

# **HWH CORPORATION**

## **INTRODUCTION TO HYDRAULICS**

This document has been designed for HWH Products exclusively. Statements and descriptions may or may not be applicable to other brands of hydraulics.

This publication has been set up as a study guide. Key topics are highlighted in red. If you do not understand these concepts contact HWH Tech services.

## **Introduction**

The objectives covered are listed at the beginning of each chapter.

CHAPTER 1	INTRODUCTION TO HYDRAULICS . . . . .	1-1
CHAPTER 2	HYDRAULIC SYSTEM COMPONENTS . . . . .	2-1
CHAPTER 3	BASIC INFORMATION FOR PERFORMING HYDRAULIC SYSTEM MAINTENANCE. . . . .	3-1
CHAPTER 4	TROUBLESHOOTING . . . . .	4-1
<b>Glossary of Hydraulic Terms . . . . .</b>		<b>e</b>

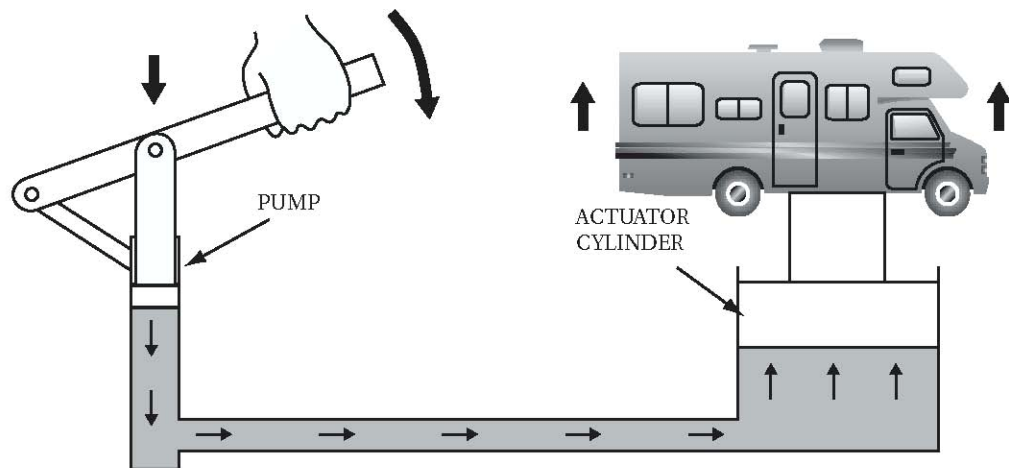
# Chapter

# 1

## Introduction to Hydraulics

### 1-1 Introduction and Overview

Hydraulics are used in many types of industry, from transportation to food processing. Applications vary from machines that are required to do heavy lifting to stopping vehicles. One reason for using hydraulics is that you can gain tremendous mechanical advantage. For example, with little effort on a jack handle, we can raise a large recreation vehicle, as shown in Figure 1-1. Another advantage of the hydraulic system is that it permits control from another location from where the work is performed. Similar to an electrical switch, a control in the hydraulic system can be activated to have the pump apply pressure to the system, while the work is conducted at another location, such as the slide out mechanism of an RV's expandable room. Hydraulics have the advantage over an air operated system, because **AIR IS HIGHLY COMPRESSIBLE WHERE FLUIDS HAVE A VERY LOW COMPRESSIBILITY.** Therefore, forces and motion are more easily controlled.



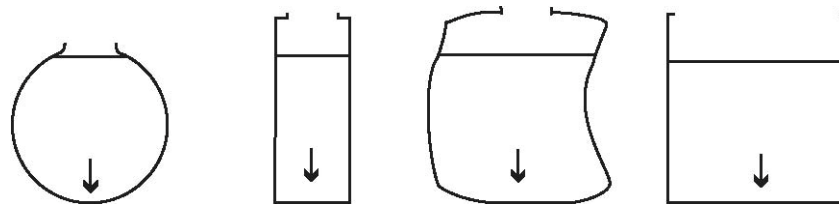
**Figure 1-1** *A Basic Hydraulic System*

Regardless of the industry or the application, if you are involved in the maintenance of hydraulic equipment or systems, it is very important that you have an understanding of how the components in the systems operate and the hydraulic principles that make them function. Leveling systems, brakes and slide-out rooms are just some of the RV systems that utilize hydraulics.

## 1-2 Basic Principles

### 1-2.1 Physical Laws

1. **STATIC PRESSURE EXERTED BY A COLUMN OF FLUID IS PROPORTIONAL TO THE HEIGHT OF THE TOP OF THE FLUID AND IS NOT AFFECTED BY ITS VOLUME, AS ILLUSTRATED IN FIGURE 1-2.** If we have different shaped containers, as shown, the pressure at the bottom of the containers will be the same, as long as the height of the fluid in the containers is the same. This is true regardless of the shape or volume of the container.



equal height of fluid in a container will give equal pressure at the bottom of the container regardless of the shape of the container

Figure 1-2 Static Pressure.

2. Fluids (liquids) are relatively incompressible. While air can be compressed, fluid can only be compressed a very small amount.

3. **PASCALS LAW SIMPLY STATED, IS: “PRESSURE IN AN ENCLOSED CONTAINER IS TRANSMITTED EQUALLY AND UNDIMINISHED TO ALL PARTS OF THE CONTAINER AND ACTS AT RIGHT ANGLES TO THE ENCLOSING WALLS.”** This is demonstrated in Figure 1-3. This is an important law and will be discussed in more detail later in this book.

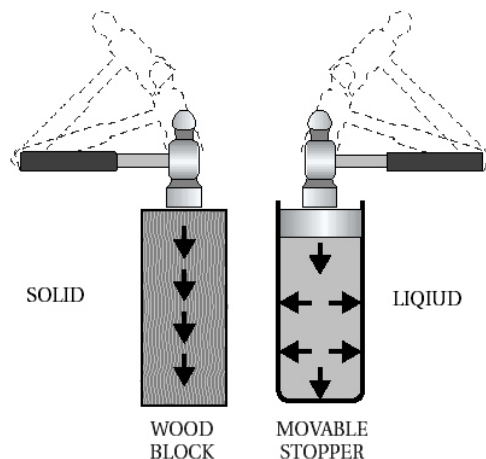
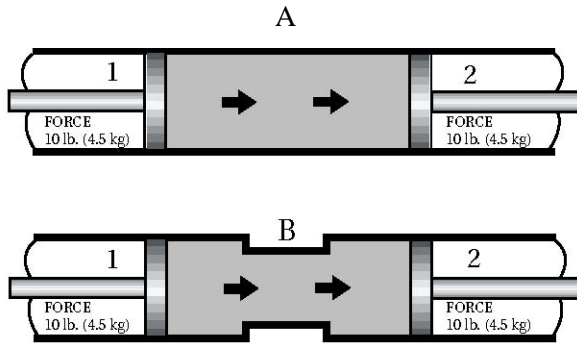


