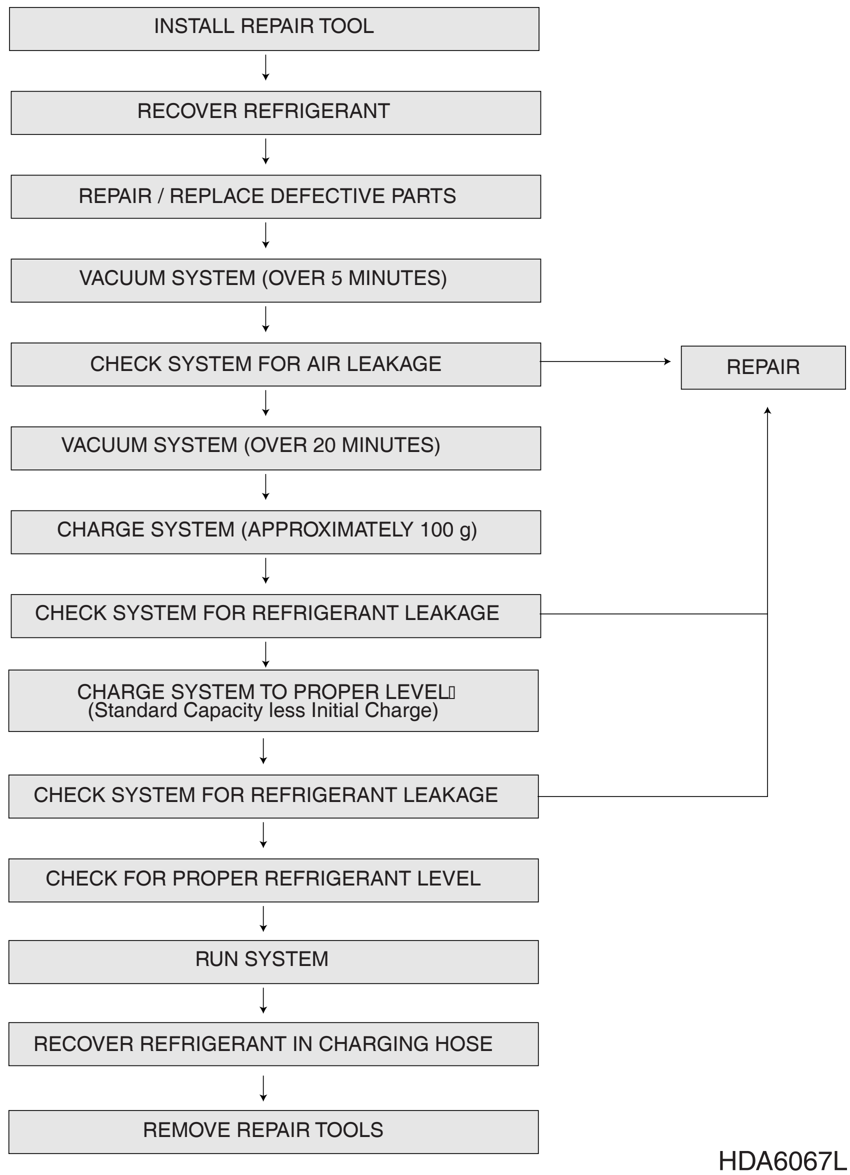

INSTALL REPAIR TOOL
RECOVER REFRIGERANT
REPAIR / REPLACE DEFECTIVE PARTS
VACUUM SYSTEM (OVER 5 MINUTES)
CHECK SYSTEM FOR AIR LEAKAGE
REPAIR
VACUUM SYSTEM (OVER 20 MINUTES)
CHARGE SYSTEM (APPROXIMATELY 100 g)
CHECK SYSTEM FOR REFRIGERANT LEAKAGE
CHARGE SYSTEM TO PROPER LEVEL
(Standard Capacity less Initial Charge)
CHECK SYSTEM FOR REFRIGERANT LEAKAGE
CHECK FOR PROPER REFRIGERANT LEVEL
RUN SYSTEM
RECOVER REFRIGERANT IN CHARGING HOSE
REMOVE REPAIR TOOLS
HDA6067L

Figure 194

Refrigerant Recovery

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

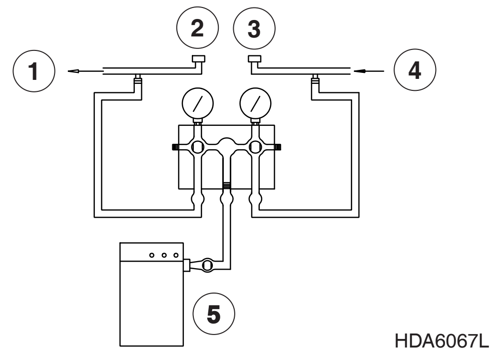


Figure 195

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 bar (50 psi), slowly open the low-pressure valve.
4. Open both the high and low-pressure valves slowly until manifold gauge dials indicates 0 bar (0 psi).

