TORO®

University

Hydraulics

Circuits, Components, Schematics, Hydrostatic Drives and Test Equipment

PART NO. 09169SL

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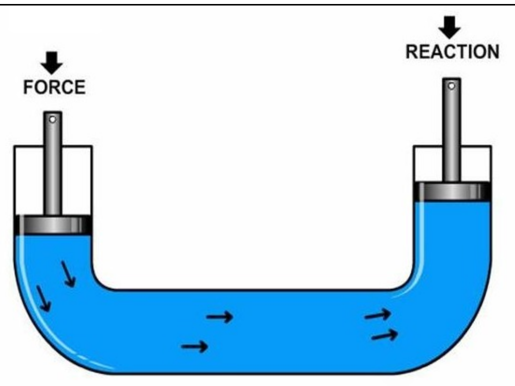
Hydraulic Circuits and Components

This study guide will discuss basic hydraulic systems. We will look at fundamental principles and how they pertain to hydraulic systems. We will also learn about various hydraulic components and their function.

A hydraulic circuit, whether it is simple or complex uses the basic hydraulic principles discussed on the following pages.

LIQUID ASSUMES SHAPE OF TUBE

A liquid can assume any shape and be bidirectional. Fluid is able to flow in any and all directions within a container.

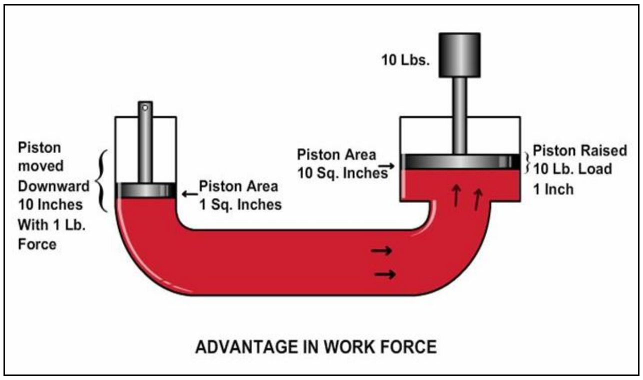


DOWNWARD FORCE OF PISTON CAUSES OIL MOVEMENT OR FLOW IN THE TUBE

Pascal's Law

Pascal's law states that when a confined fluid is placed under pressure, the pressure is transmitted equally in all directions and on all faces of the container. This is the principle used to extend the ram on a hydraulic cylinder.

By applying a force to move the piston on one end, the piston on the other end will move the same distance with same amount of force.



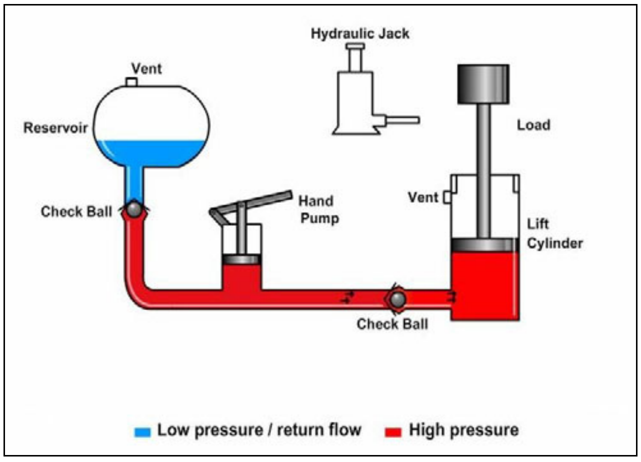
Hydraulic "Leverage"

If we take the concept discussed on the previous slide and use containers or cylinders of different sizes, we can increase the mechanical advantage to lift a heavier load.

This is the principle that allows you to jack up a very heavy object while exerting a small amount of force on the handle of a hydraulic jack.

The animated illustration shows that 1 lb. of force exerted on a 1 sq. in. piston, moved 10 in. will lift 10 lbs. a distance of 1 in. with a 10 sq. in. piston. Click on the 'Play' button in the illustration to see a demonstration. The larger piston will move a shorter distance, but provides the mechanical advantage to lift a much heavier load.

The mechanical workforce advantage in hydraulics can be thought of as leverage, but it is *hydraulic leverage*.



All hydraulic circuits are essentially the same regardless of the application.

There are four basic components required; a **reservoir** to hold the fluid; a **pump** to force the fluid through the system; **valves** to control the flow; and an **actuator** to convert the fluid energy into mechanical force to do the work.

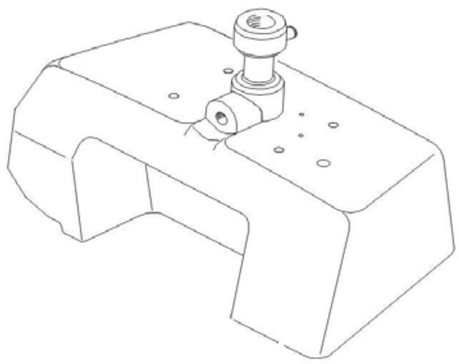
Basic Hydraulic System

Although hydraulic circuit layouts may vary significantly in different applications, many of the components are similar in design or function. The principle behind most hydraulic systems is similar to that of the basic hydraulic jack.

Oil from the reservoir is drawn past a check ball into the piston type pump during the piston's up-stroke. When the piston in the pump is pushed downward, oil will be directed past a second check ball into the cylinder.

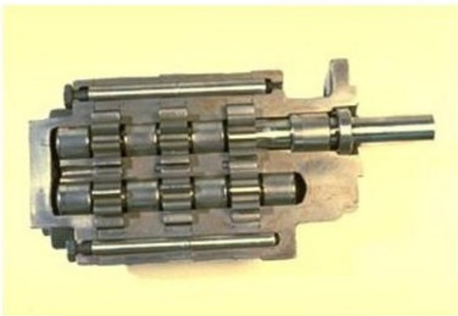
As the pump is actuated up and down, the incoming oil will cause the cylinder ram to extend. The lift cylinder will hold its extended position because the check ball is being seated by the pressure against it from the load side of the cylinder.

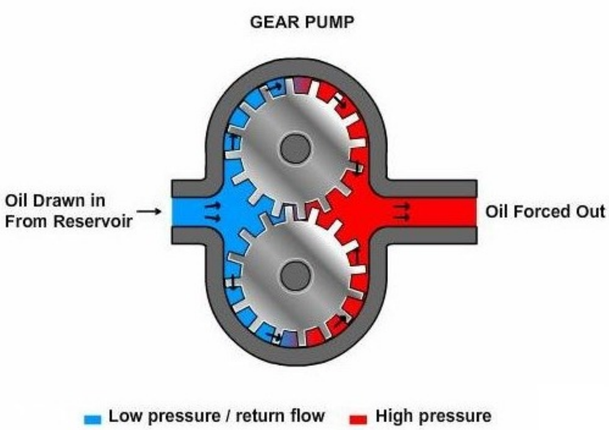
Because the pump displacement is usually much smaller than the cylinder, each stroke of the pump will move the cylinder a very small amount. If the cylinder is required to move at a faster rate, the surface area of the pump piston must be increased and/or the rate which the pump is actuated must be increased. Oil FLOW gives the cylinder ram its SPEED of movement and oil PRESSURE is the work force that lifts the load.



Reservoir

Here is an example of a reservoir; one of the four basic requirements to make a hydraulic system. This particular reservoir is made of molded plastic and is from a Greensmaster riding mower.



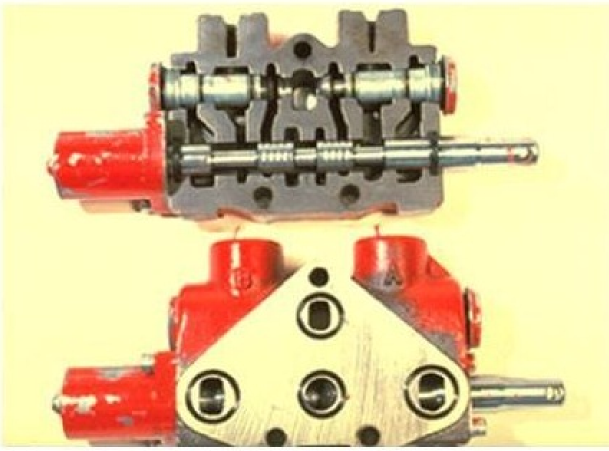


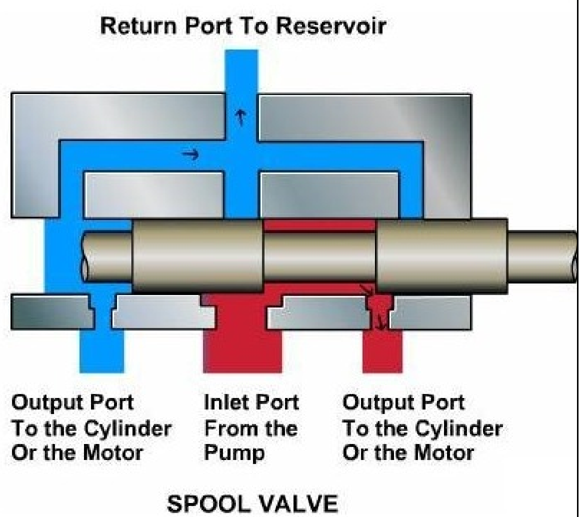
Pump

We can improve the efficiency and increase the versatility of a basic circuit by adding some more sophisticated components and changing the circuit layout. By incorporating a gear pump in place of a hand piston pump, we increase oil flow to the cylinder which will increase the actuation rate of the ram. The image to the right shows a cutaway view of a three section gear pump. We can see the gear sets for all three sections and the input (drive) shaft. A gear pump is a positive displacement pump, meaning that whenever the pump is turning the pump must pump oil. If pump flow is totally blocked, sudden failure of the pump or other component will occur.

As the gears in the pump rotate, suction is created at the inlet port of the pump. The fluid is drawn in to the pump and is carried in the spaces between the gear teeth to the discharge port of the pump. At the discharge side of the pump the gear teeth mesh together and the oil is discharged from the pump. Click on the 'Play' button in the animated illustration to see the pump in operation.

Note that the pump creates flow. The pump, by itself, does not create pressure. Pressure results only when there is resistance to flow. You cannot have pressure without flow (or potential flow).



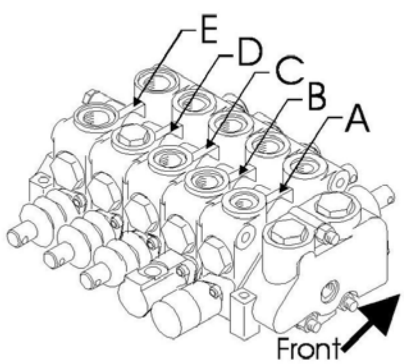


Control Valve

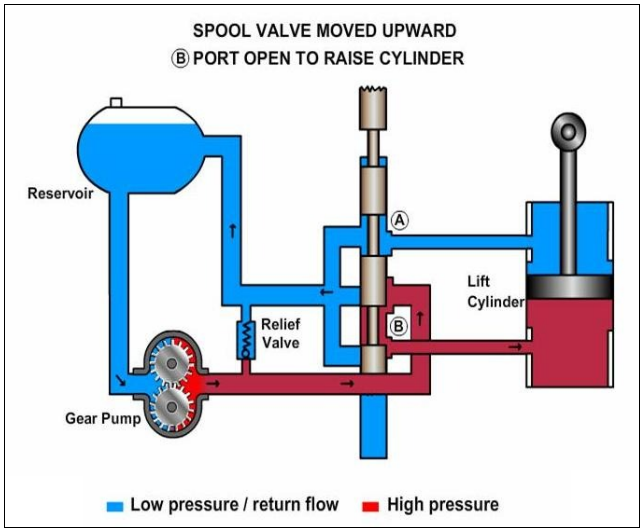
The flow from the pump to the cylinder is controlled by a sliding spool valve which can be actuated a hand or foot operated lever or an electric solenoid. The image to the right shows a cutaway of an actual hydraulic control valve.

The valve shown in the illustration is a open center valve, meaning that the oil flow is returned to the reservoir when the valve is in the neutral position.

The spool valve has the capability to direct fluid flow to either end of the actuator. As the spool is moved, fluid is redirected to one end or the other of the actuator, while fluid being pushed out the other end of the actuator is directed back to reservoir through the valve.



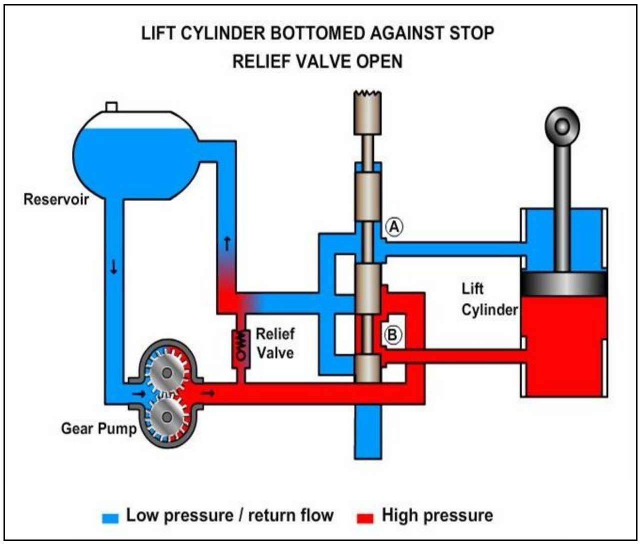
This is that same spool valve, assembled with multiple sections to make a valve bank or assembly. This example is from a Greensmaster riding mower. In this example the valve bank would control all of the hydraulic functions on the machine and would be actuated by foot or hand operated levers.