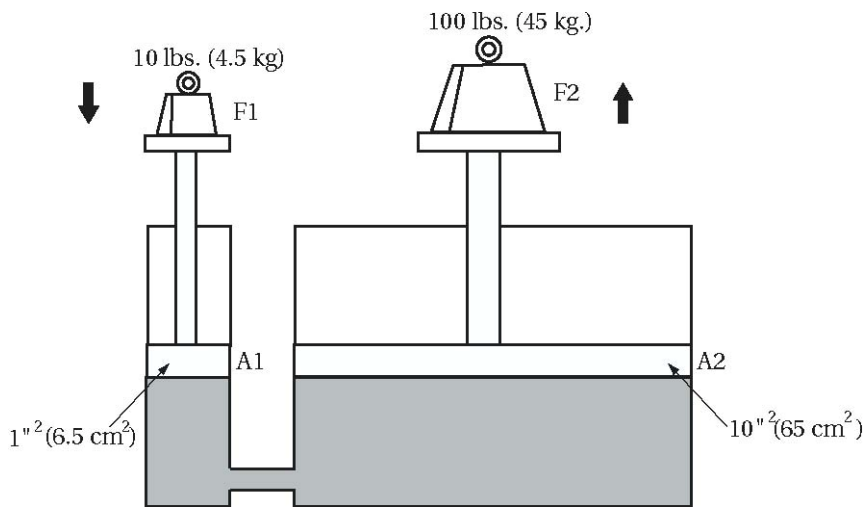
Figure 1-3 Pascal's Law

4. Transmission of force is a little more complicated, but stated as simply as possible, **UNDER STATIC CONDITIONS TWO LARGE CHAMBERS CONNECTED BY A SMALL LINE WILL HAVE THE SAME PRESSURE IN BOTH CHAMBERS.**



**Figure 1-4** *Transmission of Force*

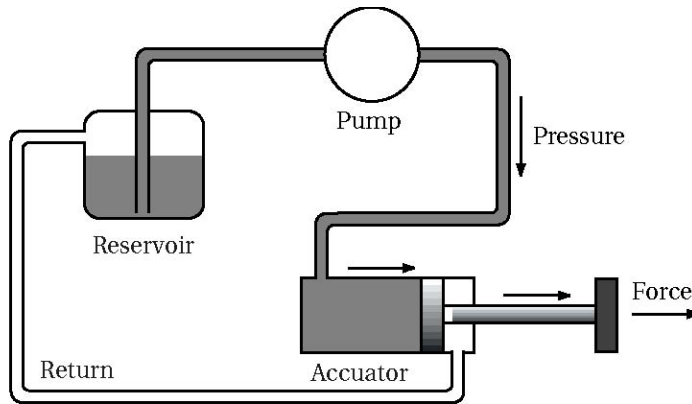
5. Mechanical advantage is demonstrated in Figure 1-5 and as stated earlier, is one of the main reasons for the use of hydraulics. **A FORCE OF 10 LBS. (4.5KG). (F1) IS BEING APPLIED TO A 1 SQUARE INCH PISTON (6.5CM<sup>2</sup>) (A1). THE FLUID PRESSURE OF 10 POUNDS PER SQUARE INCH (PSI) (69KPA) IN THE ENCLOSED SYSTEM IS THE SAME THROUGHOUT THE ENCLOSED SYSTEM.** (Pascal’s Law) Piston A2 is 10 square inches (65cm<sup>2</sup>), therefore, 10 PSI x 10sq. inches = 100 lbs. of force (69kPa x 65cm<sup>2</sup> = 45kg) at F2. We will show how the math is done later. The main thing here is to realize that we applied or “put in” a force of 10 lbs. (4.5kg) and received or “got out” a force of 100 lbs. (45kg). This is the mechanical advantage and basically explains how a hydraulic jack works.



**Figure 1-5** *Mechanical Advantage*

### 1-2.2 Hydraulics Terminology

A **force** is a push or pull that is exerted on an object in order to change its position or direction of movement, as shown in Figure 1-6. In a hydraulic system, force must be present at all times for the system to function. Force can be calculated by multiplying the area times the pressure.



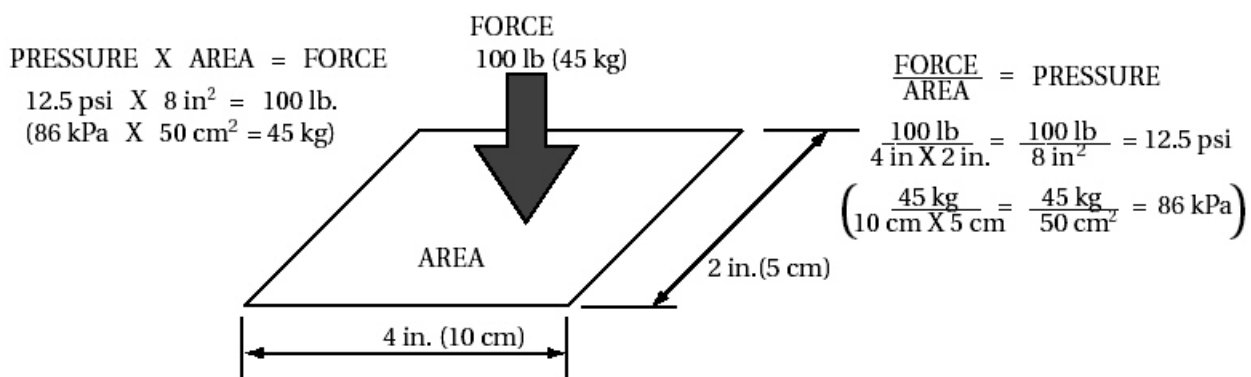
**Figure 1-6** Force in a Hydraulic System

The **weight** of an object or substance is the result of the gravitational force or pull on the object. Weight is always a downward factor, and in a hydraulic system, the fluid in the reservoir, in the lines, or in any of the system components, have weight.

**Mass** is a factor common to all objects or substances. Mass represents the amount of matter in an object, and its inertia or resistance to movement. The mass of an object determines how much force is required to start, stop or change the movement of an object. The greater its mass, the more force is required to overcome its inertia.

**Specific gravity** is the density or mass of a liquid. The specific gravity (SG) of a liquid is also its weight as compared to the weight of water in the same amount and at the same temperature. The SG of water is 1.0, while petroleum-based hydraulic fluids have a SG of about 0.78, other types of hydraulic fluids may have a SG of 1.42. Although the SG of a fluid is usually not functionally important, it can be useful to help determine the type of hydraulic fluid present in a system.

**Pressure** is determined by dividing the force (in pounds) exerted on an object or a substance by the area (in square inches) over which the force is exerted, see Figure 1-7. Although pressures are measured and specified in different ways, the use of pounds per square inch (PSI) kilopascals (kPa) is the most common. PSI always refers to the fluid pressure in a hydraulic system. Force can also be calculated by multiplying the pressure times the area.