Vacuuming Refrigerant System

Reference Number	Description
1	To Compressor
2	Low-pressure Side
3	High-pressure Side
4	From Receiver
5	Vacuum Pump

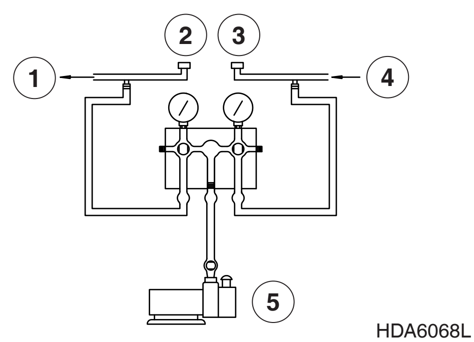


Figure 196

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.

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 low-pressure gauge dial reads approximately 750 mmHg.

   C. Close both valves and stop the vacuum pump.

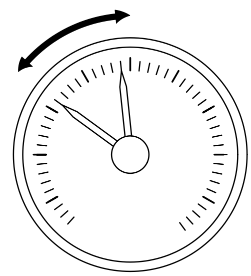


Figure 197

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. Now, 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.

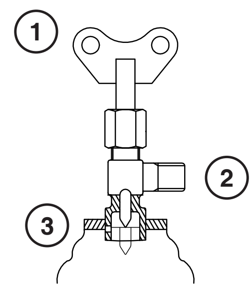


Figure 198

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 low side gauge dial indicates a pressure of 1 bar (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.

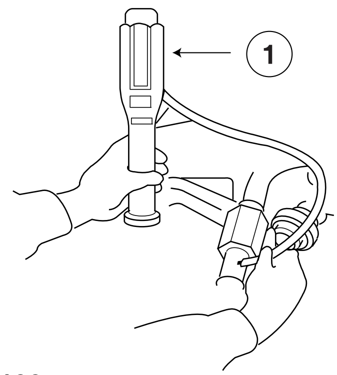


Figure 199

WARNING

AVOID DEATH OR SERIOUS INJURY

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

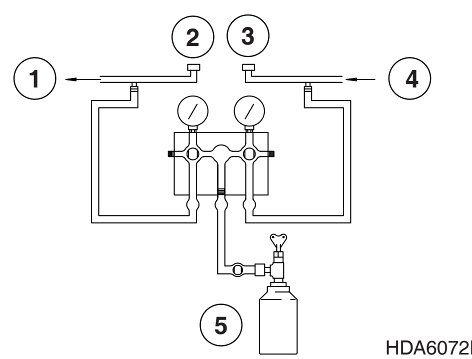


Figure 200

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

   Initial charge amount: 100 g (3.5 ounces).

3. If refrigerant does not flow freely into system, try starting engine first before operating air conditioner.

   - Temperature control switch setting: Maximum Cooling

     Blower Speed Setting: Hi (3 step)

     Engine Speed: 1,300 - 1,500 rpm

WARNING

AVOID DEATH OR SERIOUS INJURY

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 bar (185 - 285 psi)
Low Side Gauge	1.5 - 3.5 bar (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.*

IMPORTANT

- **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 machine.

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 an accurate test.*

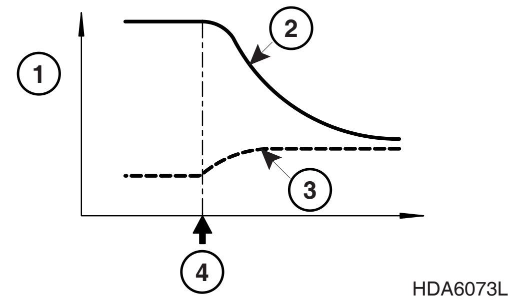


Figure 201

Reference Number	Description
1	Pressure
2	High-pressure
3	Low-pressure
4	Compressor Stop

Inspection Procedure

1. High-pressure Side

   Compressor outlet → condenser inlet → receiver dryer inlet → air conditioner unit inlet.

2. Low-pressure side

   Compressor inlet → air conditioner unit outlet.

3. Compressor

   Compressor shaft area, bolt hole area and magnetic clutch area.

4. Receiver dryer

   Pressure switch and plug area.

5. Connection valve area

   Inspect all valve areas.

   Verify all valves are capped to prevent leaking.

   Check for foreign material inside of valve cap.