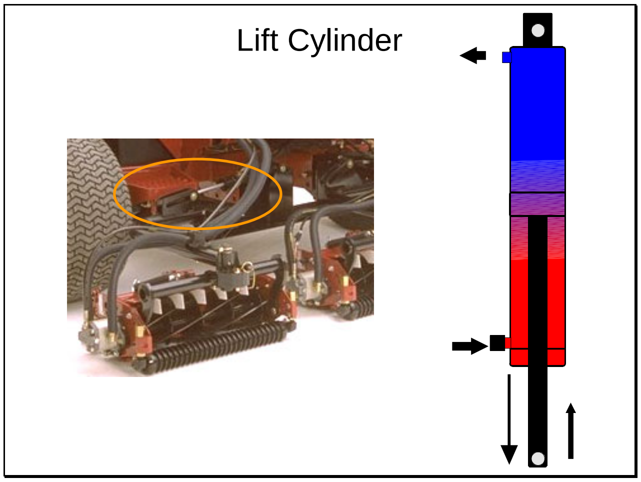
Basic Hydraulic System

Here we have a spool valve in our simple hydraulic system. You can see that the valve is in the neutral position and all the flow from the pump is directed back to the reservoir.

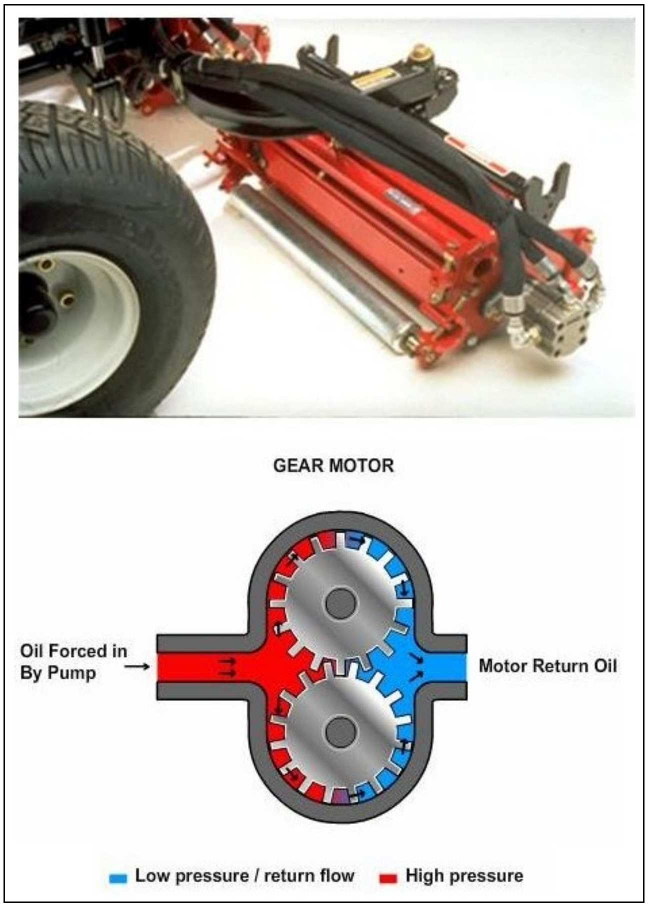
If the spool is moved upward, the oil flow from the pump is directed through the spool to one end of the lift cylinder. The oil in the opposite end of the cylinder is pushed out as the ram extends, and will pass through the valve and return to the reservoir.



Since the fluid from a positive displacement pump must flow continuously whenever the pump is running, it must have some where to go if not being used by the actuators. If the load on the cylinder becomes too great or if the ram bottoms out, the flow from the pump will be directed past the relief valve returning to the reservoir.



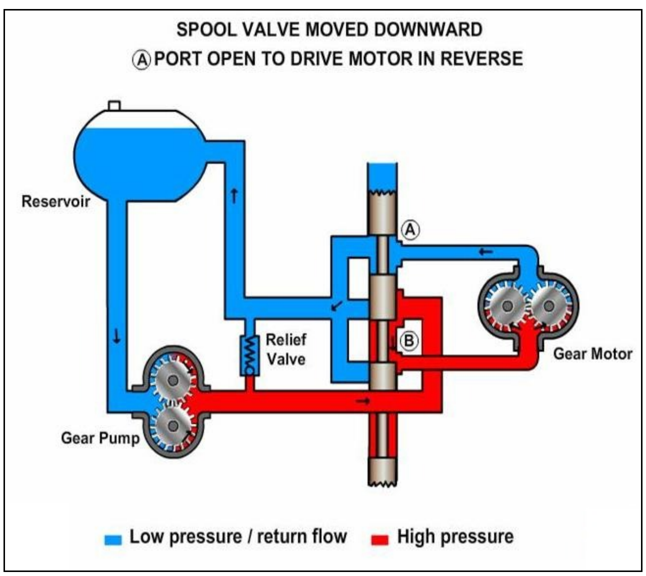
The flow diagram in the previous two illustrations shows the piston (barrel) end of the cylinder being pressurized to lift the load. Some lift circuits on Toro equipment pressurize the rod (ram) end of the cylinder to lift the load (e.g. Reelmaster 5000 series).



Motor

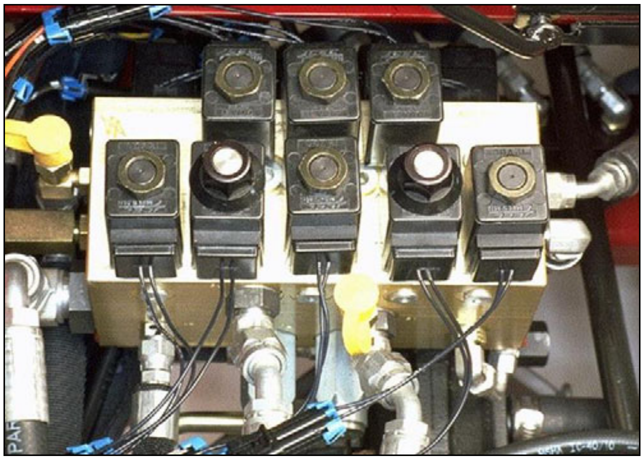
Substituting the lift cylinder with a gear motor, we can now utilize our basic circuit to create rotational movement to drive attachments. The adjacent photo shows a hydraulic motor used to drive the reel on a cutting unit.

Note that there are three hydraulic lines connected to the motor shown in the photo. Many hydraulic motors will have two larger hoses for the pressure and return lines and a small case drain hose. The smaller case drain hose carries fluid from internal motor leakage back to the reservoir. A small amount of internal leakage is designed in to these motors to lubricate and cool motor components.



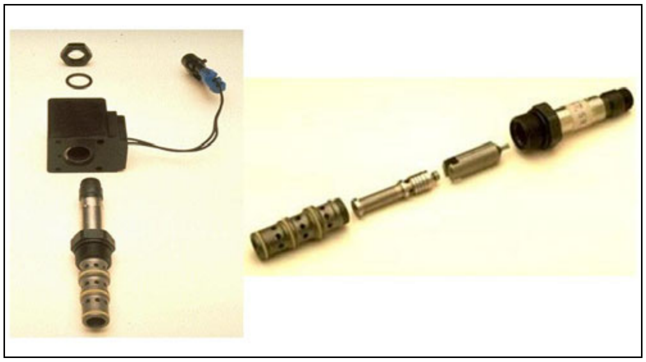
This illustration shows the basic circuit and components necessary to drive the cutting unit reels. With the spool in the upward position, the oil flow is directed through the spool valve to the lower port driving the motor in the forward direction.

Actuating the spool to the down position, the flow of oil from the pump is directed to the opposite port of the motor. The motor then rotates in the reverse direction, such as when back-lapping the cutting unit.



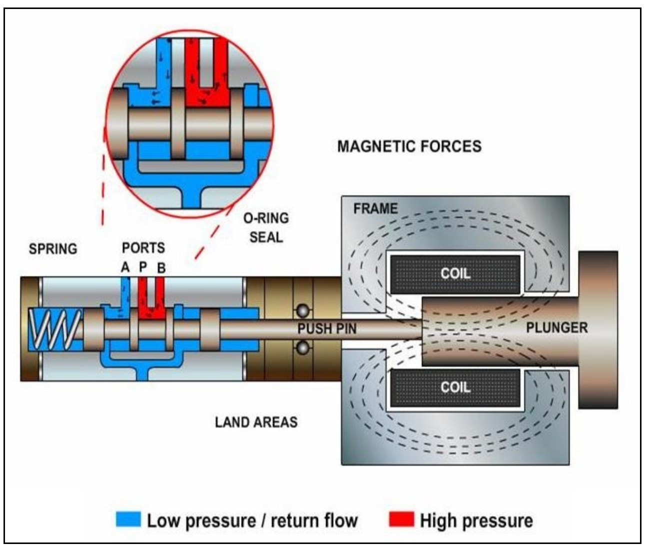
Electric / Hydraulic Control Valves

The valve system may consist of several spool valves threaded into a machined valve body. This valve body contains the internal porting to direct the fluid flow. The outer ports on the valve block are threaded to allow hoses and lines to be connected to it.

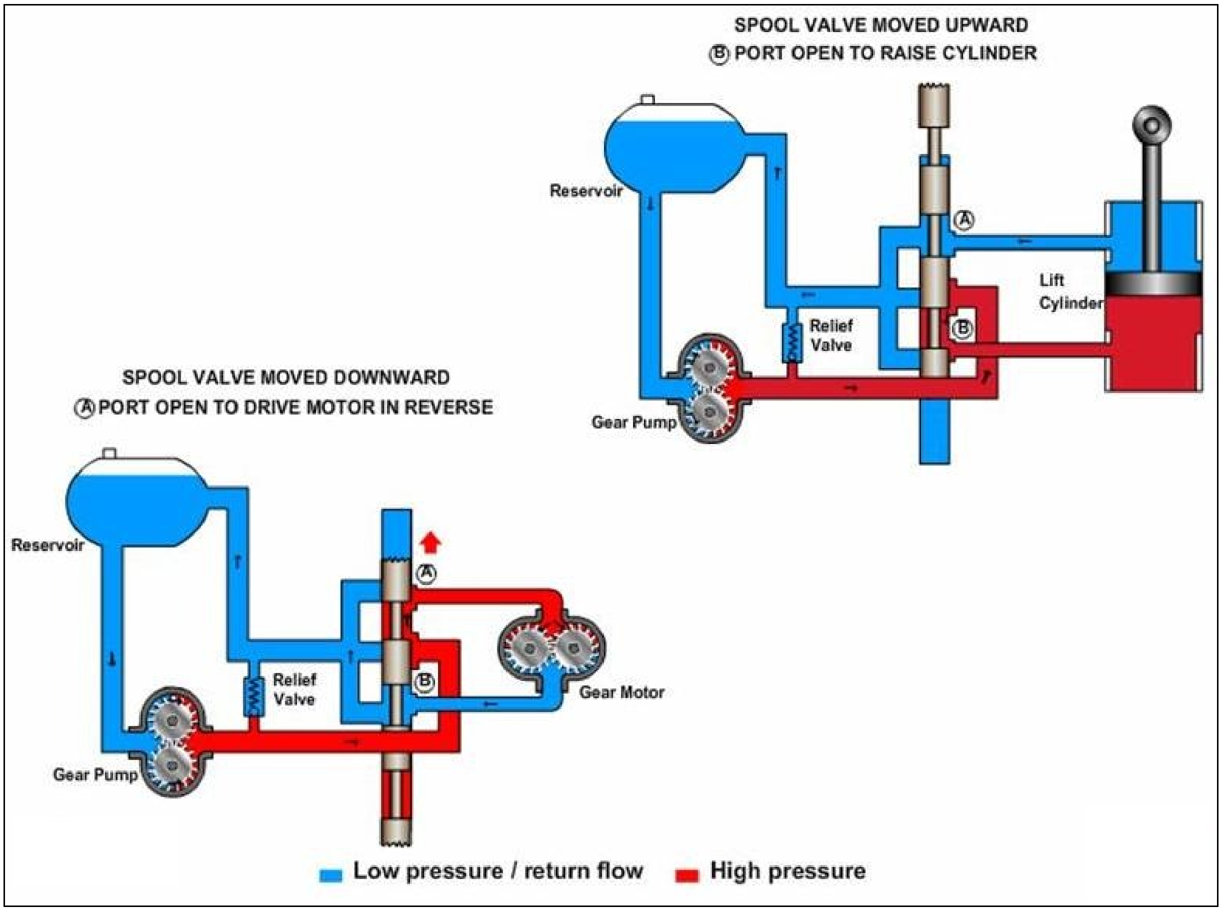


Solenoid Valve

The solenoid valves consist of the valve cartridge and the solenoid coil. To disassemble the valve remove the coil assembly and then carefully unscrew the valve body. The O-rings and seals should be replaced whenever a valve body is removed or replaced.