**Figure 1-7** Determining Pressure

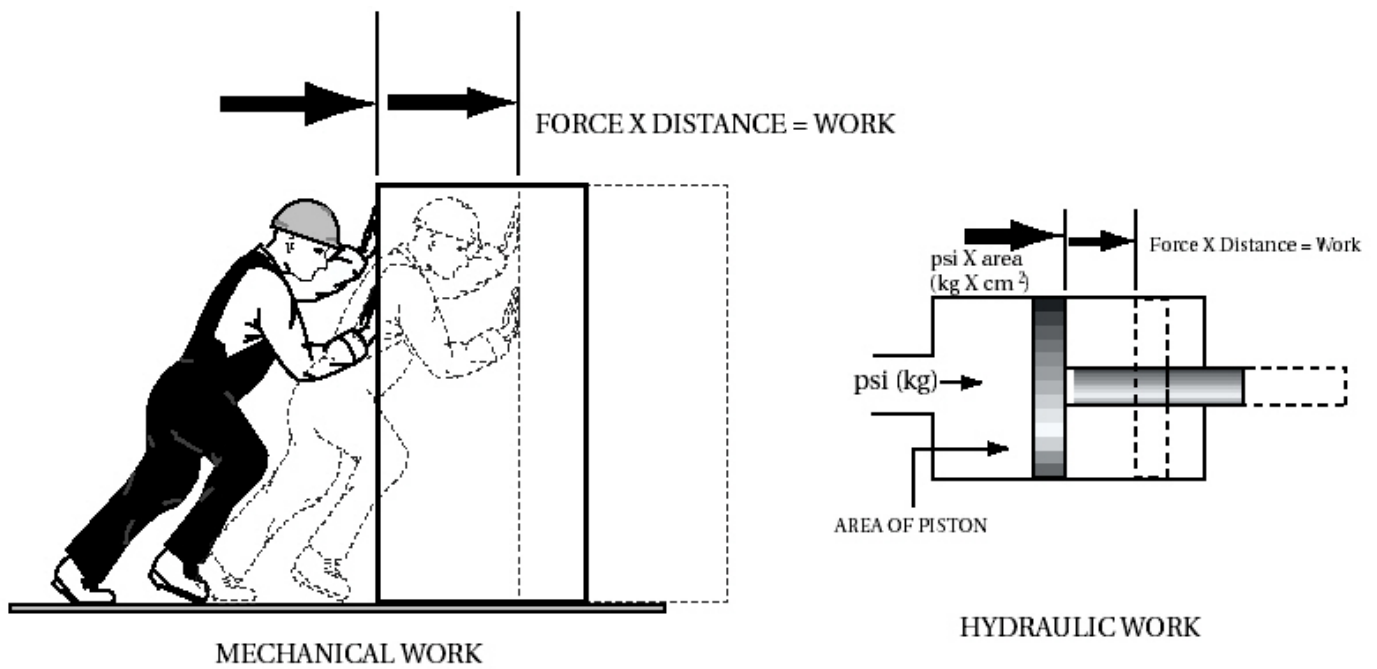
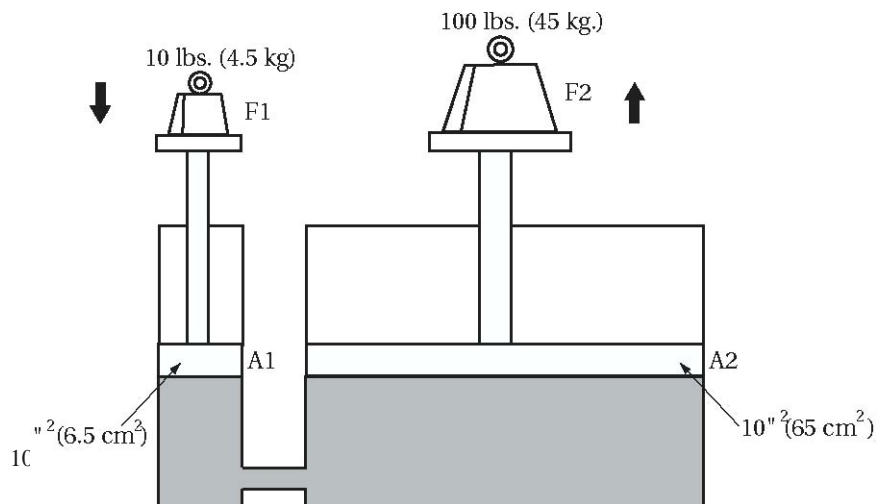


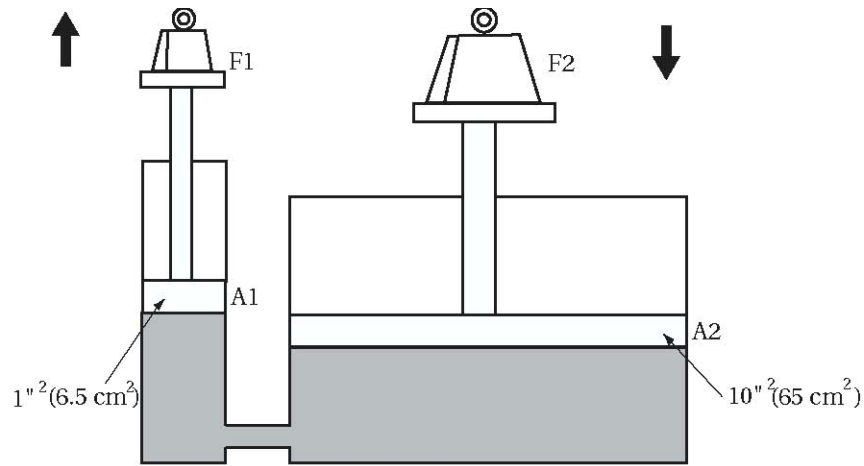
Figure 1-8 Mechanical vs. Hydraulic Work

**WORK TAKES PLACE WHEN A FORCE (IN POUNDS) IS MOVED THROUGH A DISTANCE (IN FEET). THE AMOUNT OF WORK DONE IS EXPRESSED IN FOOT-POUNDS.**

Earlier, we talked about mechanical advantage. It has a relationship with work, as shown in Figure 1-9. We put in 10 pounds (4.5 kg) of force and got out 100 pounds (45 kg) of force. That was great, but we all know you can't get something for nothing. We had to give up something to gain the mechanical advantage. In this case, we gave up speed and distance. Let's just consider the distance part. If we move the 1 square inch piston down 1 inch, 1 cubic inch of fluid (16cc) will be pushed into the A2 side of the system. Piston A2 is 10 square inches (65cm<sup>2</sup>). Therefore, if we spread that 1 cubic inch (16cc) out over 10 square inches (65cm<sup>2</sup>), we see that piston A2 will move up 1/10th of an inch (.25cm) (1 in<sup>3</sup> ÷ 10 in<sup>2</sup> = 0.1 in (16 cc ÷ 65 cm<sup>2</sup> = 0.25 cm)). We gained force, but we gave up distance. Now, think of the jack again. We move the jack handle a greater distance than the object we are lifting moves up. That is where the speed comes in. We have to move the handle further and faster to lift the heavier object a reasonable distance. If we reversed the process and applied the 100 pounds of force to F2 we would only get 10 pounds of force out, but the speed and distance of piston A1 would be huge. Now you can see how we can move objects by working small pistons versus large ones.







**Figure 1-9** Mechanical Advantage/Work Relationship

**POWER IS DEFINED AS AN AMOUNT OF WORK (FOOT-POUNDS) DONE IN A GIVEN AMOUNT OF TIME (SECONDS OR MINUTES).** In order to get some meaning from the term power, it must be compared with some unit of measure. The common unit of measure for power is the horsepower, which is expressed as follows:

$$1 \text{ Horsepower} = 33,000 \text{ foot-pounds/one minute}$$

or

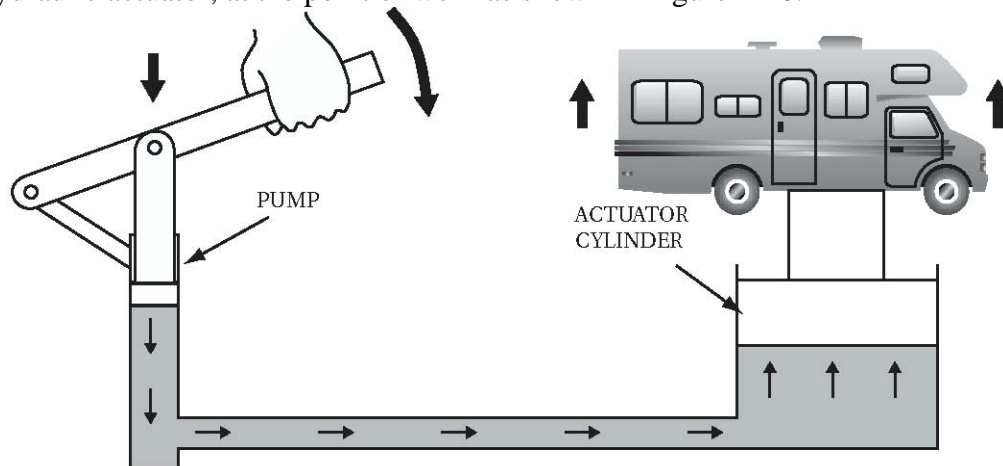
$$1 \text{ Horsepower} = 550 \text{ foot-pounds/one second}$$

**ENERGY IS THE CAPACITY FOR DOING WORK.** There are several types of energy used in hydraulic systems, including:

- Electrical Energy - to operate the pump motor.
- Hydraulic Energy - produced by the pump.
- Kinetic Energy - produced when the hydraulic fluid moves a piston in a cylinder.
- Potential Energy - present before the cylinder piston has moved the object.
- Heat Energy - produced by friction in the pump motor, pump, piston and hydraulic fluid.