6. 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

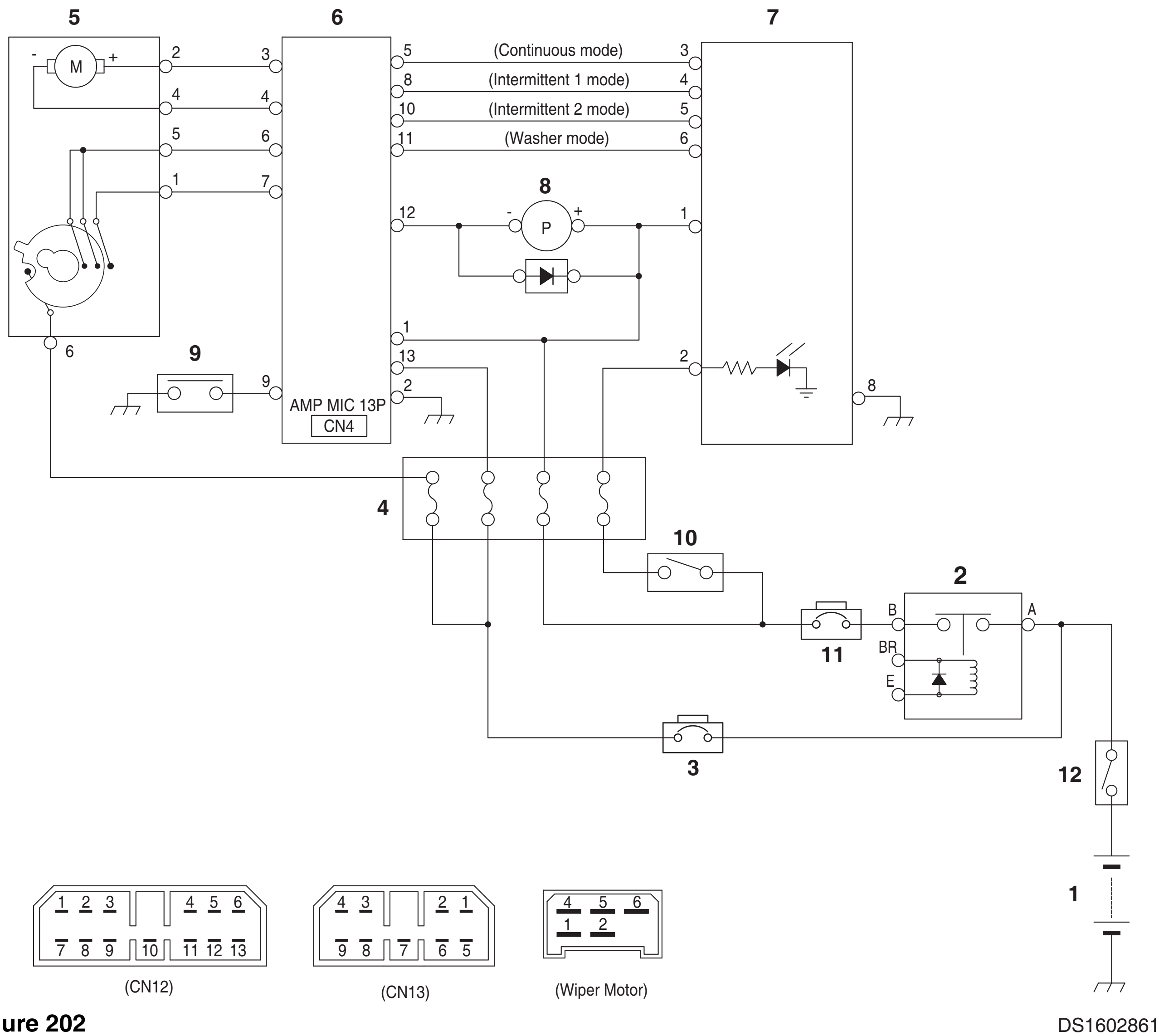


Figure 202

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker 1
4	Fuse Box
5	Wiper Motor
6	Wiper Controller
7	Wiper Switch Panel
8	Window Washer
9	Wiper Cutoff Switch
10	Light Switch
11	Circuit Breaker 2
12	Master 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 ±0.5V) to LOW (0+0.5V) and current flows by 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 ±0.5V). As the "5" and "6" terminals of the wiper motor are connected still that power is supplied to "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 by the "4" terminal of the wiper controller (6) → the "2" and "4" terminals of the wiper motor (5) → the "3" terminal of he wiper controller (6) when the "1" and "6" terminals of he wiper motor (5) are connected and thus power voltage is supplied to "7" terminal of the wiper controller (6).

The Wiper motor (5) stops reverse revolution when the contact of a cam switch connected to "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 ±0.5 V) to LOW (0+0.5 V) 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 ±0.5 V) to LOW (0+0.5 V) 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