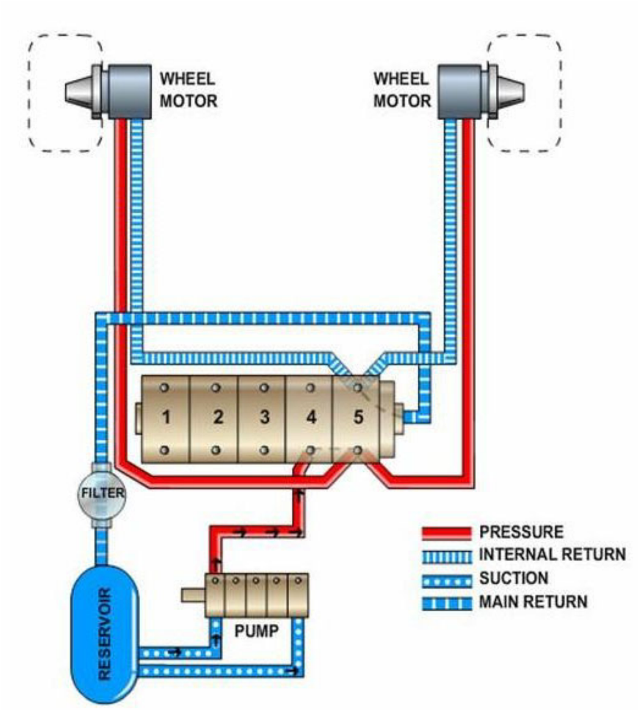
The electric solenoid valve operates by supplying electrical current to a coil magnet, the magnetic field moves a valve spool and this directs the oil. The thing to remember is that the only difference between a hydraulic\electric valve, and a manually actuated hydraulic valve is the way that the spool is moved.



Understanding the basic hydraulic systems and components can be of great value when troubleshooting and testing hydraulic equipment.

The upper illustration would be a circuit used to raise a cutting unit with a hydraulic cylinder. The lower illustration would be a circuit that uses a hydraulic motor to drive a cutting unit reel.

Most hydraulic circuits will be similar to one of these two basic circuits.

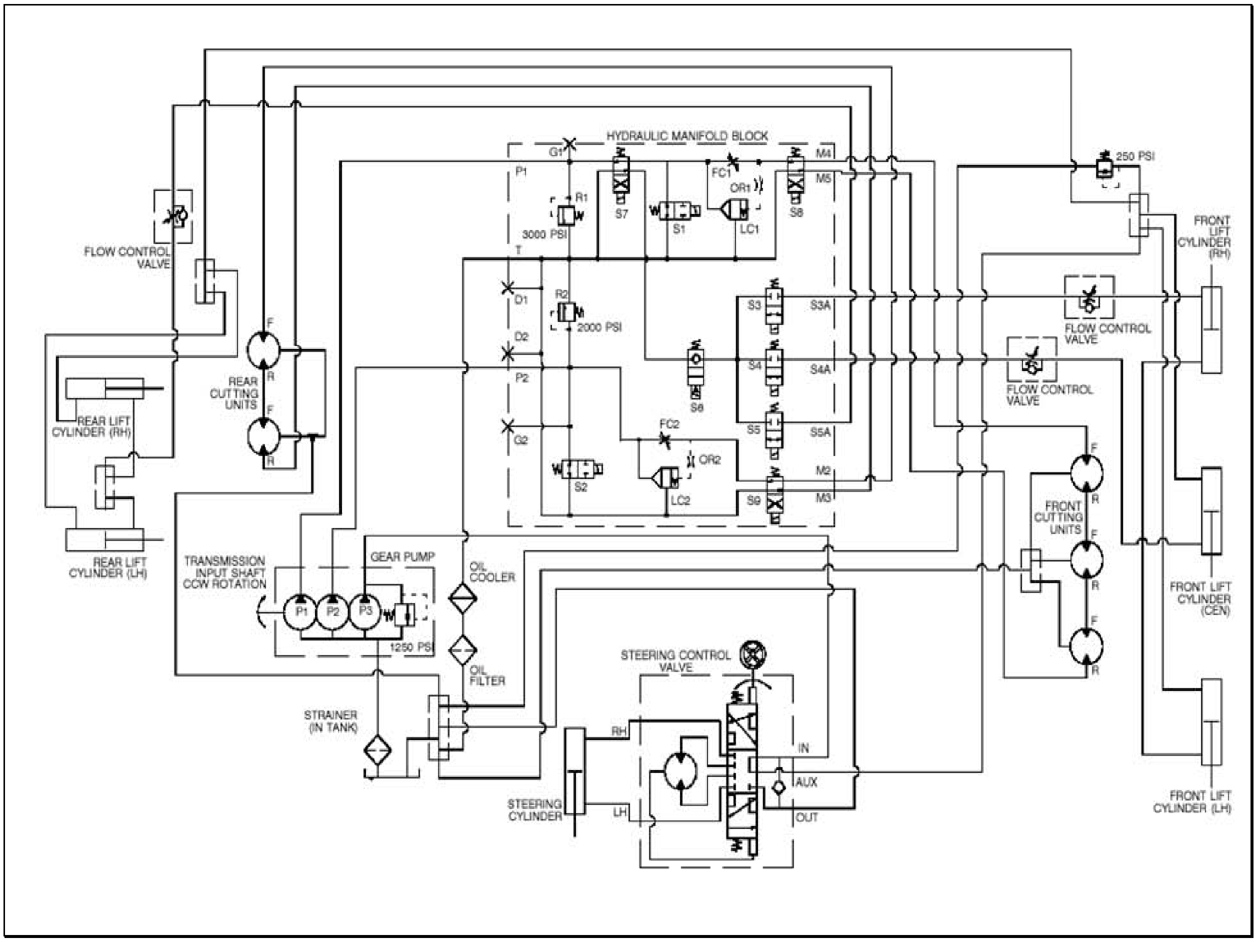


This illustration shows the traction drive circuit for a Greensmaster riding mower. This circuit and components are used to drive the unit in the No.1 traction position. When the engine is started, the pump draws oil from the reservoir through the suction lines. Oil from the No.4 section of the pump passes through the fitting in the No.4 spool valve into the valve. The traction lever, when located in the No.1 position, moves the spool so oil is directed to flow into the No.5 metering valve section. When the traction pedal is pushed forward oil flows out the lines at the rear of the metering valve section to each motor to drive the motors. Low pressure oil returns through the valve and the main return line, through the filter to the reservoir.

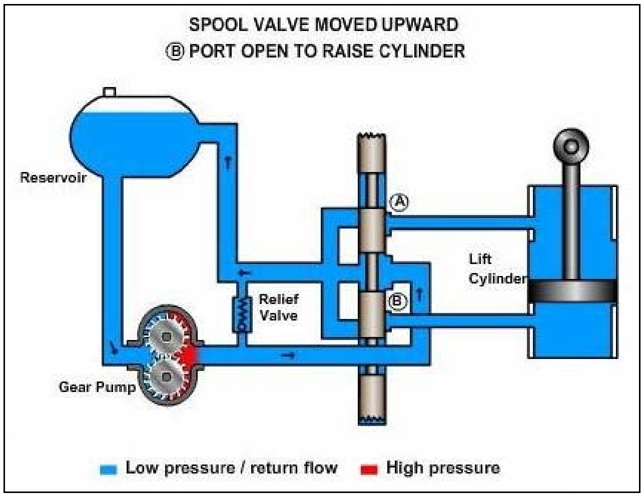
The more sophisticated a hydraulic system becomes, the greater the importance of separating the system into individual circuits when diagnosing a hydraulic problem.

Hydraulic Schematics

Accurate diagrams of hydraulic circuits are essential to the technician who must repair it. If you don't understand how the system operates, it is very difficult to diagnose possible hydraulic problems.



This looks very complicated. To make it easier to understand, we are going to learn how to look at individual circuits (e.g., steering, lift, mow) instead of the entire system.

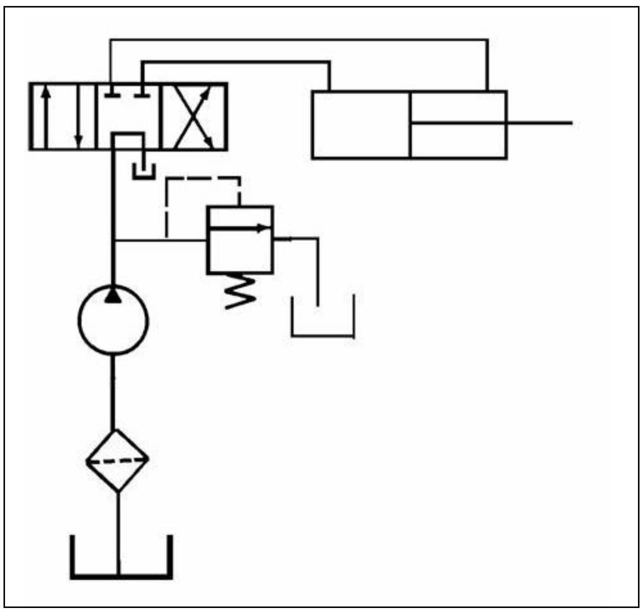


Accurate diagrams of hydraulic circuits are essential to the technician who must diagnose and repair possible problems. The diagram shows how the components will interact. It shows the technician how it works, what each component should be doing and where the oil should be going, so that he can diagnose and repair the system.

There are two types of circuit diagrams.

Cutaway Circuit Diagrams show the internal construction of the components as well as the oil flow paths. By using colors, shades or various patterns in the lines and passages, they are able to show many different conditions of pressure and flow.

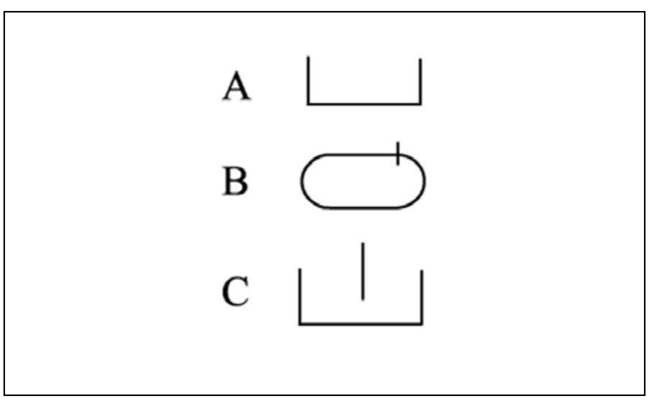
The other type of diagram is the **Schematic Circuit Diagram**.



Schematic Circuit Diagrams are usually preferred for troubleshooting because of their ability to show current and potential system functions. A schematic diagram is made up of consistent geometric symbols for the components and their controls and connections.
Schematic symbol systems:

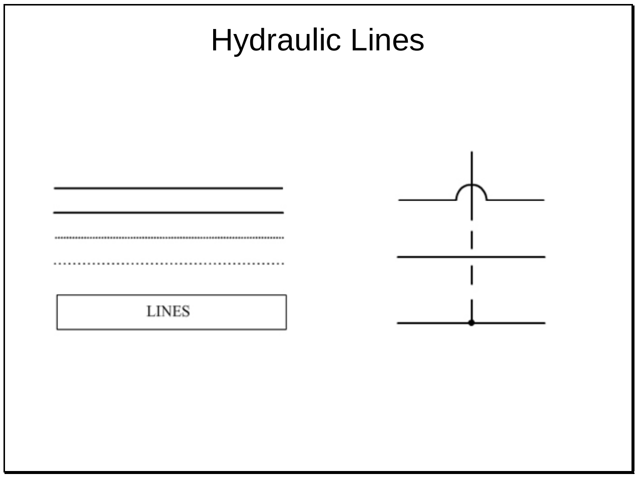
I.S.O. = International Standards Organization.
A.N.S.I. = American National Standards Institute
A.S.A = American Standards Association
J.I.C. = Joint Industry Conference

A combination of these symbols are shown in this manual. There are difference between the systems but there is enough similarity so that if you understand the symbols in this manual you will be able to interpret other symbols as well.



Hydraulic Reservoirs

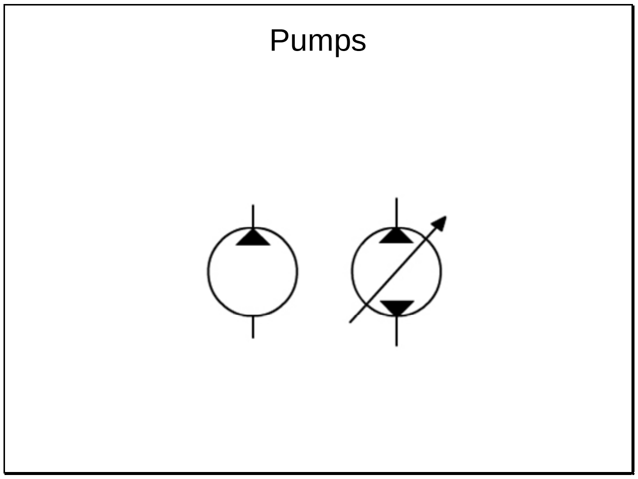
Reservoirs are pictured as either an open square meaning it is a vented reservoir, or a closed reservoir meaning that it is a pressurized reservoir. Every system reservoir has at least two lines connected to it, and some have many more. Often the components that are connected to it are spread all over the schematic. Rather than having a lot of confusing lines all over the schematic, it is customary to draw individual reservoir symbols close to the component. Similar to the ground symbol in some wiring schematics. The reservoir is usually the only component to be pictured more than once



Lines

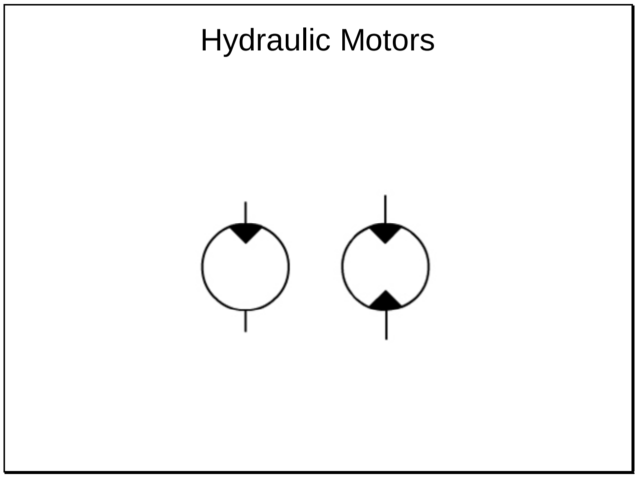
A hydraulic line, tube, hose or any conductor that carries the liquid between components is shown as a line. Some lines have arrows to show direction of oil flow, and lines may be shown as dashed lines to show certain types of oil flow.