### 1-2.3 Principles of Hydraulics

In hydraulic systems, energy in the form of pressurized liquid flow is controlled and transmitted through a piping system, to a hydraulic actuator, at the point of work as shown in Figure 1-10.



**Figure 1-10** A Basic Hydraulic System

### 1-2.3.1 Fluid Theory

Examination of the effects of fluid pressure exerted on a confined vessel shows that the applied pressure is transmitted equally in all directions throughout the fluid. In contrast, if a solid block of wood were to be pushed on one of its ends, the effect of the force would be transmitted only in a straight line, as shown in Figure 1-11. In a hydraulic system, fluid pressure is applied against all interior surfaces of all components equally, as shown in Figure 1-12. This concept is the essence of Pascal's Law, and applies to all fluid power equipment.

**Note:** According to Pascal's Law, pressure on a confined fluid is transmitted undiminished in every direction to the surface(s) of the containing vessel (see Figure 1-12).

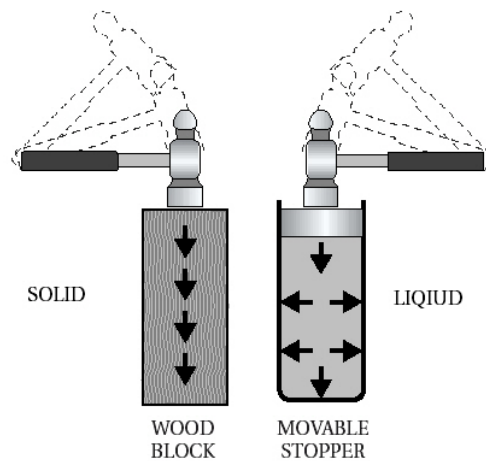


Figure 1-11 Pascal's Law

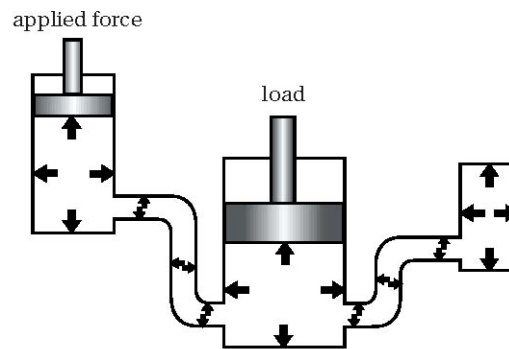


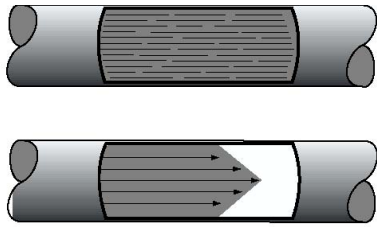
Figure 1-12 Transmission of Fluid Pressure

### 1-2.3.2 Flow Theory

The flow of fluid in a hydraulic system is the means used for transferring the applied pressure through the system to cause work to be conducted. When the system is properly designed, the fluid flow through the system is smooth and efficient. This is referred to as laminar flow. If the system has too small of a line, kinked lines or sharp bends, the result is turbulent flow.

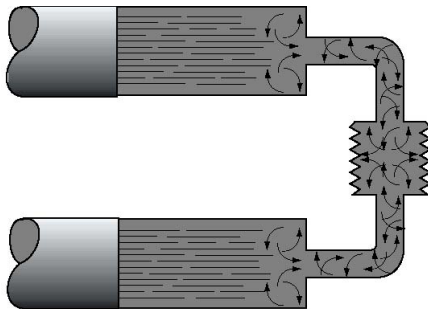
Streamline or laminar flow, is the ideal type of fluid flow in a hydraulic system, because all the particles of fluid move in parallel lines, as depicted in Figure 1-13. During the flow, the layer of fluid next to the surface of the pipe moves the slowest, because of friction between the fluid and the pipe, or other

containment device. Each inner layer of fluid slides along the next outer layer of fluid with less and less friction until the fluid layers near the center of the flow passage move the fastest. Laminar flow results from low fluid friction. The lower the friction, the less heat is generated within the hydraulic system and the more efficient the system will operate.

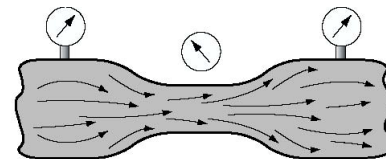


**Figure 1-13** *Streamline Flow*

Turbulent flow conditions usually occur because the fluid passage is too small for the required flow velocity, or because the viscosity of the hydraulic fluid is too low. Also, rough or irregularly formed fluid passages (e.g., kinks in lines or sharp bends), sudden enlargements or reductions in the diameter of the fluid passages, and sudden changes in the direction of flow, contribute to turbulence and should be avoided (see Figure 1-14 and Figure 1-15).



**Figure 1-14** *Turbulent Flow*



**Figure 1-15** *Gradual Piping Constriction*

Turbulent flow heats up the hydraulic fluid more than laminar flow. It wastes power by requiring more fluid pressure. In addition, turbulent flow can release the air that is suspended in the hydraulic fluid, thus forming large bubbles or pockets in the lines and components. This is called *cavitation*. Cavitation is undesirable because air bubbles make the hydraulic system sluggish and less responsive. Cavitation can also cause internal damage and accelerated wear to components.

Damage to components may result because the hydraulic system components not only move the fluids within the system, but also use the fluids for lubrication of the internal components. Air bubbles within the system cause internal components to wear due to the absence of fluid. Larger air pockets in the system can render a hydraulic system completely inoperable.

### 1-2.3.3 Characteristics of Fluids

1. **Viscosity:** Viscosity is the resistance of a fluid to flow.
2. **Fluidity:** Fluidity is the ability of the fluid to take the shape of the container it is in.
3. **Flash Point:** The lowest temperature at which vapors from a volatile liquid will ignite. When a fluid is heated to a point it becomes flammable, it has reached its flash point.
4. **Incompressible Fluid:** A fluid which is not reduced in volume by an increase in pressure. All liquids are compressible to a small degree.
5. **Thermal expansion:** The dimensional changes in increased volume exhibited by solids, liquids, and gases for changes in temperature while pressure is held constant. All liquids tend to expand when heated. Some liquids expand more than others.

A good hydraulic fluid should have a high flash point and a viscosity that will allow it to flow easily through the system. Liquids tend to expand when they are heated, and if hydraulic fluid is placed in a completely closed vessel and heated, it will exert greater pressure on all interior surfaces of the vessel. As liquids are incompressible, a great deal of damage could result if the pressure became too great. Heat also causes hydraulic fluids to thin out. If they are thinned out too much, the maximum pressure that the pump can develop may be reduced. In many cases, heat causes seals and packings to leak, because of the lowered fluid viscosity. Ultimately, the heat will cause the fluid to deteriorate. It is obvious that unnecessary heating of the fluid in a hydraulic system must be avoided, and cooling systems should be used whenever necessary. Thermal relief valves are used in systems where heated fluid damage may occur.

#### **1-2.3.4 Types of Hydraulic Fluid**

- There are three basic types of hydraulic fluid.
- Vegetable fluid has an alcohol and castor oil base.
- Mineral fluid has a petroleum base.
- Synthetic fluid has a phosphate ester base. It is used where a fire resistant fluid must be used.