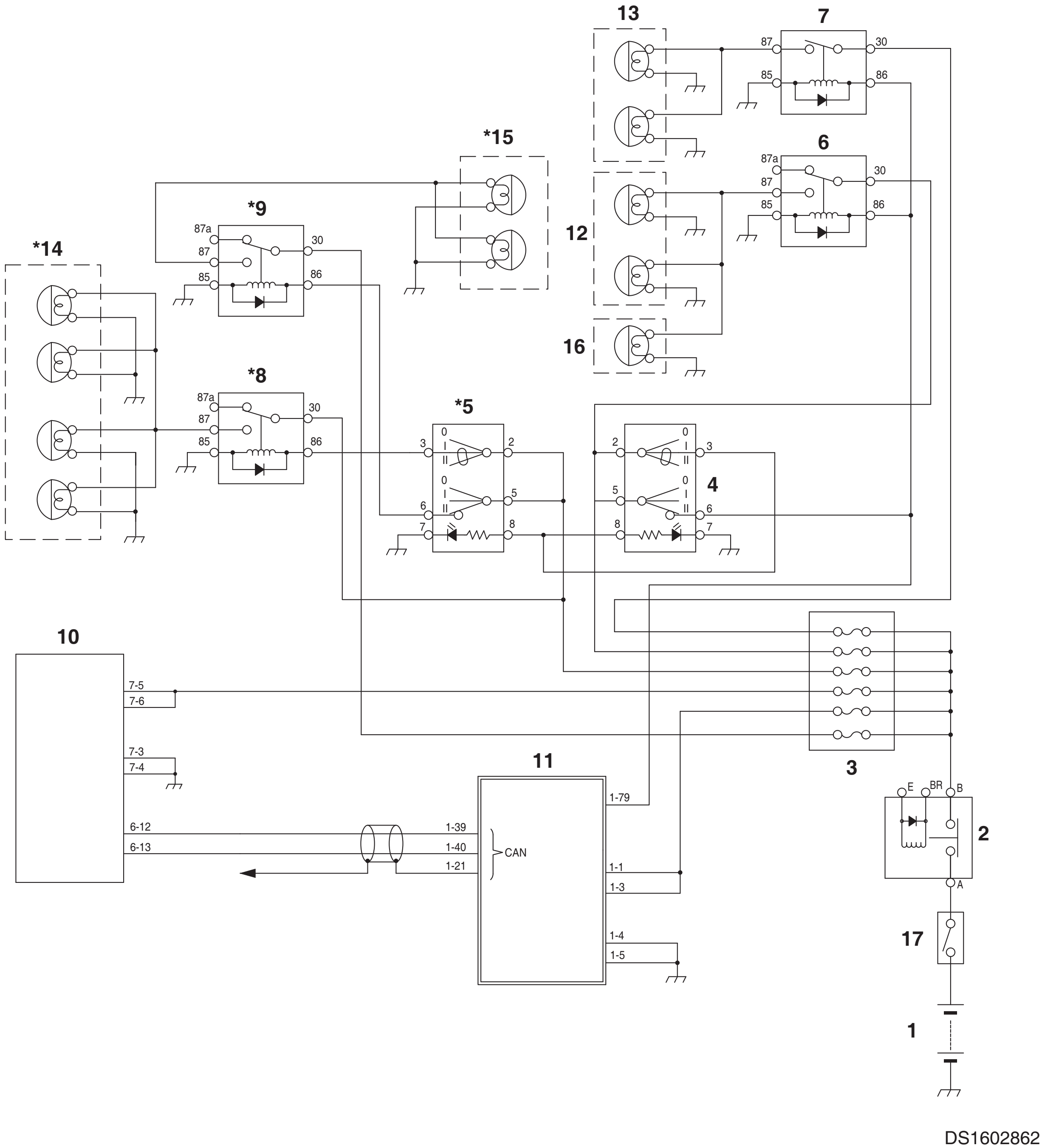


Figure 203

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
9	Rear Cabin Light Relay
10	Instrument Panel
11	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.)
17	Master Switch

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 Cabin Light (2 ea.)