There are lines that cross other lines but are not connected, there are several ways to show lines that are not connected. Lines that are connected are shown with a dot or sometime just as two lines crossing. If the schematic shows a specific symbol to show lines that are not connected then anything else is connected.



Hydraulic Pumps

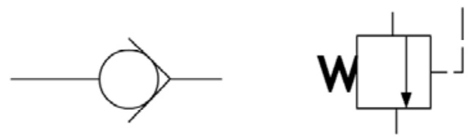
There are many basic pump designs. A simple fixed displacement pump is shown as a circle with a triangle that is pointing outward. The triangle points in the direction that the oil will flow. If the pump is reversible or is designed to pump in either direction, it will have two triangles in it and they will point opposite of each other indicating that oil may flow in both directions. An arrow through the pump shows that it is a variable displacement pump.



Hydraulic Motors

Hydraulic motor symbols are circles with triangles, but opposite of a hydraulic pump, the triangle points inward to show the oil flows in to the motor. One triangle is used for a non-reversible motor and two triangles are used for a reversible motor. An arrow through a motor shows that it is a variable speed motor.

Check Valves and Relief Valves



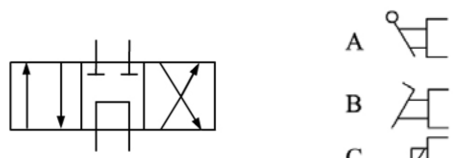
Check Valves

A check valve is shown as a ball in a V seat. When oil pressure is applied to the left side of the ball, the ball is forced into the V and no oil can flow. When oil pressure is applied to the right side of the ball, the ball moves away from the seat and oil can flow past it. A by-pass check is a one way valve with a spring on the ball end of the symbol. This shows that pressurized oil must overcome the spring pressure before the ball will unseat.

Relief Valves

A relief valve is shown as a normally closed valve with one port connected to the pressure line and the other line connected to the reservoir. The flow direction arrow points away from the pressure line and toward the reservoir. When pressure in the system overcomes the valve spring, pressure is directed through the valve to the reservoir.

Control Valves

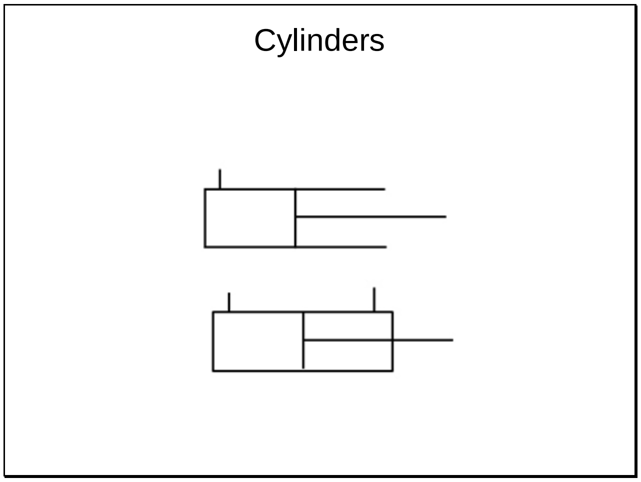


Control Valves

A control valve has envelopes (squares) that represent the valve spool positions. There is a separate envelope for each valve position and within these envelopes there are arrows showing the flow paths then the valve is shifted to that position. All the port connections are drawn to the envelope that shows the neutral position of the valve. We can mentally visualize the function of the valve in any position. A valve that has parallel lines drawn outside of the valve envelopes shows that this valve is capable of infinite positioning. This valve usually operated between the positions shown. An example of this type of valve would be a flow priority valve or a pressure regulating valve.

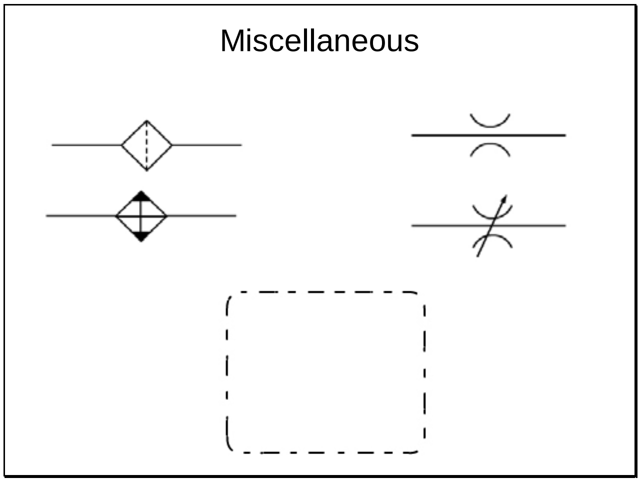
Valve actuators

The valve spools can be controlled a variety of ways. The top picture (A) shows the symbol for a lever control. The middle picture (B) shows the symbol for a pedal control (foot operated). The lower control (C) is an electric solenoid.



Hydraulic Cylinders

A cylinder symbol is a simple rectangle representing the barrel. The rod and piston are represented by a tee that is inserted into the rectangle. The symbol can be drawn in any position.



Filters and Coolers

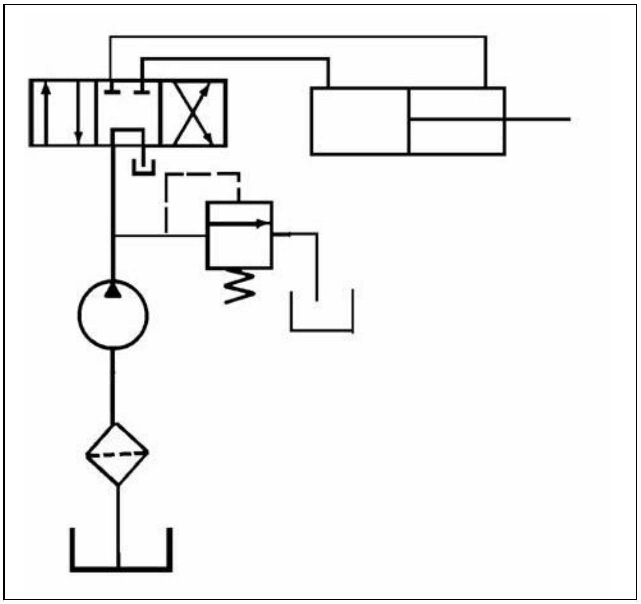
Filters, strainers and heat exchangers (coolers) are shown as squares that are turned 45 degrees and have port connections at the corners. A dotted line 90 degrees to the oil flow indicates a filter or a strainer. A solid line 90 degrees to the oil flow with 2 triangles pointing out indicates a cooler. The symbol for a heater is like that of a cooler, except the triangles point inward.

Flow Controls

The basic flow control is a representation of a restrictor. If the restrictor is adjustable a slanted arrow will be drawn across the symbol.

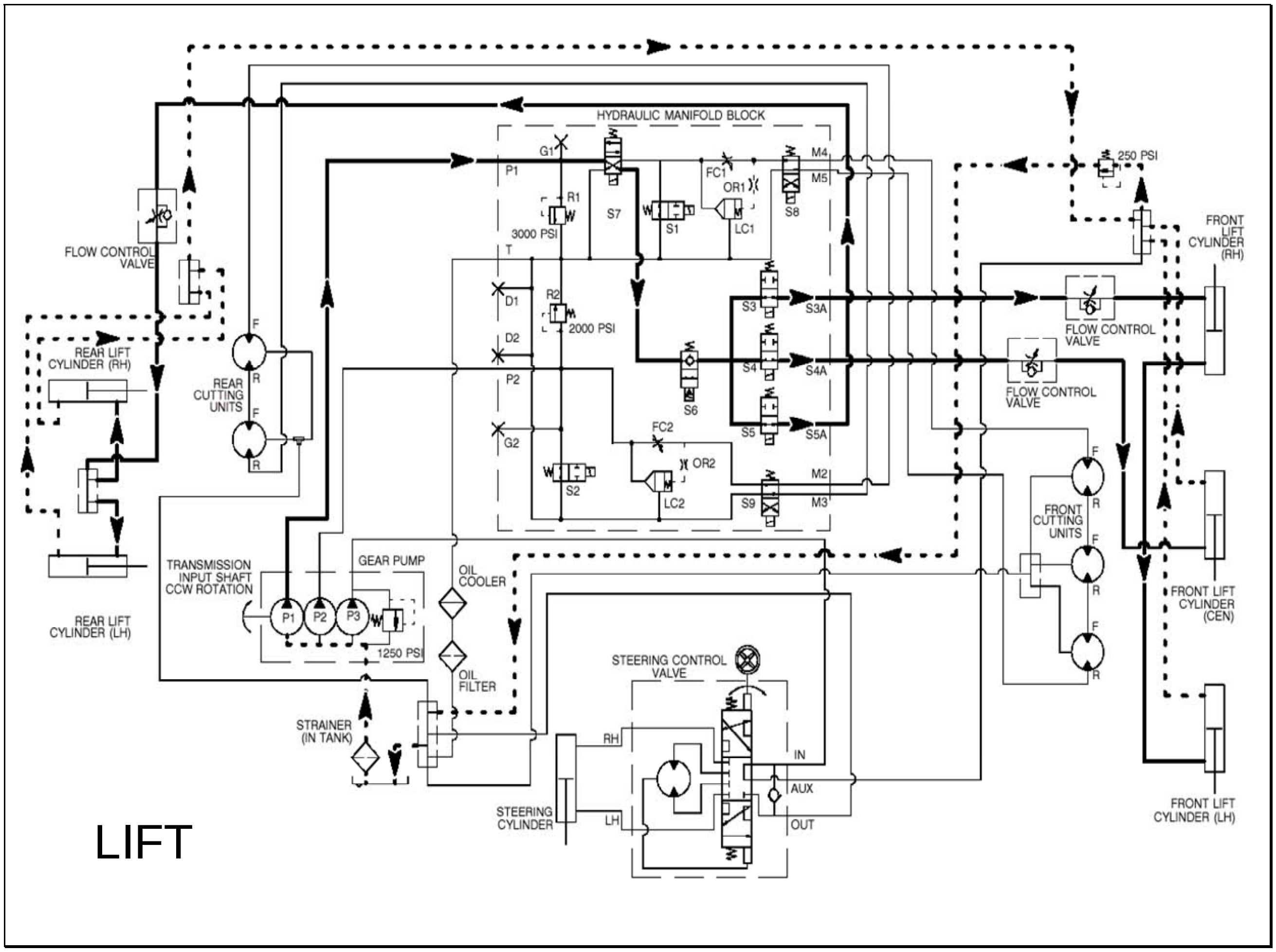
Valve Enclosures

When you see an enclosure outline, that indicates that there are several symbols that make up a component assembly such as a valve body or valve stack. The enclosure outline appears like a box and is broken with dashes on all sides.



Complete Hydraulic Schematic

Here we have a simple hydraulic schematic using the symbols that we discussed and how they are used in a complete schematic. You can see that we have a hydraulic pump which gets it’s fluid from the reservoir, pulls the fluid through the filter than sends it to the valve. The valve directs the oil to the hydraulic cylinder.



The key to understanding complex schematics is to break them down into their individual circuits. If you are troubleshooting a lift/lower problem, you don’t need to be looking at the cutting drive or steering circuits.

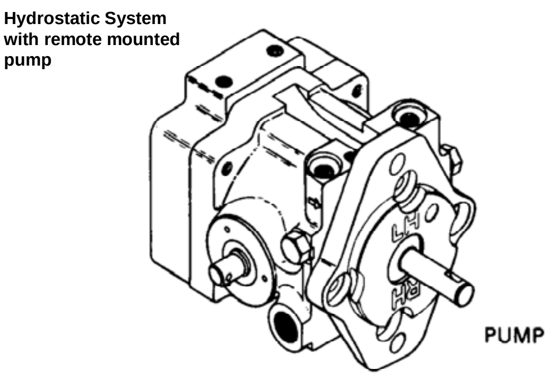
This schematic is from the Reelmaster 5200/5400-D Service Manual. As you can see, in the Service Manual, we provide a information on where the flows and pressures are in different modes of operation to make the schematic easier to understand. There is also usually a written explanation of the circuit operation in the Manual.

Hydrostatic Transmissions

There are three distinct types of hydrostatic drive systems currently used in turf mowing equipment.