**Note:** The important thing is that fluids can not be mixed. Each type of fluid has its own compatible seals. It is extremely important to determine the type of fluid being used in the system you're servicing by reading the manual or checking with the manufacturer. **HWH HYDRAULIC OIL IS RECOMMENDED FOR HWH HYDRAULIC SYSTEMS BECAUSE IT IS FORMULATED TO CONFORM TO HWH REQUIREMENTS.**

#### **1-2.3.5 Basic Mechanical Systems**

Modern industrial equipment makes use of many fluid power systems that are used to transmit force through a fluid to perform work. The fluid can be either a liquid, such as water or oil, or a gas, such as compressed air, nitrogen or carbon dioxide. A system that uses gas as the transmitting force is called a pneumatic system. A system that uses a liquid as the transmitting force is called a hydraulic system. For almost all machines, the energy that does the ultimate work is mechanical energy. Even other forms of energy transmission generally result in mechanical energy. For this reason, they require an actuator before the point of work. Actuators transform hydraulic energy into mechanical energy.

# 1-3 Calculations

## 1-3.1 Force-Area-Pressure Formulas

Pressure is the amount of force (in pounds) exerted on an object or a substance divided by the area (in square inches) over which the force is exerted. Although pressures are measured and specified in different ways, the use of pounds per square inch (PSI) is the most common. Force can also be calculated by multiplying the pressure by the area. In transmitting pressure through a confined liquid, some sort of movable member (e.g., a piston) is used to apply the pressure. **TO DETERMINE THE INTENSITY OF THE FORCE OR PRESSURE BEING APPLIED TO THE SYSTEM, THE FORCE IS DIVIDED BY THE SEALED AREA OF THE MOVABLE MEMBER:**

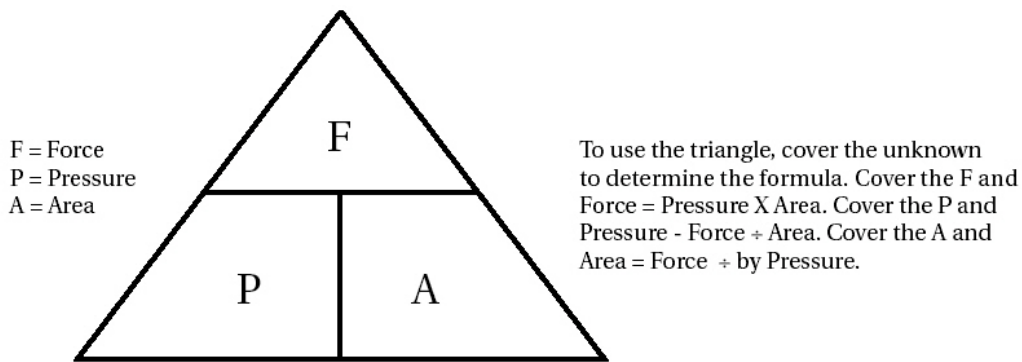


Figure 1-16 Force-Area-Pressure Triangle

$$\text{Force} = \text{Pressure} \times \text{Area}$$

$$\text{(PSI or kPa) (in}^2 \text{ or cm}^2 \text{)}$$

$$F = P \times A$$

Figure 1-17 Force-Area-Pressure Formulas

Mechanical forces can be multiplied using hydraulics. The determining factor for force multiplication is the surface area on which hydraulic pressure is applied. Since pressure is transmitted equally throughout a confined liquid, if the piston in a cylinder has more area than the movable member on which the force is applied, the output force will be greater than the input force. With a smaller cylinder area, the force would be less for the same system pressure, as shown in Figure 1-18.

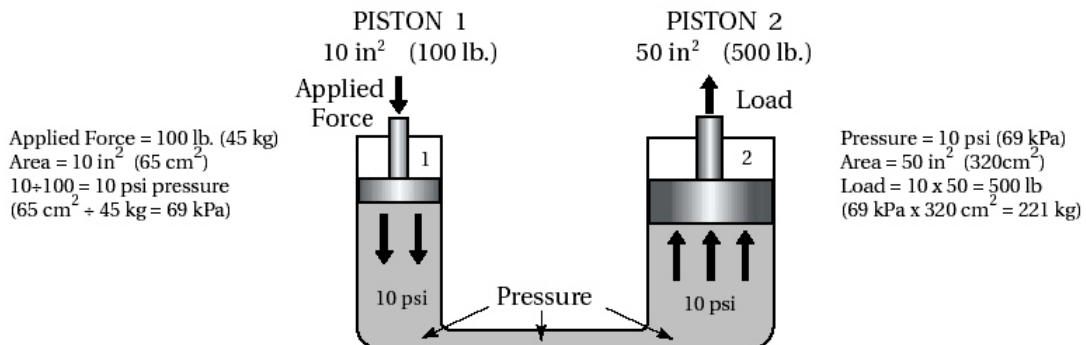


Figure 1-18 Unequal Piston Areas

### 1-3.2

## Calculations of a Piston's Surface Area

In finding the area of a round piston's surface area, the following formula is used:

$$A = \pi r^2$$

p or Pi = 3.14  
r = radius  
2 = squared

Using a 4 inch (10 cm) diameter piston, we would find the area in square inches (square centimeters) in the following manner:

1/2 of the diameter = the radius. In this case, the radius is 2 in (5 cm).

Squaring the radius, by multiplying it by itself = 2 in x 2 in = 4 in (5 cm x 5 cm = 25 cm).

Finally, multiplying the squared radius by pi will provide the area.

$$4 \times 3.14 = 12.56 \text{ square inches}$$
$$25 \times 3.14 = 78.50 \text{ square centimeters}$$

### 1-3.3

## Volume and Stroke

In a hydraulic system, pressure in pounds per square inch (PSI) or kilopascals (kPa) is exerted by fluid pressure acting over the flow area. The flow area of a cylinder can be expressed as the product of the piston area times the length of the piston's stroke.

## 1-4 Hydraulic System Special Tools & Equipment

### 1-4.1 Basic Hand Tools

The tools required to work on a hydraulic system are normal hand tools. Included should be a set of tubing wrenches, and a flare and swage kit. Safety glasses are also required. Gauges are discussed in the next paragraph and you might want to have a gauge that you can tap into the system if you ever need to know the system pressure. Most systems do not have permanent gauges installed because, even though they are dampened, the needle vibrates so much they tend to wear out and become inaccurate.

### 1-4.2 Hydraulic Pressure Gauge

In hydraulic systems there are two kinds of pressure: atmospheric and hydraulic. Atmospheric pressure 14.7 PSI, at sea level, is the pressure at work at all times on fluid reservoirs that are vented to the atmosphere. Hydraulic pressure is created by the fluid pump and acts on all internal passages on the discharge side of the pump.

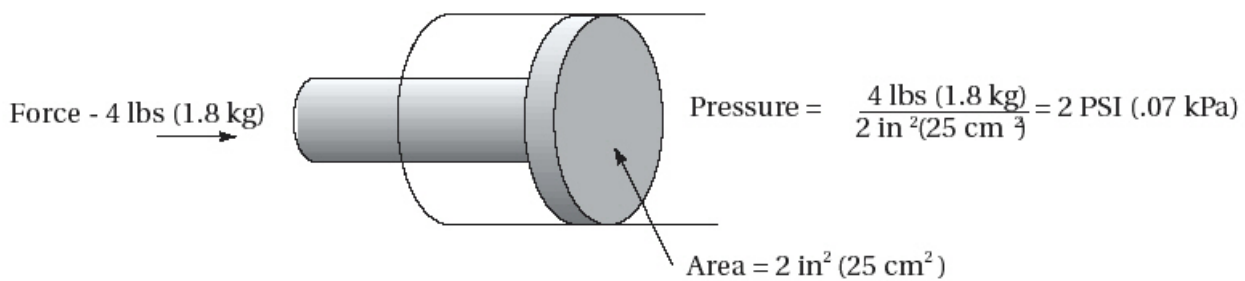
**Note:** Pressure on a gauge is normally measured in pounds per square inch (PSI) or kilopascals (kPa)), thus the force will be expressed in units of pounds (kg), and the area expressed in units of square inches (cm<sup>2</sup>).