AUDIO CONTROLLER

Audio Controller Circuit Diagram

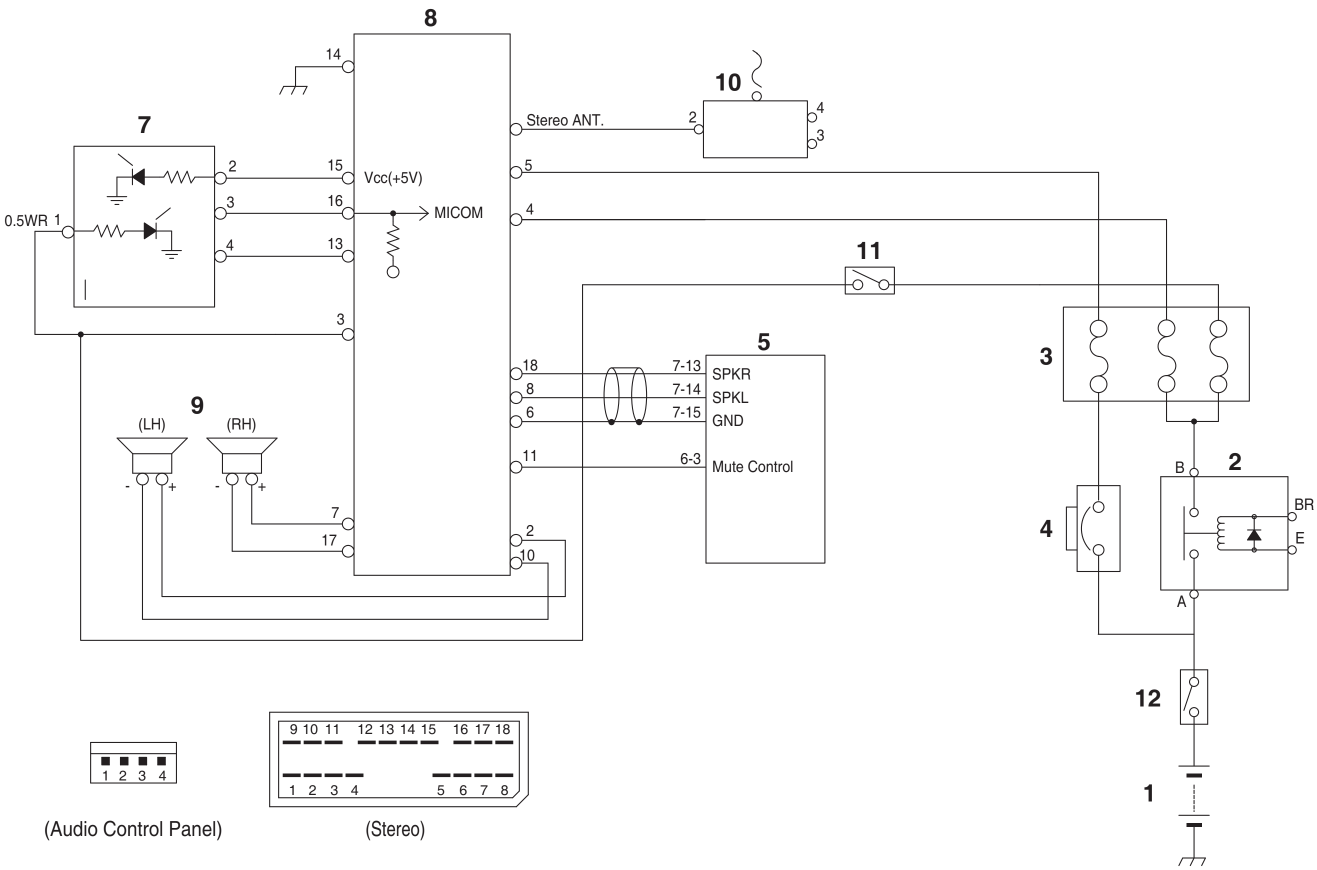


Figure 204

Reference Number	Description
1	Battery
2	Battery Relay
3	Fuse Box
4	Fusible Link
5	Instrument Panel
7	Audio Control Panel

Reference Number	Description
8	Stereo
9	Speaker
10	Antenna Module
11	Light Switch
12	Master Switch

Operations by Audio Control Panel

Switch	Connected Terminal of switch	Measured values	Operations
PWR	"3-4"	4.36 ±0.2V	Stereo ON, OFF
▲		1.24 ±0.2V	Volume up
▼		0 + 0.2V	Volume down
SCAN		2.49 ±0.2V	Frequency selection

Schematic

Hydraulic Schematic / Electrical Schematic

HX220LL
Hydraulic Schematic (1/2)