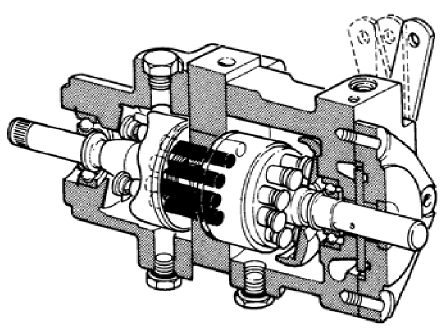
To begin to understand hydrostatic drive units, lets start by looking at the various types and configurations of hydrostatic transmissions.

Pump with Remote Wheel Motors



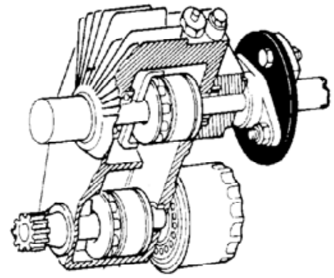
The first type is a hydrostatic system which consists of a hydrostatic pump with a remotely mounted motors. In this type of hydrostatic system the hydrostatic pump is mounted by, and driven by, the units engine. The pump is connected to the drive motor by hoses or steel lines. These motors can be mounted directly to the wheels or to a drive axle.

In-Line Pump and Motor



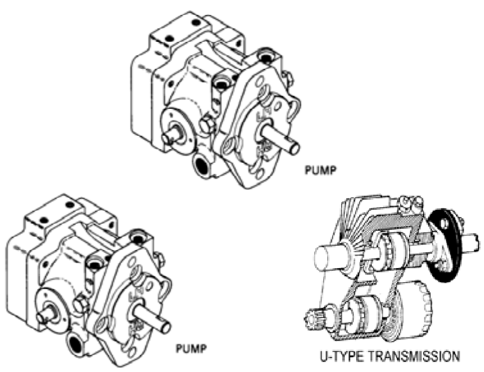
A different type of hydrostatic drive system is an inline pump and motor system. In this system the motor and pump are constructed as a single unit, this eliminates the necessity of high pressure drive lines between the pump and the motor. This unit is normally mounted to a drive axle or transaxle.

U-type Transmission



A similar version is the U-type transmission. In this type of system the pump and motor are constructed as a common component with the pump usually located above the motor.

Why Different Systems?



All three systems work well in their designed applications. The remote motor design works well when there is no transmission or transaxle, or when the location of the engine and the drive system call for such a configuration. The U type hydrostatic system is more compact while the inline hydrostatic system is usually easier to repair and maintain.

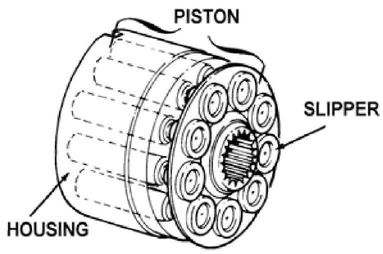
We will be using the inline hydrostatic pump and motor system in this session for illustration purposes.

A hydrostatic drive consists of a hydrostatic pump, which pumps oil to a drive motor. The most significant feature of a hydrostatic system is the pump. The pump is a variable displacement pump. This means that the output of the pump can be varied and is not controlled only by the engine RPM like a fixed displacement pump. This requires that the pump be a piston pump.

Components

Let’s look at the components that make up a complete hydrostatic drive system.

Piston Group Assembly

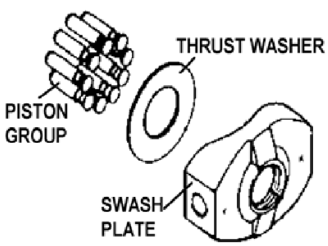


The pump consists of the following components:

Piston group assembly

This rotating piston group is mounted to the input shaft and is driven by the engine. It consists of a piston block with numerous precision machined bores which house the pump pistons. The small pump pistons consist of the piston and the piston slipper. The slipper is usually a brass or aluminum component which is connected to the piston and moves the pistons when the pump is operating.

Swash Plate

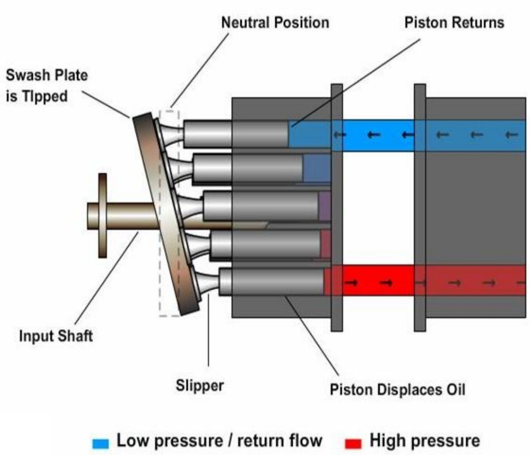


PISTON PUMP DETAIL

Swash plate

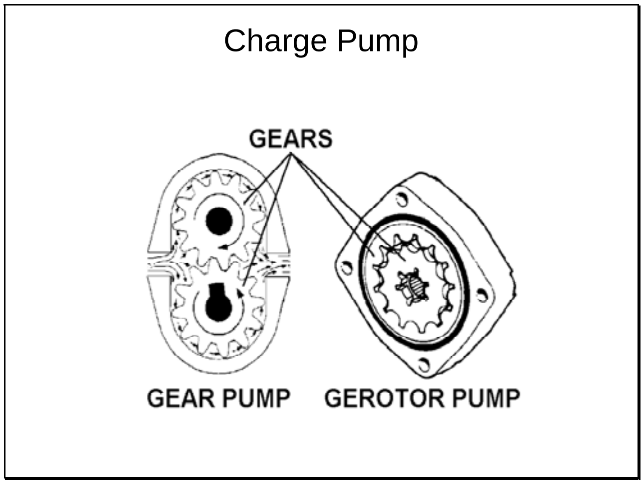
The piston slippers pivot and slide against a hardened washer called a thrust washer. The thrust washer is located in the swash plate. The swash plate pivots on two support pins and controls the pump output. As the operator moved the traction control pedal to increase travel speed the swash plate angle increases.

SWASH PLATE AND PISTON GROUP FUNCTION



Piston Group Operation

As the piston group spins the pistons are moved in and out of their bores and they pump oil. As we saw in the previous slides the quantity of the oil being pumped is controlled by the angle of the swash plate. As long as the swash plate is kept in the neutral position, no oil will be pumped. As the operator moves the traction control pedal the angle of the swash plate increases, this in turn increases the piston travel. As the piston travel increases the amount of oil pumped increases and the travel speed changes.



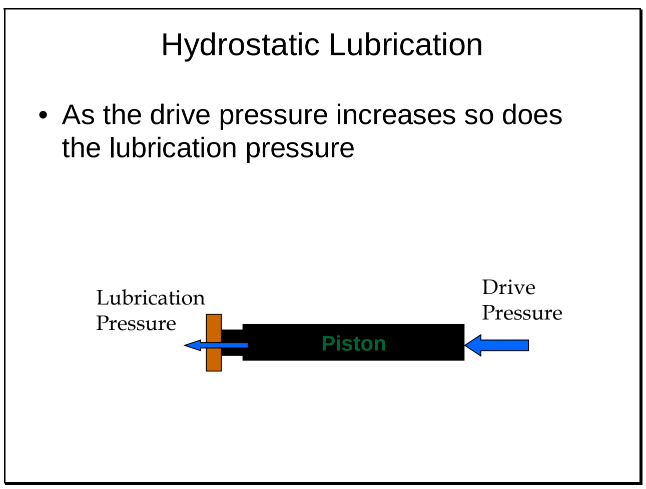
Charge pump

While the transmission is in operation there is a constant loss of oil (by design) within the components of the pump and motor. For example, holes in the end of each piston allow a small amount of oil to form a cushion between the slipper's face and the thrust washer. This oil must be continuously replenished. Built in to the system is pump called a charge pump. This pump can be a gear pump, or a gerotor pump. Both of these pumps are fixed displacement. Fixed displacement means that the pump's output is fixed by the RPM of the engine. It cannot be varied except by increasing or decreasing the speed of the engine. Excessive oil not required by the drive circuit opens the charge relief valve and flows back to the reservoir.

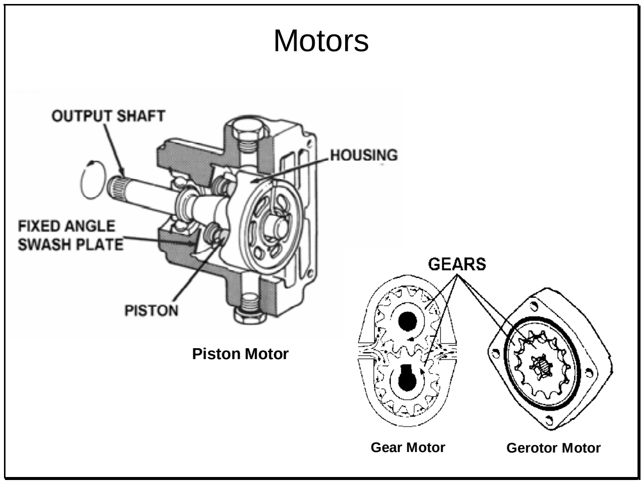
Charge Circuit

Oil is lost during use through designed in leakage areas.

- Replenishes lost oil used for:
- Cooling
- Lubrication

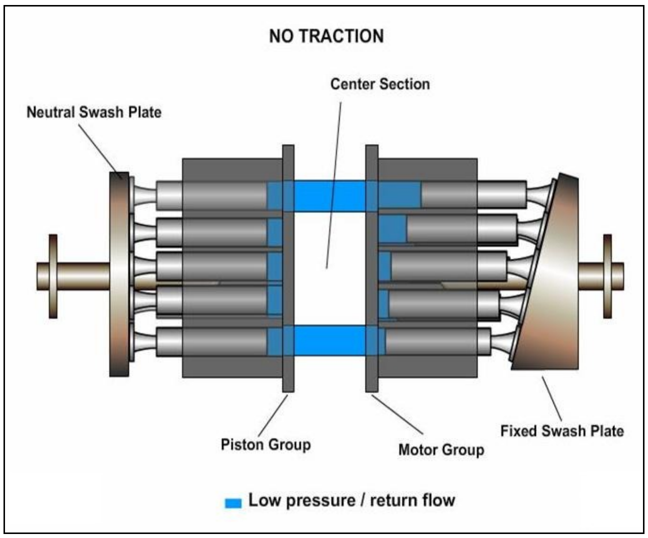


One piston is shown here illustrate the principle that the drive pressure increases so does the lubrication pressure for the piston slipper and swash plate surface.



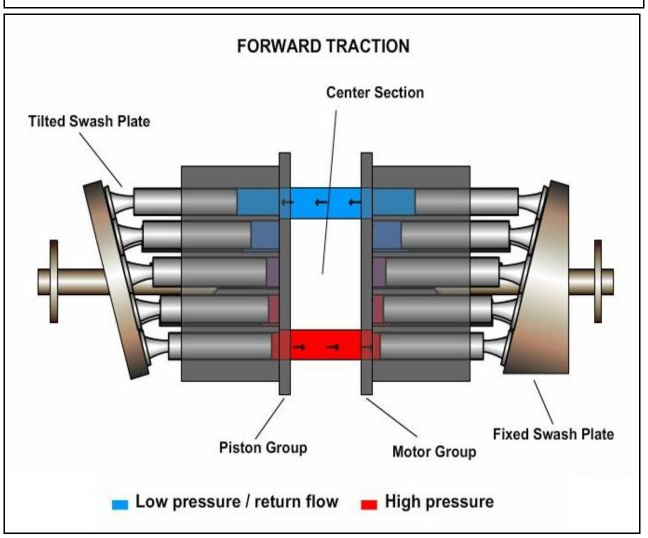
On a remote hydrostatic motor type system the hydrostatic motors can be a gear motor, gerotor motor or a piston type motor as shown here. On some designs a single motor is used to drive a differential transaxle. Another design uses individual motors for each wheel, either driving the wheels directly or through a planetary gear drive.

When the motor is built as part of the complete assembly like an inline or U type system the motor is a piston type motor very similar the piston pump except that the swash plate is usually a fixed swash plate. Being fixed the stroke of the pistons remain constant. The motor's speed of rotation can not be changed except by changing the volume of oil that it receives from the pump. Remember that a given column of oil will cause the motor to turn at a given speed. More oil will in-crease the motor speed. Less oil will slow it down.