Pressure gauges used in hydraulic systems measure only pressure that is higher than the atmospheric pressure that surrounds them. Therefore, an unconnected pressure gauge has a reading of zero pounds per square inch gauge (0 psig). A reading of 100 on a hydraulic pressure gauge indicates a fluid pressure of 100 psig. If sea level atmospheric pressure (14.7) is added to the gauge pressure, the total is 114.7 psia (pounds per square inch, absolute).

**Note:** Normally, the distinction between psig (gauge) and psia is unimportant, so the term psi is commonly used in place of psig.

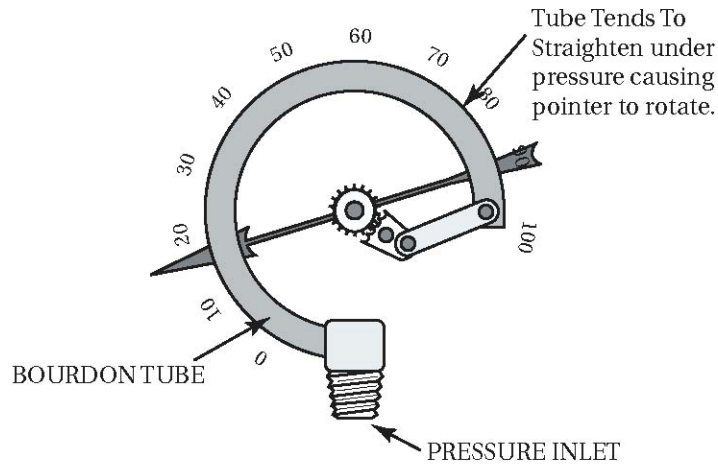
Pressure gauges are used to adjust pressure control valves to their required value, and to determine the forces being exerted by a cylinder or the torque of a hydraulic motor.

$$P = \frac{F}{A}$$



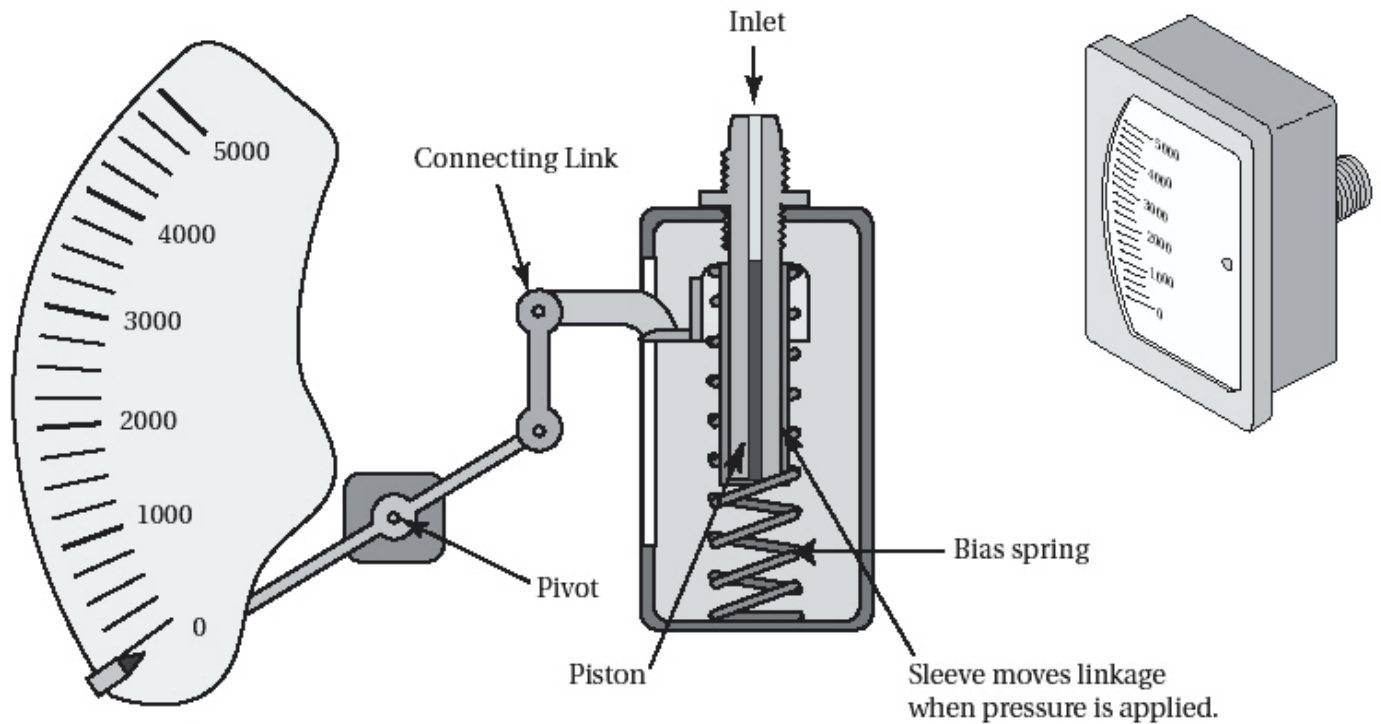
A pressure gauge is a device that measures the intensity of a force applied to a liquid. Two types of pressure gauge that are commonly used in hydraulic systems are the bourdon tube gauge and the plunger gauge.

A bourdon tube gauge, shown in Figure 1-20, basically consists of a dial face, calibrated in units of PSI and kPa, and a needle pointer attached through a linkage to a flexible metal coiled tube, called a bourdon tube. The bourdon tube is connected to system pressure. As pressure in a system rises, the bourdon tube tends to straighten out because of the difference in areas between its inside and outside diameters. This action causes the pointer to move and indicate the appropriate pressure on the dial face. Bourdon tube gauges are generally precision instruments with accuracies ranging from 0.1% to 3.0% of full scale.



**Figure 1-20** Bourdon Tube Gauge

A plunger gauge, shown in Figure 1-21, consists of a plunger connected to system pressure, a bias spring, pointer, and a scale calibrated in appropriate units of psi and kPa. As pressure in a system rises, the plunger is moved by the pressure acting against the force of the bias spring. This movement causes the pointer attached to the plunger to indicate the appropriate pressure on the scale.