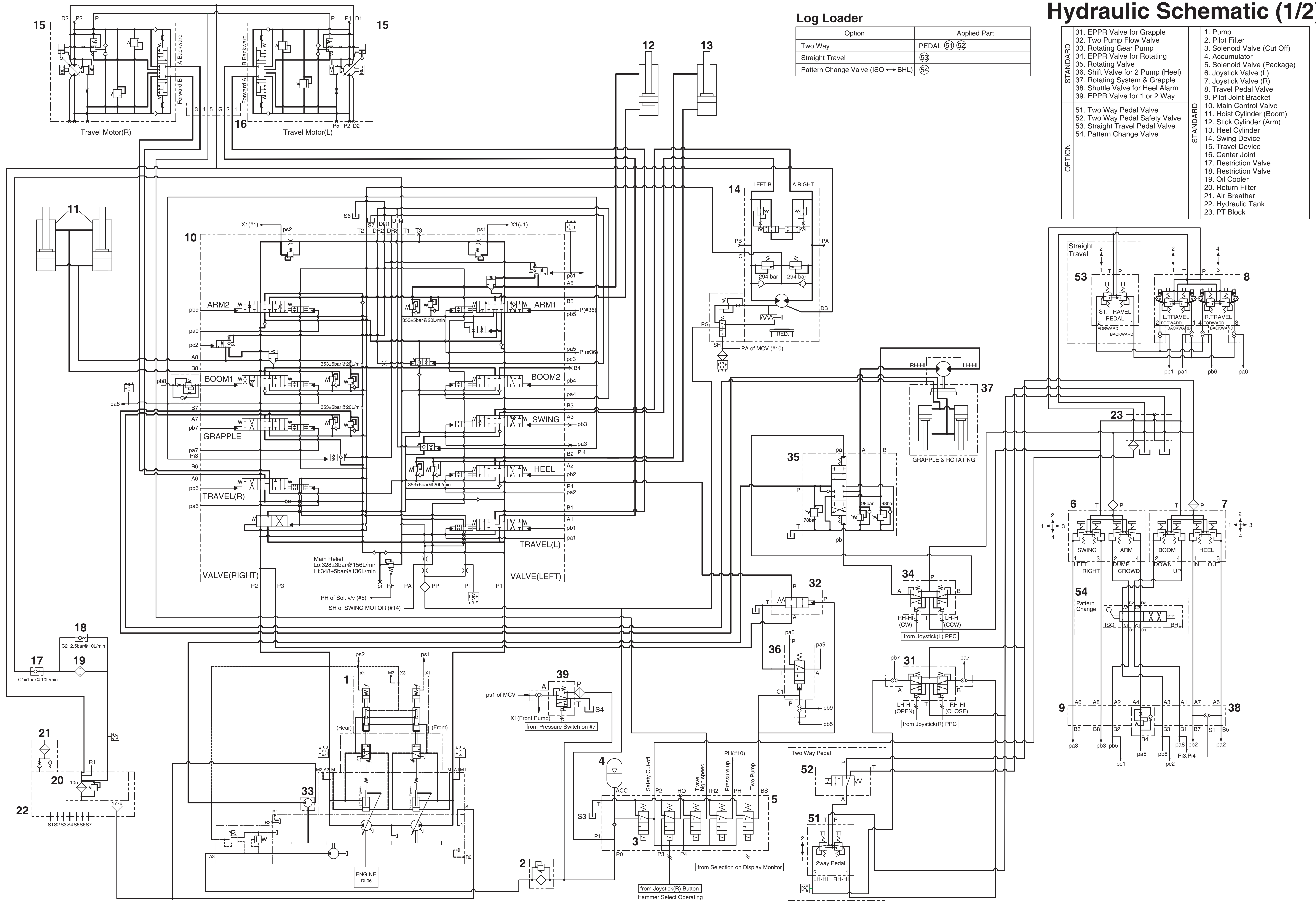
Log Loader

Option	Applied Part
Two Way	PEDAL 51 52
Straight Travel	53
Pattern Change Valve (ISO ←→ BHL)	54

STANDARD
31. EPPR Valve for Grapple
32. Two Pump Flow Valve
33. Rotating Gear Pump
34. EPPR Valve for Rotating
35. Rotating Valve
36. Shift Valve for 2 Pump (Heel)
37. Rotating System & Grapple
38. Shuttle Valve for Heel Alarm
39. EPPR Valve for 1 or 2 Way

OPTION
51. Two Way Pedal Valve
52. Two Way Pedal Safety Valve
53. Straight Travel Pedal Valve
54. Pattern Change Valve

STANDARD
1. Pump
2. Pilot Filter
3. Solenoid Valve (Cut Off)
4. Accumulator
5. Solenoid Valve (Package)
6. Joystick Valve (L)
7. Joystick Valve (R)
8. Travel Pedal Valve
9. Pilot Joint Bracket
10. Main Control Valve
11. Hoist Cylinder (Boom)
12. Stick Cylinder (Arm)
13. Heel Cylinder
14. Swing Device
15. Travel Device
16. Center Joint
17. Restriction Valve
18. Restriction Valve
19. Oil Cooler
20. Return Filter
21. Air Breather
22. Hydraulic Tank
23. PT Block