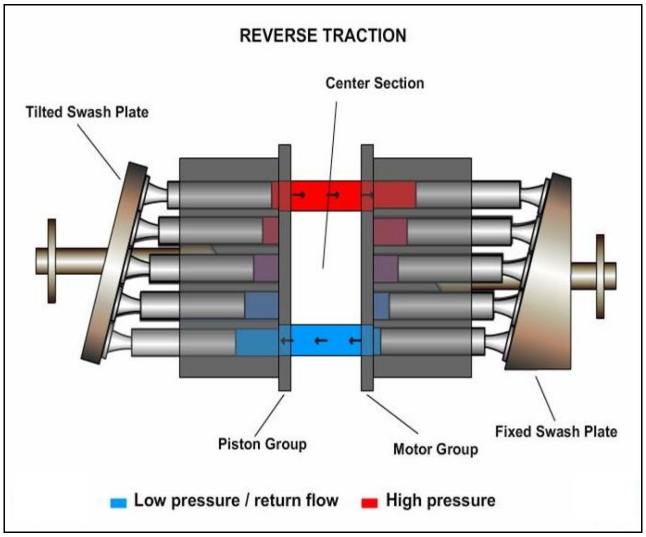


Overall Operation

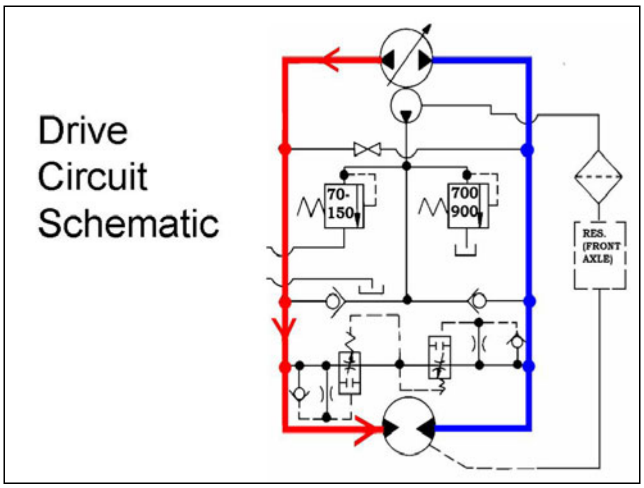
As the engine turns the pump rotating group, the pistons run on the swash plate which is in the neutral position. With the swash plate in neutral there is no movement of the pistons so no oil is being pumped.



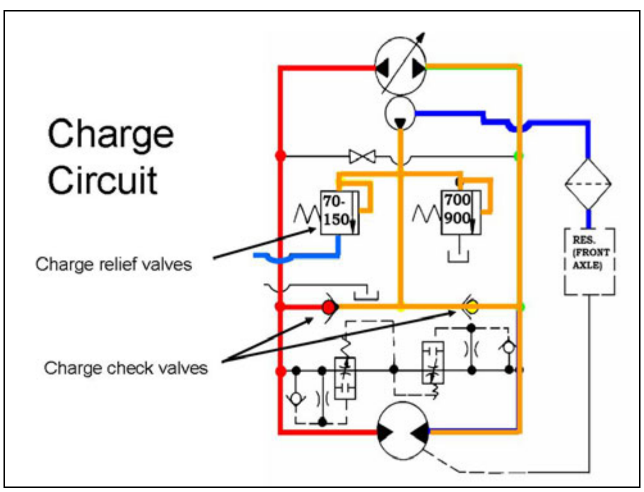
As the operator moves the traction control pedal the swash plate angle increases and the pump pistons begin to displace oil. This oil is directed to the pump section and the unit moves.



When the operator needs to change directions the traction pedal is moved back to the neutral position and than moved to the reverse position. In the reverse position the swash plate moves in the opposite direction as it did in the forward direction. In this position the oil is pumped to the opposite side of the motor and the unit moves in reverse.



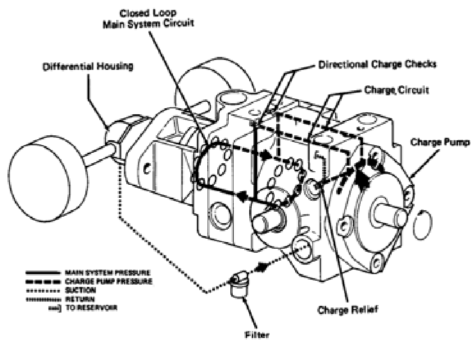
Here is the closed loop circuit of an inline hydrostatic transmission shown in a schematic view.



Directional charge checks

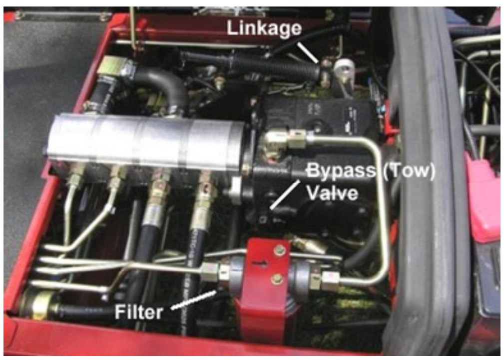
Directional charge check valves are incorporated into the charge circuit to direct the charge pump output to the low pressure side of the drive circuit. The oil will flow into the low pressure side to replace the oil lost through normal leakage. The oil in the high pressure side closes the remaining charge check valve so that no high pressure oil can bleed off into the charge circuit.

Charge Flow – GM300



Here is a view of the closed loop main circuit and charge circuit within the inline hydrostatic transmission from a Groundsmaster 300 Series.

Simple items often overlooked

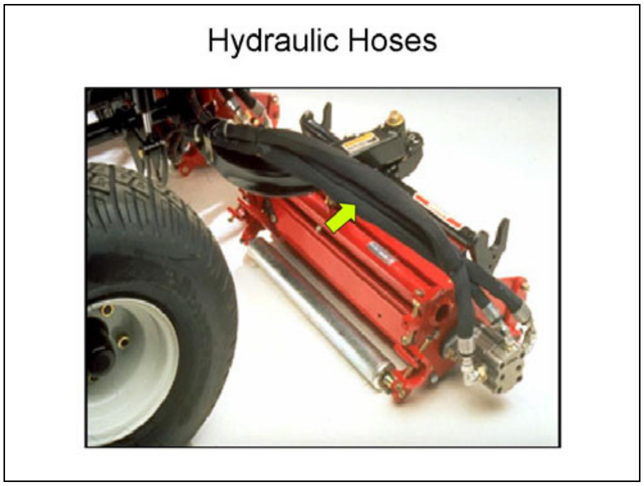


The hydrostatic transmission will provide trouble free operation if it is serviced and maintained properly. There are, however, a few simple items that are often overlooked when poor performance is evident.

1. The “ no-load” engine RPM. setting is too slow.
2. Worn, loose or misadjusted linkage is not posi-tioning the swash plate actuating arm far enough, even though the traction control pedal or hand lever is fully pushed.
3. The tow or bypass valve is partially open, letting oil bypass in the main system.
4. The hydraulic oil filter or inlet line is not tightened sufficiently; air is being drawn in past the filter seal into the charge pump, and then into the main circuit. Air in the hydraulic system will cause cavitation and damage the rotating components.

IMPORTANT: The “tow valve” is not to be used for towing long distances, but should be used only to get the machine out of the way or onto a trailer. Towing over a distance will cause the traction circuit to run out of oil because charge pump is not running.

Hydraulic Hoses and Fittings



Hydraulic Hoses

Hydraulic hoses are subject to extreme conditions such as, pressure differentials during operation and exposure to weather, sun, chemicals, high temperature operating conditions or mishandling during operation or storage. Hoses that move during operation are more susceptible to these conditions than others.

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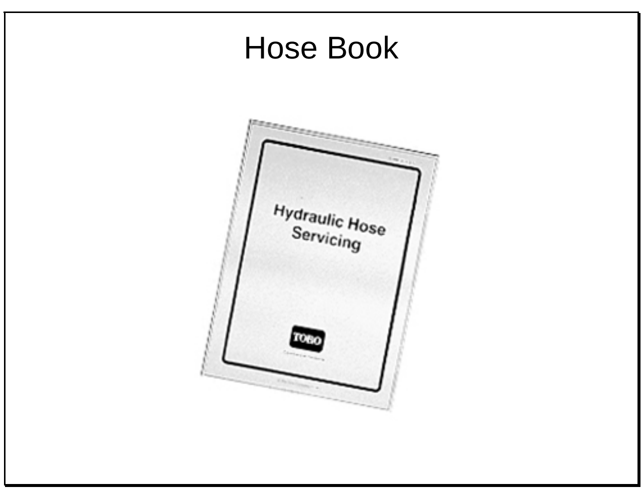
Before disconnecting or performing any work on a hydraulic system, all pressure in the system must be relieved by stopping the engine and lowering or supporting the implement.

Inspect hoses frequently for signs of deterioration or damage. Check hoses for leakage and replace when leaks are found.

Keep body and hands away from pin hole leaks or nozzles that eject hydraulic fluid under pressure. Use paper or cardboard, not hands, to search for leaks. Hydraulic fluid escaping under pressure can have sufficient force to penetrate the skin and do serious damage. If fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene may result.



When replacing a hydraulic hose, be sure that the hose is straight (not twisted) before tightening the fittings. This can be done by observing the imprint on the hose. Using two wrenches, hold the hose straight with one wrench and use the other wrench to tighten the hose swivel nut to the fitting. Use procedures shown in the Toro Hydraulic Hose Servicing Manual, Part No. 94813SL.

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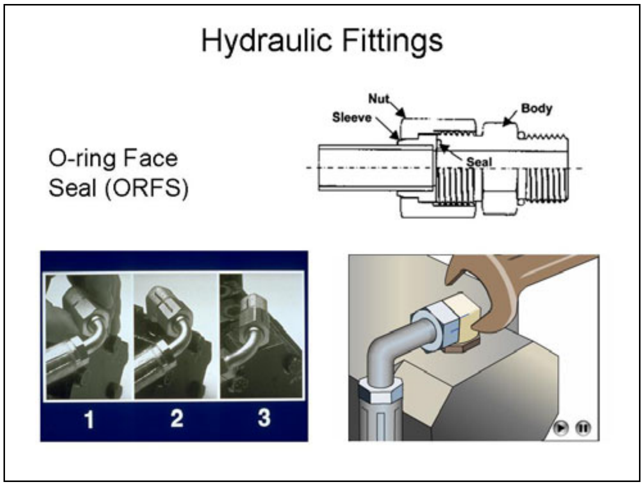
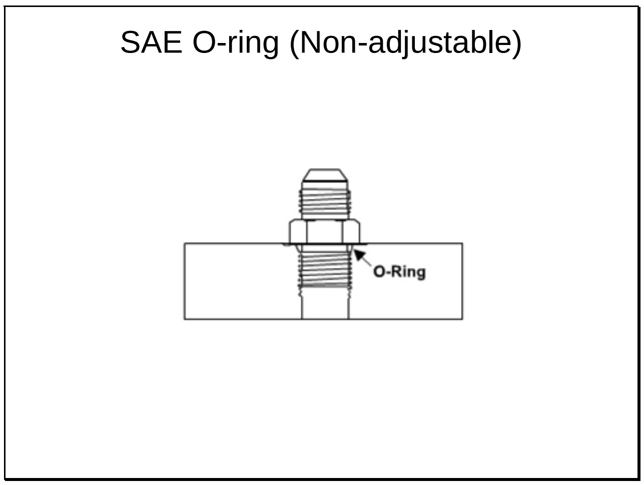


O-ring Face Seal (ORFS Fittings

Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material.

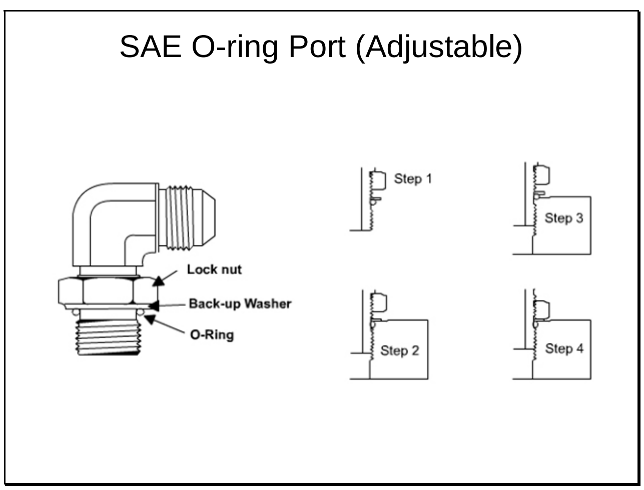
Make sure the O-ring is installed and properly seated in the groove. It is recommended that the O-ring be replaced any time the connection is opened.

Lubricate the O-ring with a light coating of oil.



SAE Straight thread O-ring Port Fittings (Non-Adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or any foreign material.
2. Always replace the O-ring seal when this type of fitting shows signs of leakage.
3. Lubricate the O-ring with a light coating of oil.
4. Install the fitting into the port and tighten it down until finger tight.
5. Tighten the fitting to the correct torque.



SAE Straight thread O-ring Port Fittings (Adjustable)

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches, or nay foreign material.
2. Always replace the O-ring seal when this type of fitting shows signs of leakage.
3. Lubricate the O-ring with a light coating of oil.
4. Turn back the jam nut as far as possible. Make sure the back up washer is not loose and is pushed up as far as possible (step 1).
5. Install the fitting into the port and tighten finger tight until the washer contacts the face of the port (step 2).
6. To put the fitting in the desired position, unscrew it by the required amount, but no more than one full turn (step 3).
7. Hold the fitting in the desired position with a wrench and turn the jam nut with another wrench to the correct torque (step 4).

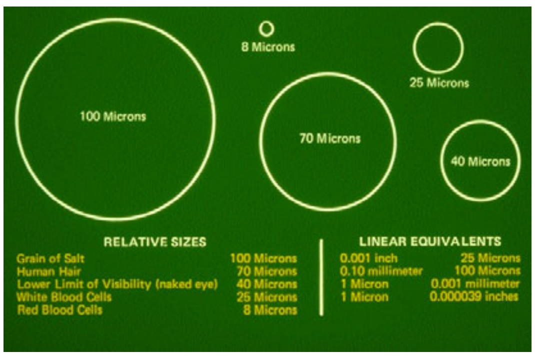
O-Ring Kit

O-ring Kit

O-ring face seal connections on Toro equipment require the use of special 90 Durometer O-rings. Toro recommends that the O-rings need to be re-placed whenever a connection is loosened. An O-ring kit is available containing quantities of O-rings for both face seal and port seal connections used in Toro equipment.