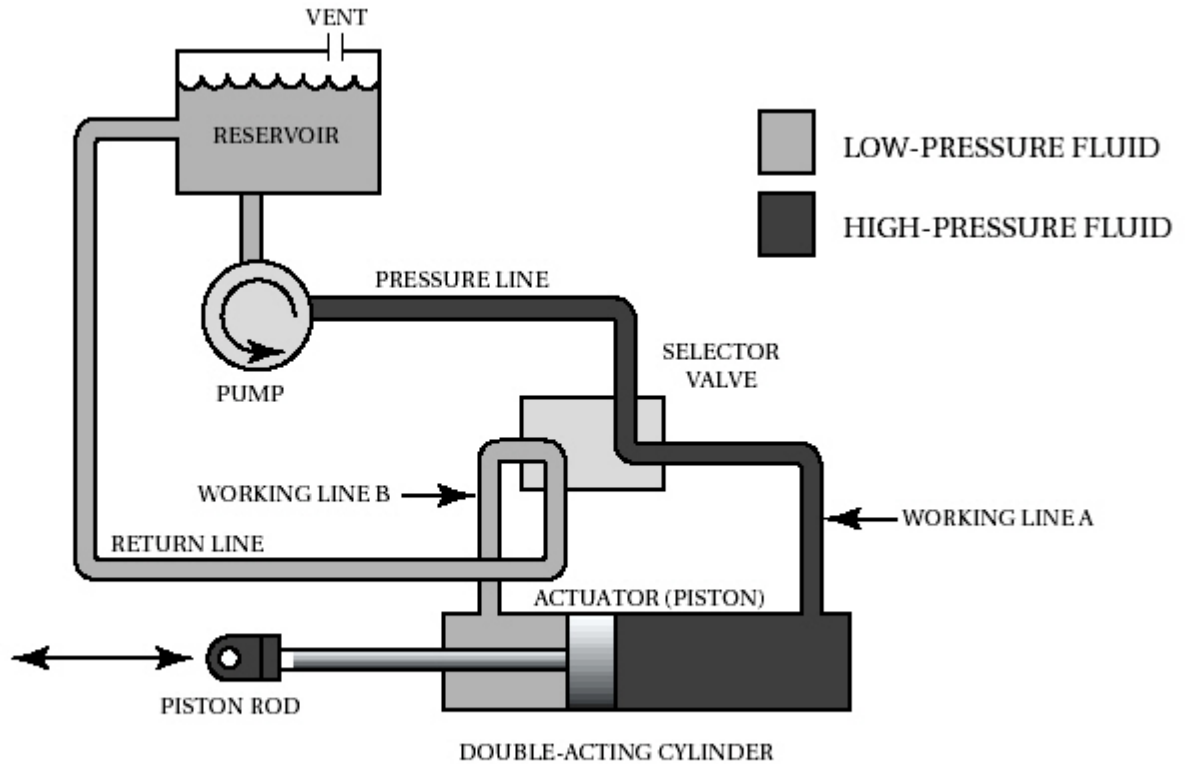
**Figure 1-21** Plunger Pressure Gauge

### 1-4.3 Electrical Test Equipment

In order to test various electrical components of systems a VOM and 12 VDC amp meter is required. A 12 VDC test light can be used for simple diagnostics but should not be used for accurate voltage and resistance testing.



## 1-5 Basic Hydraulic Circuit



**Figure 1-22** *Components of a Basic Hydraulic Circuit*

The components of a basic hydraulic circuit, as shown in Figure 1-22, are as follows:

- **Reservoir:** An area within the system that holds the hydraulic fluid. As the pump works to produce mechanical power, a supply of additional fluid is needed. The system receives this extra fluid from the reservoir.
- **Pump:** Mechanical power is converted into hydraulic power by the pump. The pump is required to move the fluid within the system.
- **Lines (or conductors):** Hydraulic power is transmitted by the fluid that is contained within the lines.
- **Valves:** Hydraulic power is regulated by valves. The valves determine whether the piston rod is extending or retracting.
- **Actuator:** Hydraulic power is converted to mechanical power by the actuator or piston. The actuator moves the fluid within the circuit to the work. The pressure of the fluid pushes up on the piston within the cylinder to lift the weight.

## • **Hydraulic System Components**

- Identify uses/function of hydraulic systems on RVs (power steering, hydraulic surge brakes, expandable room sections, shock absorbers, leveling systems).
- Identify hydraulic system components.
- Disassemble, clean and reassemble a hydraulic component.
- Identify the functions and types of reservoirs.
- Identify and select lines, fittings and couplings.
- Identify sealing devices and installation procedures.
- Identify hydraulic fluids, filters and additives.
- Identify system contaminants.
- Identify types of pumps and their construction.
- Identify hydraulic valves, cylinders and accessories.

### **2-1 Vented Reservoirs**

A reservoir is a container or containment area for keeping a supply of working fluid in a hydraulic system. The functions of a reservoir are:

- To contain excess fluid resulting from system volume changes.
- To help cool the system.
- To replace fluid lost through system leakage.
- To help separate dirt and air from the fluid.

Reservoirs for the equipment typically found in an RV system are of the vented type, as shown in Figure 2-1. This means the reservoir has a vent opening to the atmosphere, usually in the filler cap. Typically, the venting is provided by a breather cap, covering the opening where hydraulic fluid is added to the system. A magnet helps remove steel particles from the hydraulic fluid. Strainers and filters are used to keep the fluid clean.

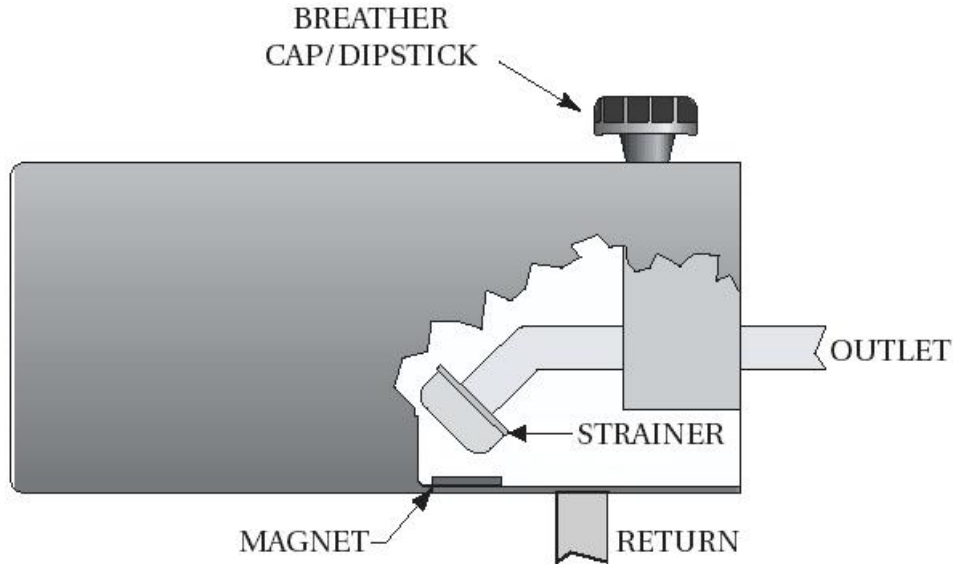


Figure 2-1 Parts of a Properly Designed Vented Reservoir

## 2-2 Plumbing

### 2-2.1 Tubing

Most metal tubing on the high pressure side of the hydraulic system will be made of stainless steel or steel. The tubing on the high pressure side will be provided and installed by the component manufacturer. The tubing flares used on the high pressure side of the system will generally be flares of 37 degrees. Return lines are usually plastic tubing with compression fittings.

### 2-2.2 Hoses

**HWH HOSES ARE SPECIFICALLY DESIGNED TO MEET HWH SYSTEMS REQUIREMENTS.**

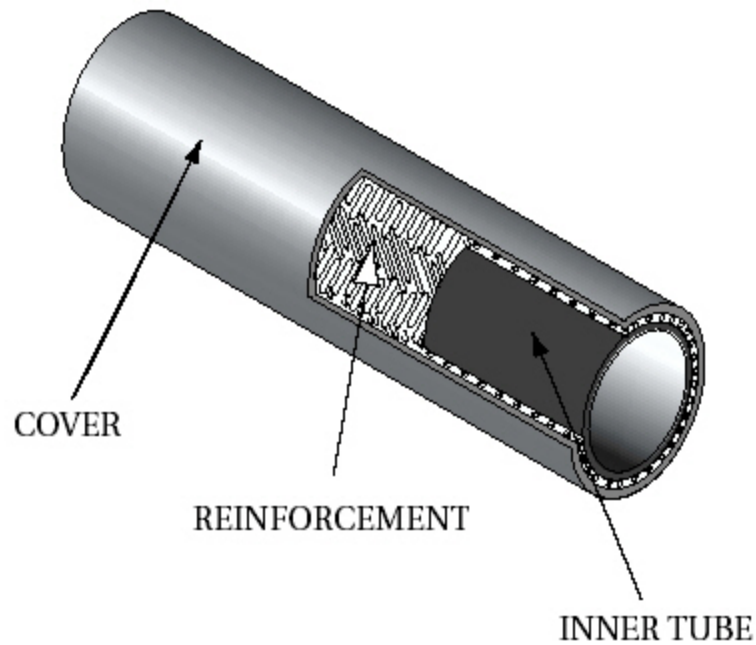
**NOTE: IF HOSE REPLACEMENT IS NEEDED, USE THE EXACT TYPE AND CAPACITY OF HOSE PREVIOUSLY USED. IF YOU ARE UNSURE OF THE TYPE OF OR CAPACITY HYDRAULIC HOSE TO USE, CALL HWH TECHNICAL SERVICE.**