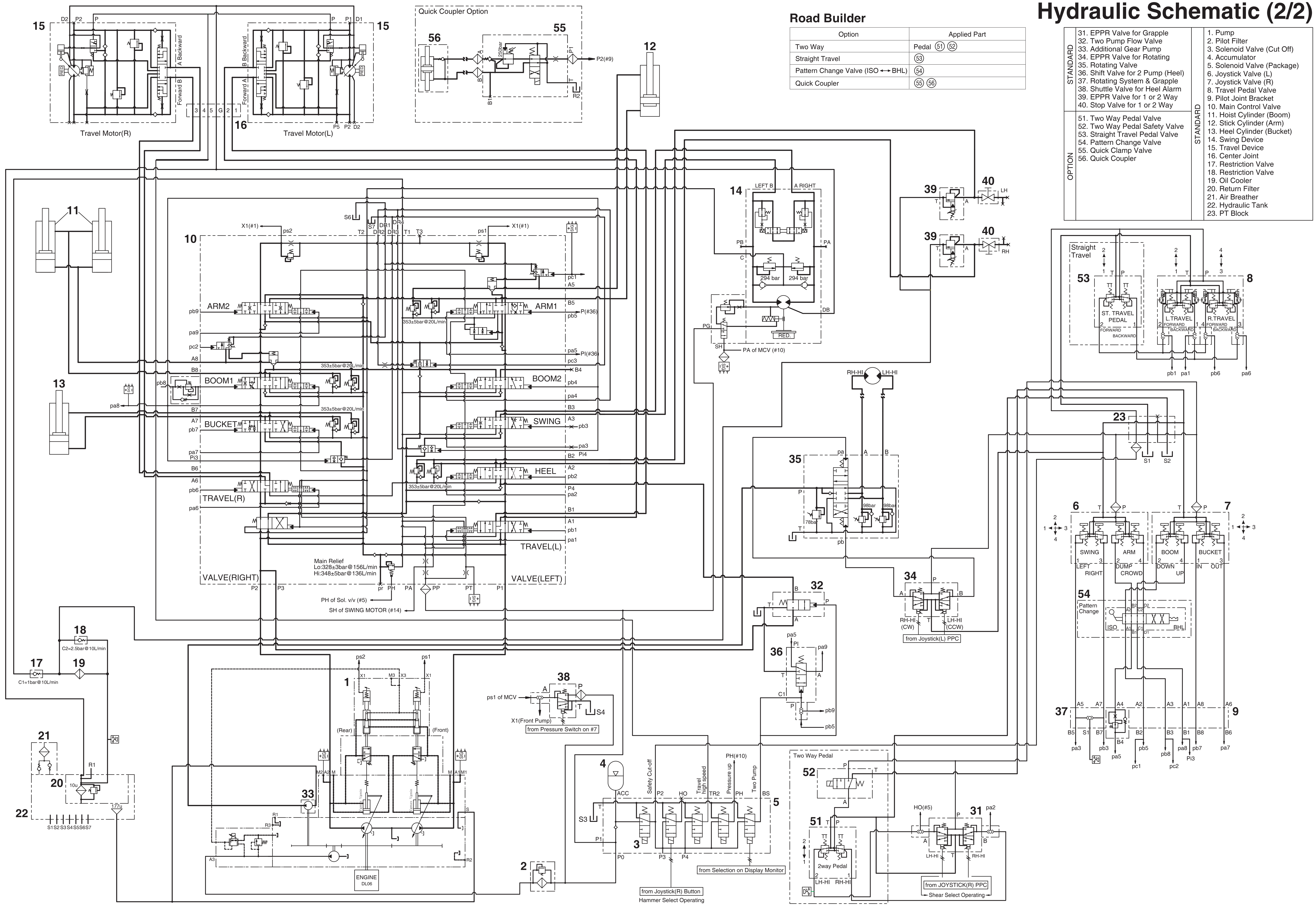


HX220LL
Hydraulic Schematic (2/2)

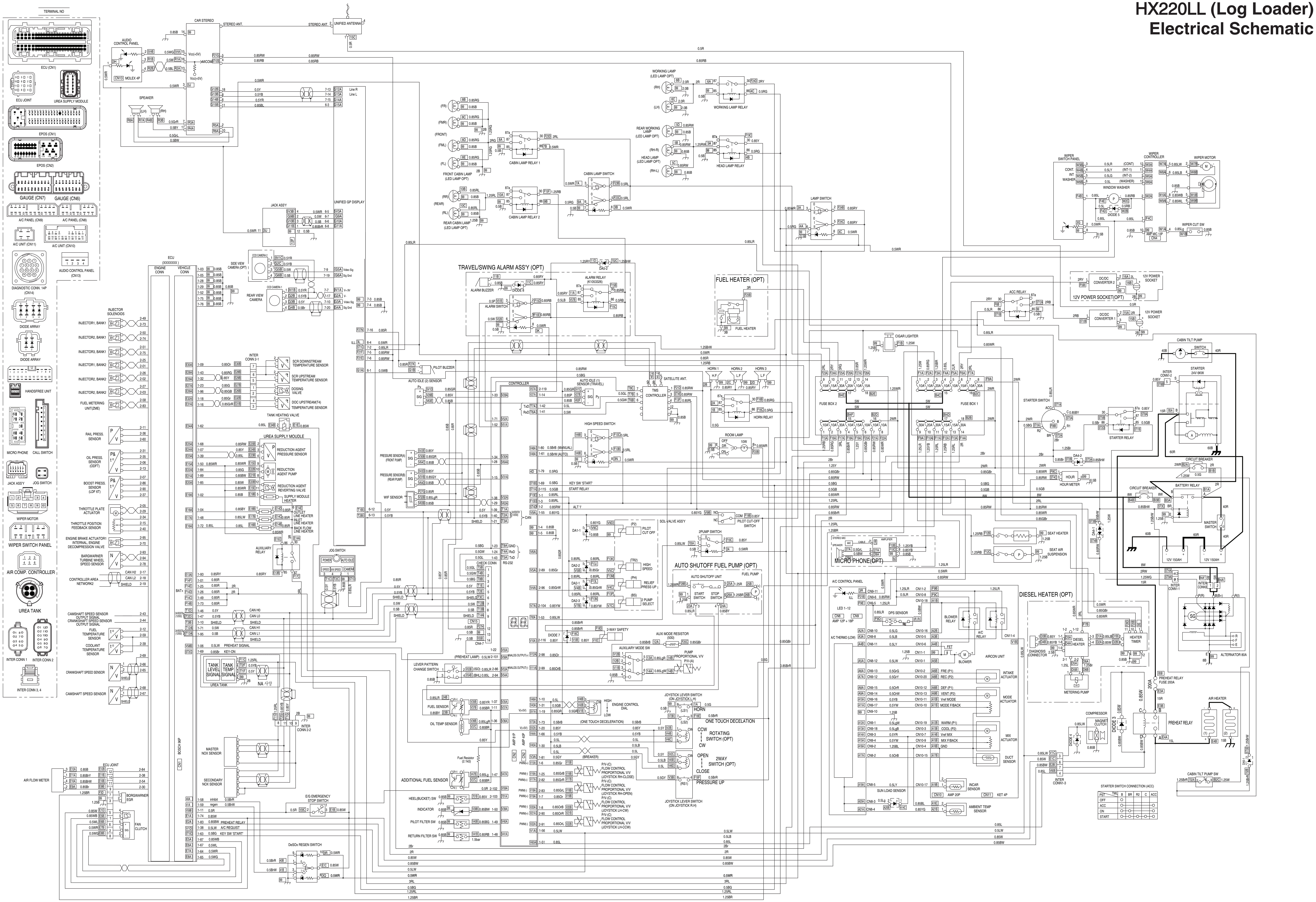
Road Builder

Option	Applied Part
Two Way	Pedal 51 52
Straight Travel	53
Pattern Change Valve (ISO ↔ BHL)	54
Quick Coupler	55 56