O-ring Kit: P/N **16-3799**

Relative Size of Particles



The most important rule of hydraulic system maintenance is
KEEP EVERYTHING CLEAN !

Removing Hydraulic System Components

1. Thoroughly clean the machine before disconnecting, removing or disassembling any hydraulic components. Always keep in mind the need for cleanliness when working on hydraulic equipment.
2. Put caps or plugs on any hydraulic lines or fitting left open or exposed.
3. Put labels on disconnected hydraulic lines and hoses for proper installation after repairs are completed.

After Repair or Replacement

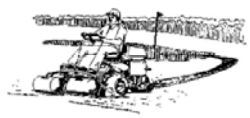
After Repair or Replacement of Components

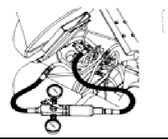
1. Check oil level in hydraulic reservoir and add correct oil if necessary.
IMPORTANT: Drain and refill hydraulic system reservoir and change oil filter if component failure was severe or system is contaminated. If there is a severe failure in a closed loop system, flush all lines and components in the system.
2. After repairs, check the control linkage for proper adjustment, binding or broken parts.
3. After disconnecting or replacing components, operate the machine functions slowly until the air is out of the system.
4. Check for hydraulic leaks. Shut off the engine and correct leaks if necessary. Check oil level in the reservoir and add the correct oil if necessary.

Hydraulic Testing

Hydraulic Troubleshooting

- Know the system
- Talk to the operator
- Operate the machine
- Inspect the machine
- List possible causes
- Determine most likely cause
- Test your findings





When troubleshooting a hydraulic problem:

1. Know the hydraulic system for the machine:
Study the schematics, Operators Manual and Service Manual.
Know how the system works and what the relief valve setting and the pump output should be.

2. Talk to the operator:
How did the machine act just as it started to malfunction?
Was any “do-it-yourself” service performed or did anyone else attempt to repair the machine?
How was the machine used and when was maintenance last performed?

3. Operate the machine:
Operate the machine in conditions simulating when the malfunction occurred. Verify what the operator described.
Are the gauges and warning lights operating correctly.
Do the controls feel spongy or stick.
Check for any unusual sounds, smells, or smoke. At what speed or operating cycles does this occur.

4. Inspect the machine:
Check the hydraulic fluid level and condition. Is the fluid dirty or filters plugged?
Check for overheating. Does the oil have a burnt odor? Is the oil cooler plugged or lines caked with dirt?
Look for bent or collapsed fluid lines. Check for leaks, loose fasteners, cracked welds, binding pivot points, damaged linkage, etc.

5. List possible causes:
Note what was reported by the operator and verified by you.
List what you found during your inspection.
Remember that there may be more than one cause leading to the failure or malfunction.

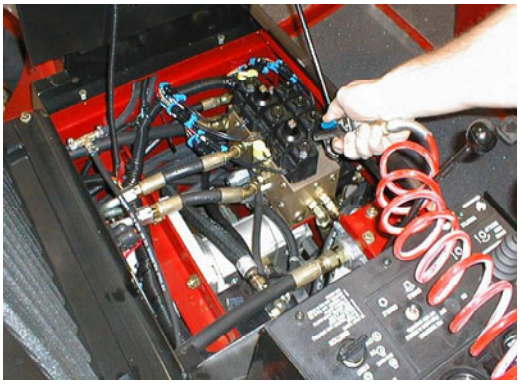
6. Determine which cause is most likely the problem:
Look at your list of most possible causes and determine which are the most likely. Use the troubleshooting charts in the Service Manual.

7. Test your findings
Operate the machine with a hydraulic tester connected to the suspected malfunctioning circuit. It may be necessary to replace or adjust a component to verify your findings.

Before Performing Hydraulic Tests

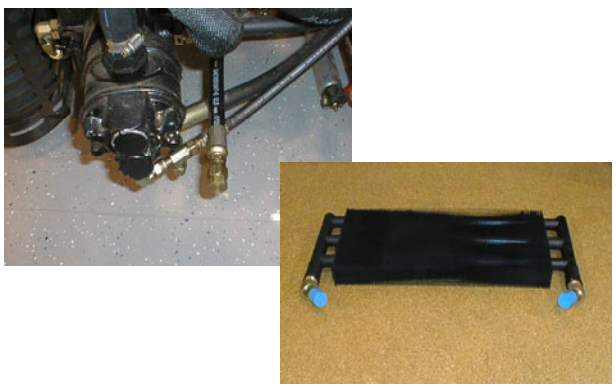
ALL OBVIOUS AREAS SUCH AS OIL SUPPLY, FILTERS, IMPROPER ADJUSTMENT BINDING LINKAGE, OR LOOSE FASTENERS MUST BE CHECKED BEFORE ASSUMING THAT A HYDRAULIC COMPONENT IS THE SOURCE OF THE PROBLEM BEING EXPERIENCED.

Cleaning



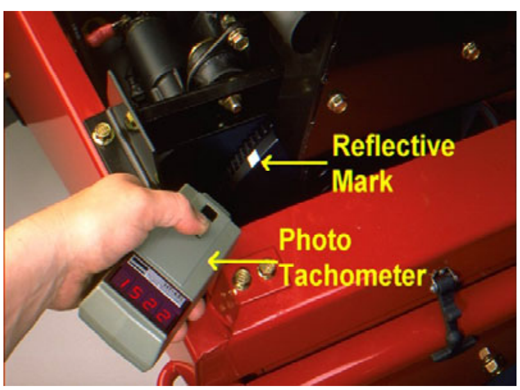
Thoroughly clean the machine before disconnecting or disassembling any hydraulic components. Always keep in mind the need for cleanliness when working on hydraulic equipment.

Caps and Plugs



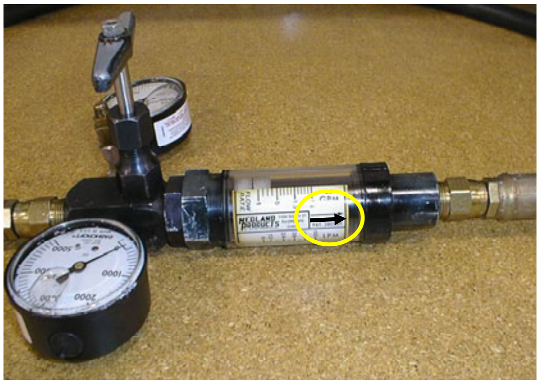
Put caps or plugs on any hydraulic lines left open or exposed during testing or removal of components.

Verify Engine RPM



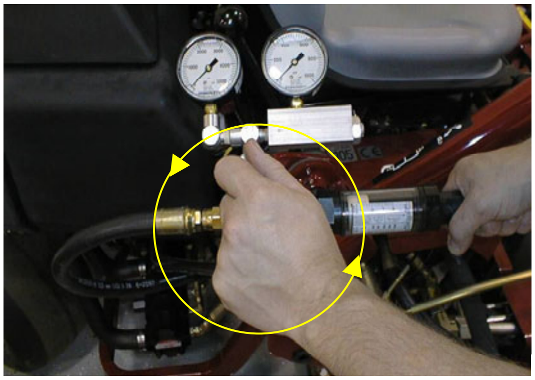
The engine must be in good operating condition. Always use a tachometer when doing a hydraulic test. ENGINE SPEED WILL AFFECT THE ACCURACY OF THE TESTER READINGS.

Flow Tester - Install in Series with Circuit Being Tested



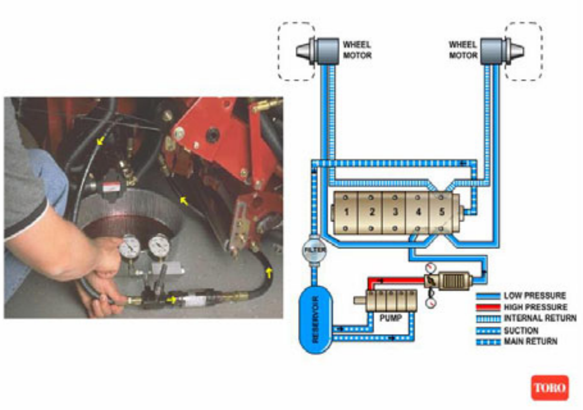
To prevent damage to the tester or components, the inlet and outlet hoses must be properly connected and not reversed (tester with pressure and flow capabilities).

Make Sure Restrictor Valve is Open Before Starting the Engine



To minimize the possibility of damaging the components, completely open the load valve by turning it counter clockwise (tester with pressure and flow capabilities).

Pump Flow Test



This is an example of a pump flow test. This test is also known as a pump efficiency test.

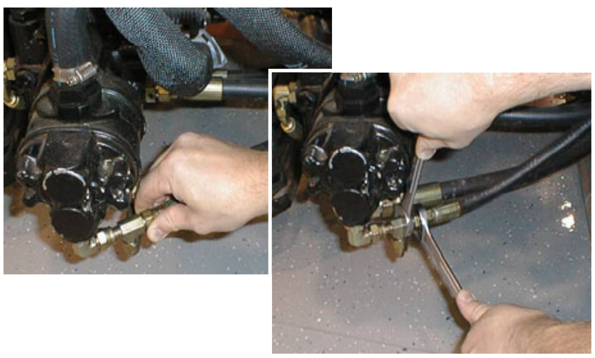
Note how the tester is connected in series between the outlet of the pump and the inlet of control valve. The pump is a positive displacement gear pump, and the tester is installed before the relief valve, so we must make certain the restrictor valve is open before starting the engine.

Positive Displacement Pump

- A positive displacement pump
  Must Pump Oil!
- Fully restricting oil can damage pump

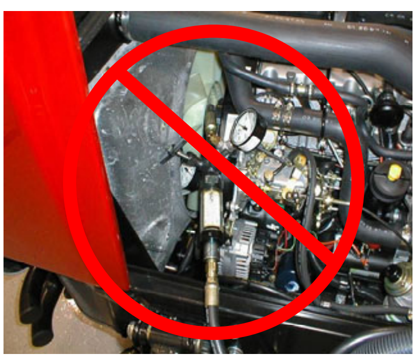
IMPORTANT: Pumps used on Toro equipment are of a positive displacement type. If a tester is installed in a portion of the circuit not protected by a relief valve and the pumps output flow is completely restricted or stopped, damage to the pump or other components could occur.

Tighten Fittings



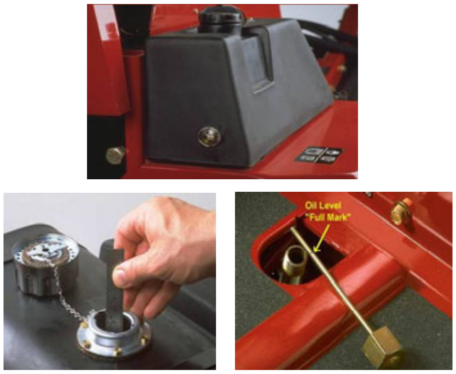
Install fittings finger tight, far enough to insure that they are not cross-threaded, before tightening them with a wrench.

Safety



Position the tester hoses so that rotating machine parts will not make contact with them and result in hose damage.

Check Oil Level Before Testing



Check the oil level in the reservoir.

Check Linkage

Check the control linkage for improper adjustment, binding or broken parts.

Check Suction Hose

All hydraulic test should be made with the hydraulic system at normal operating temperature. Check for soft or collapsed suction hose.

Nobody Plans for an Injury

Always keep safety in mind while performing tests. Keep bystanders away from the equipment.

Pressure Testing Kit
TOR47009

Hydraulic test equipment allows you to observe the amount of oil pressure and oil flow in a circuit under various conditions.

Hydraulic testers may vary significantly in size, construction, accuracy, and cost. The decision as to which tester to purchase should be influenced by what type of tests will be performed on all the hydraulically powered equipment in the shop.

High And Low Pressure Test Gauges

Low pressure gauge 1000 PSI, high pressure gauges 5000 PSI and 10000 PSI, and associated hoses and fittings.

Use gauges of proper pressure ratings when performing hydraulic tests. Find the specified pressure for the circuit being tested then select a gauge that will measure the pressure in the middle part of its range. This will give the most accurate reading and prevent possible damage to the gauge.