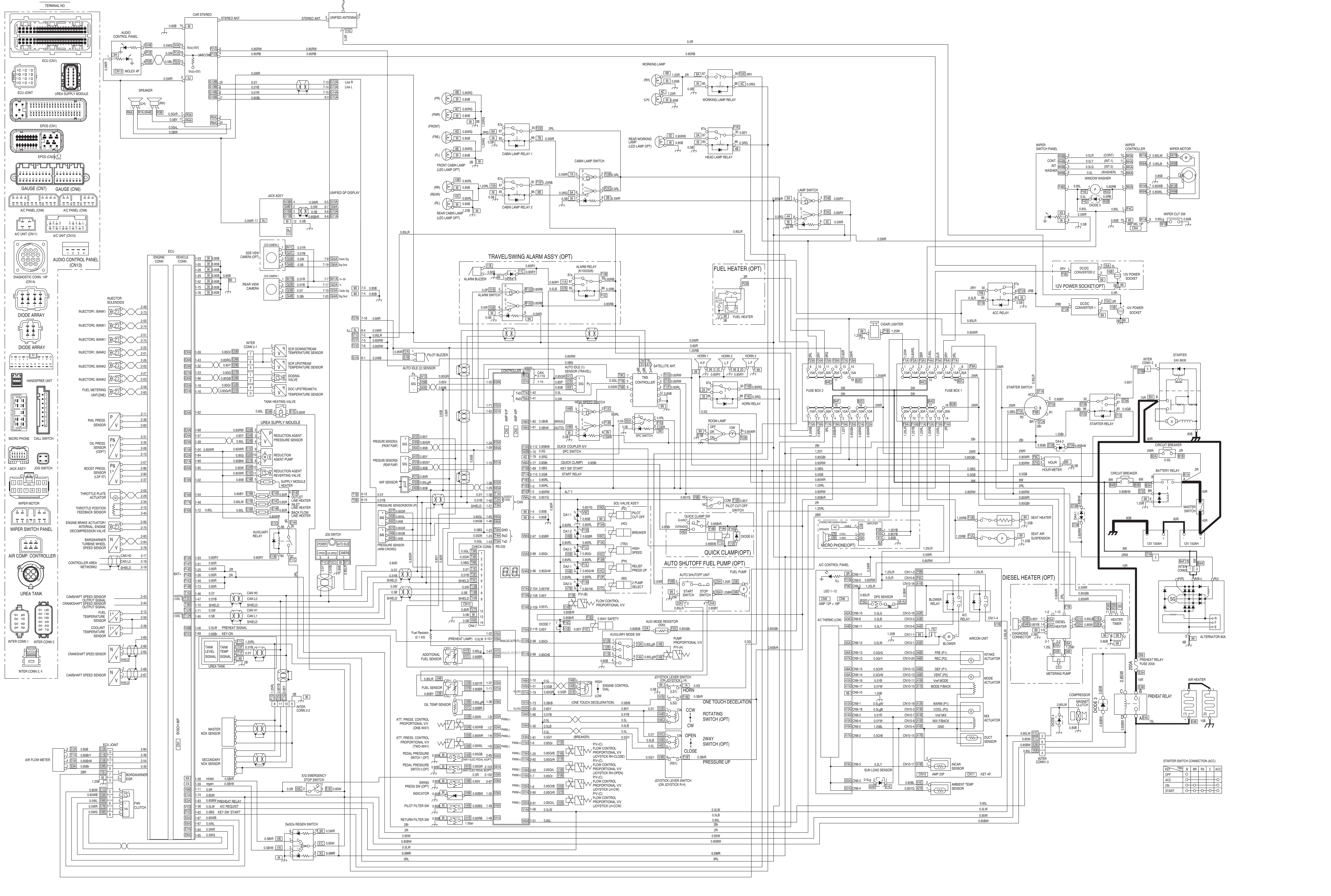
STANDARD	31. EPPR Valve for Grapple 32. Two Pump Flow Valve 33. Additional Gear Pump 34. EPPR Valve for Rotating 35. Rotating Valve 36. Shift Valve for 2 Pump (Heel) 37. Rotating System & Grapple 38. Shuttle Valve for Heel Alarm 39. EPPR Valve for 1 or 2 Way 40. Stop Valve for 1 or 2 Way	STANDARD	1. Pump 2. Pilot Filter 3. Solenoid Valve (Cut Off) 4. Accumulator 5. Solenoid Valve (Package) 6. Joystick Valve (L) 7. Joystick Valve (R) 8. Travel Pedal Valve 9. Pilot Joint Bracket 10. Main Control Valve 11. Hoist Cylinder (Boom) 12. Stick Cylinder (Arm) 13. Heel Cylinder (Bucket) 14. Swing Device 15. Travel Device 16. Center Joint 17. Restriction Valve 18. Restriction Valve 19. Oil Cooler 20. Return Filter 21. Air Breather 22. Hydraulic Tank 23. PT Block
OPTION	51. Two Way Pedal Valve 52. Two Way Pedal Safety Valve 53. Straight Travel Pedal Valve 54. Pattern Change Valve 55. Quick Clamp Valve 56. Quick Coupler		



HX220LL (Log Loader)
Electrical Schematic



HX220RB(Road Builder)
Electrical Schematic



HX220LL (Oregon Cabin)
Electrical Schematic