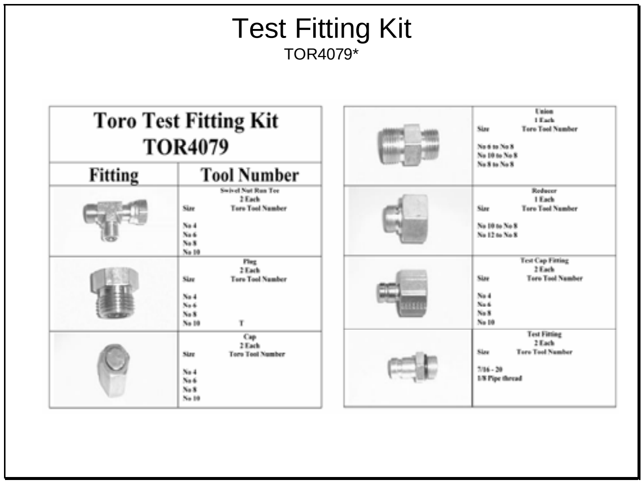
Flow Tester
TOR214678

Hydraulic Tester (With Pressure and Flow Capabilities)

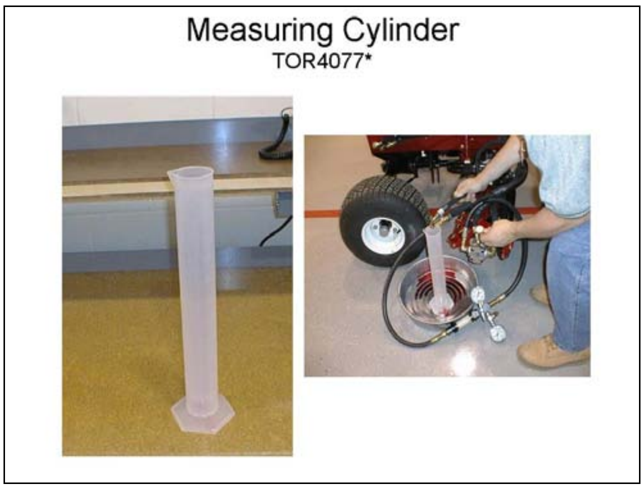
1. INLET HOSE: Hose connected from the system circuit to the inlet side of the tester.
2. LOAD VALVE: If required, upon turning the valve to restrict flow, a simulated working load is created in the circuit.
3. LOW PRESSURE GAUGE: Low range gauge to provide accurate readings at low pressure, 0-1000 PSI.
This gauge has a protector valve which cuts out when pressure is about to exceed the normal range for the gauge. The cutout pressure is adjustable.
4. HIGH PRESSURE GAUGE: High range gauge to accommodate pressure beyond the capacity of the low pressure gauge, 0 - 5000 PSI.
5. FLOW METER: This meter measures actual oil flow in the operating circuit. The reading is given in gallons per minute (GPM) with a gauge rated at 15 GPM.
6. OUTLET HOSE: Hose from the outlet side of the hydraulic tester to be connected the hydraulic circuit.

Optional Flow Tester

Higher capacity flow meters are also available from various sources. This particular one has 600 and 5000 PSI pressure gauges, a 10 GPM flow meter and a temperature gauge.

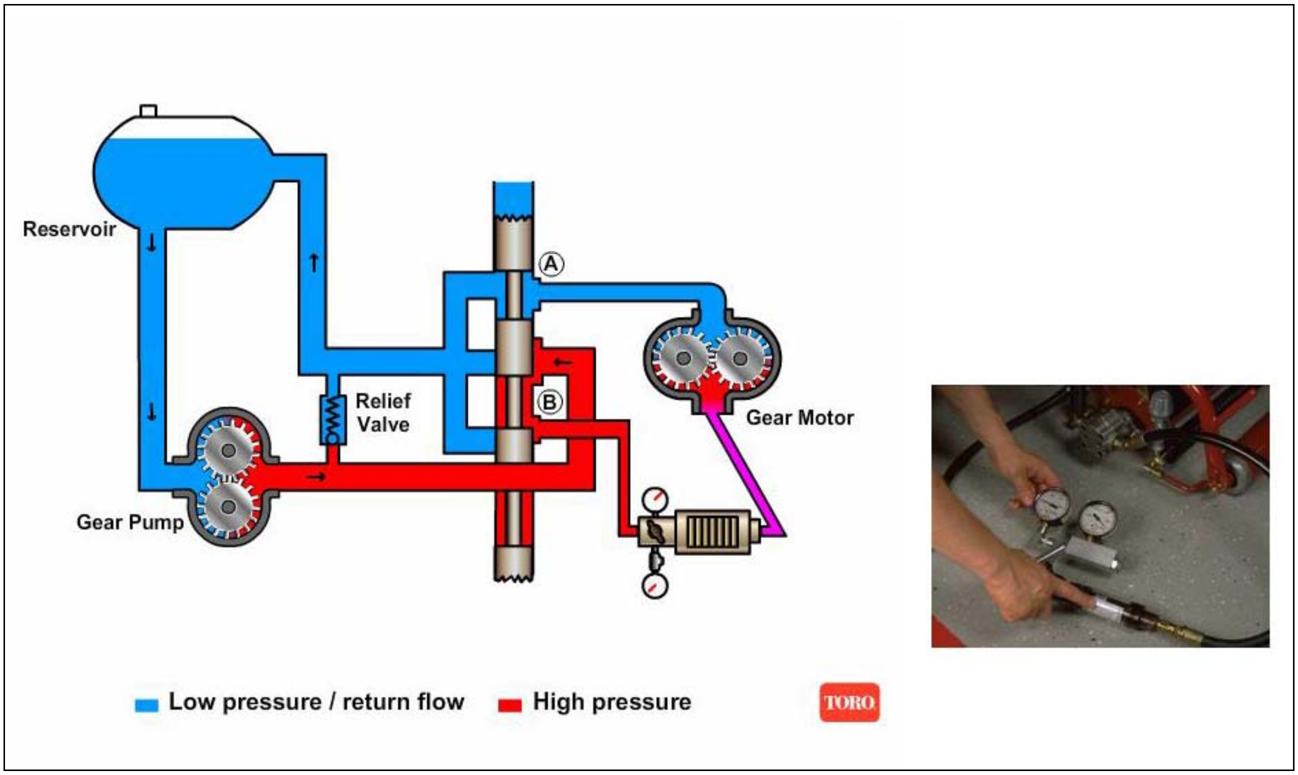


This fitting kit allows you to adapt the pressure gauges and flow meter to the hydraulic systems of various Toro equipment.



This measuring cylinder is used to measure flow on very low flow circuits. An example is measuring the flow from the case drain line of a hydraulic motor to test for motor efficiency.

Testing Examples



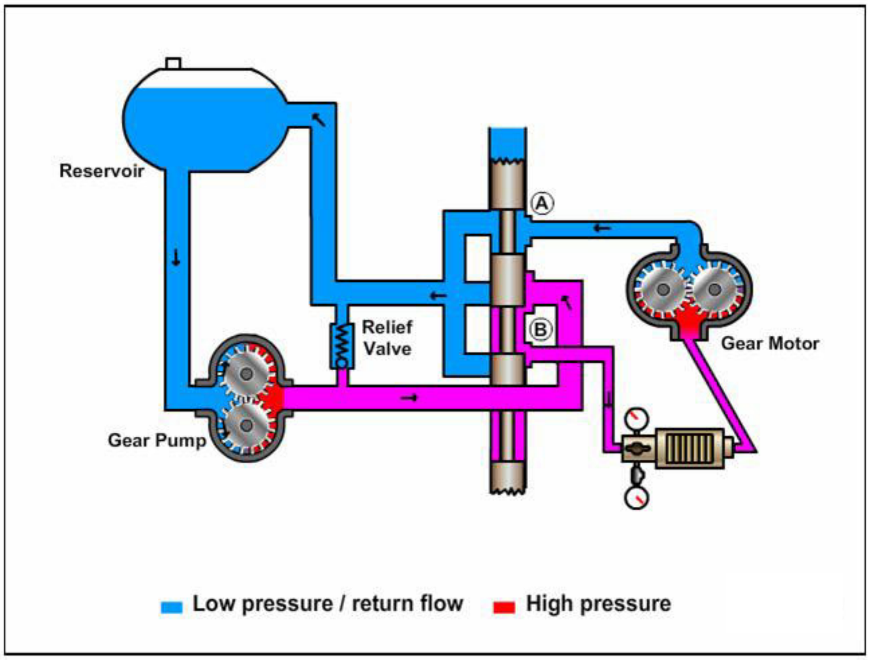
TESTER HOOK-UP NO. 1

TEST A: Flow to Motor

It is best to perform hydraulic tests at the location, where the work is being done. In this example, the complaint may be "cutting unit running slowly". With the control valve in the run position, and the flow meter in series, between the control valve and the motor, we can put a load on the circuit by closing the restrictor valve, until a specified pressure is reached.

If this flow reading is low or the specified pressure cannot be reached, it is likely the motor is ok, and the problem is the pump or valve. We would then perform a pump flow test which will be covered in HOOK up NO. 2, shown on the following pages.

If the flow reading and working pressure is ok, we should suspect the motor is worn, or damaged. If the motor has a case drain hose, we would need to use a different hook up which will be covered in HOOK up NO. 3, on the following pages. If the motor does not have a case drain hose, we would use the same hook up, and perform TEST B, detailed next.

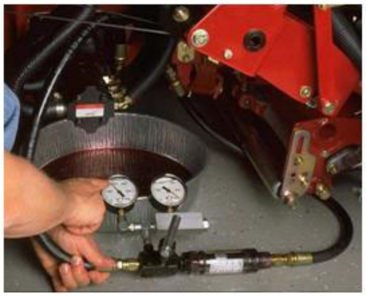


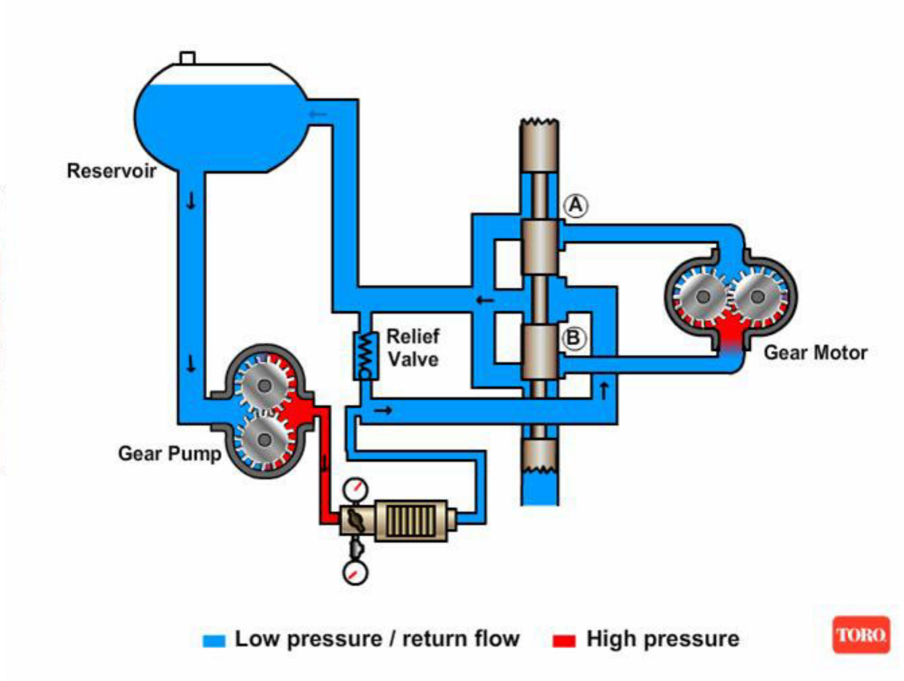
Here we have put a stick into the cutting reel to prevent the reel motor from turning.

TESTER HOOK-UP NO. 1

TEST B: Motor Efficiency (motor with no case drain)

If the specified flow and working pressure in TEST A is ok, we can lock the motor to prevent rotation. There should be no flow through the motor and this should be indicated by the flow meter. If there is flow, and it is above an acceptable level, this indicates leakage through the motor.

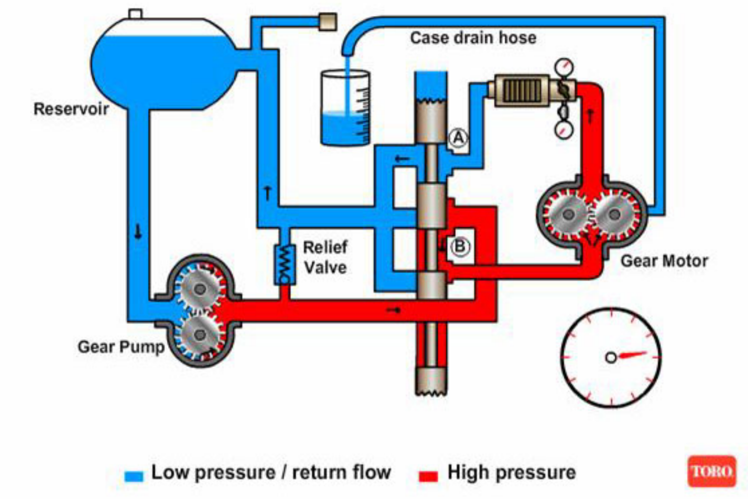




TESTER HOOK-UP NO. 2

Pump Flow Test, also known as Pump Efficiency

Connect the tester in series between the pump outlet and control valve. With the valve in the neutral (off) position, we can measure the pump output to ensure that the working pressure and flow is adequate to drive the motor at the desired speed. Use extreme caution when using this procedure; there is no relief valve, between the pump and the restrictor valve when tested in this manner. Be absolutely sure the flow meter is open when starting the engine. If the reading from Test Hook Up No. 1 is below specification, and for this test, Hook Up 2, the reading is ok, we can then suspect the relief valve or control valve as being the problem.



TESTER HOOK-UP NO. 3

Motor Efficiency (motor with case drain)

With the control valve in the run position, and the flow meter in series between the outlet side of the motor and the valve, we can measure motor efficiency. Disconnect the small diameter case drain hose. Use the restrictor valve on the flow tester, to restrict flow coming out of the motor, then measure the flow coming out of the case drain hose into a graduated container. (Oil must be at operating temperature for a valid test). Measure how much oil goes into the container for 15 seconds, then multiply that result by 4, to get a flow measurement in Gallons per minute, or Liters per minute. Too high a flow, indicates an inefficient, worn or damaged motor.

Notes:

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