**NEVER USE OTHER MANUFACTURES HOSES.**

### 2-2.2.1 Characteristics of Hydraulic Hose

#### Construction

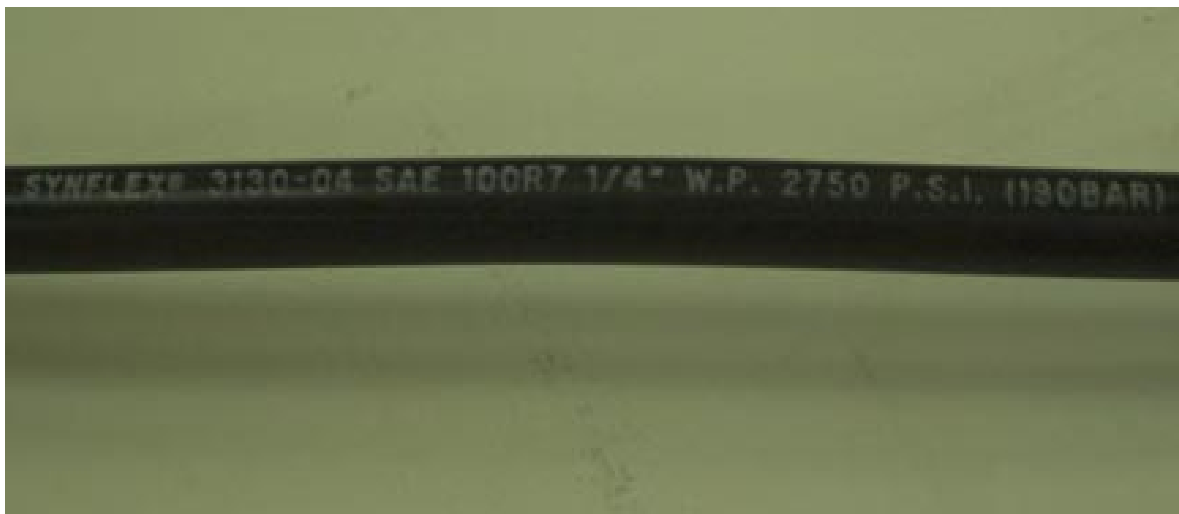
Hydraulic hoses consist of an elastomeric inner tube or of oil resistant synthetic rubber, with layers of reinforcing cord embedded in and/or bonded to the inner and outer tube. Depending on the type of hose, it may also have steel wire reinforcement and an oil-and weather-resistant synthetic rubber outer cover, as shown in Figure 2-2.



**Figure 2-2** *Hydraulic Hose Construction*

#### Hose identification

HWH hydraulic hoses, are legibly marked along their entire length, as shown in Figure 2-3.



## Application factors

### Fittings

Hydraulic hose is used with fittings. Hoses, with fittings attached, are commonly referred to as hose assemblies. Following installation instructions supplied by HWH provides adequate guidance on the hose and fittings to be used. Using fittings, hoses and swaging tools from different manufacturers is not recommended.

#### 2-2.2.2 Types of Hose Fittings Used in Hydraulic Systems

Fittings used for hydraulic hoses are numerous. It is important to get the correct fitting and hose combination for the intended application. When possible, the use of hose assemblies is recommended. Hose assemblies come with the fittings and hose pre-assembled. This eliminates confusion on hose and fitting compatibility.

The most common fitting is a swage-type fitting, as shown in Figure 2-4. A swage tool is required to assemble this type of fitting.



Figure 2-4 Swage Fitting

### 2-2.3 Fittings

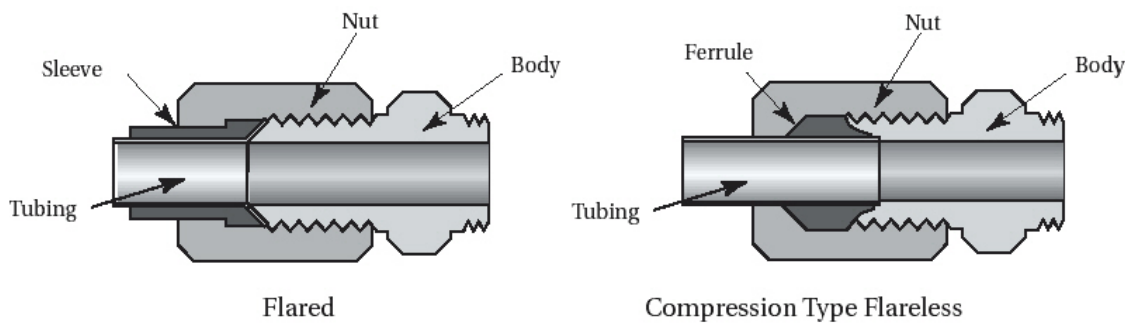
#### 2-2.3.1 Types of Hose Fittings Commonly Used with Tubing

##### Flare Type

Hydraulic systems commonly use the JIC (Joint Industry Conference standard) flare, as shown in Figure 2-5. These are 37° flares. The end of the tubing needs to be flared to mate with a fitting. The 45° single-flare and mating fittings are used in propane, natural gas and water systems, but should not be used for hydraulic applications

##### Compression Type

This is a compression fitting that uses a ferrule that is compressed onto the tubing by the action of screwing the fitting parts together, as shown in Figure 2-5. The ferrule “bites” onto the tubing.



**Figure 2-5** *Types of Fittings Commonly Used with Tubing*

## 2-2.4 Seals and Gaskets

No hydraulic system can properly operate without seals to hold the hydraulic fluid in the system when the system is under pressure. Seals also keep dirt and grime out of the system. While seals may appear to be simple objects when laying on the work bench or in your hand, they are really complex and precision parts that must be treated carefully if they are to do their job.

Hydraulic seals are used in two main applications. Static seals to seal fixed parts and dynamic seals to seal moving parts. Many types of seals are used in hydraulic systems. The type of seal used often depends on the type of hydraulic fluid used, the temperature and pressure of the application, whether the parts are dynamic or static, the speed of the moving parts and the amount of shock loading. Static seals are usually gaskets, but could be packings or O-rings. Dynamic seals involve rod and shaft seals and compression packings. Slight leakage at seals is permissible, as the leakage tends to lubricate the seals during use.

**Note:** Use only HWH parts for replacement seals and gaskets.

### 2-2.4.1 Types of Sealing Devices

#### O-rings

O-rings, depicted in Figure 2-6, are the most common type of seal. They come in all different sizes and materials. They are generally made of synthetic rubber and are compatible with most hydraulic fluids. O-rings can be used in static and dynamic applications.

**Note:** The only way to identify an O-ring is by the package it comes in. Be careful to match the O-ring to the fluid being used.

O-rings are designed to be used in grooves where they are compressed between two surfaces. In dynamic uses, they generally have a smooth surface to work against. They are not used across openings or where they must pass corners under pressure.

#### Back-up rings

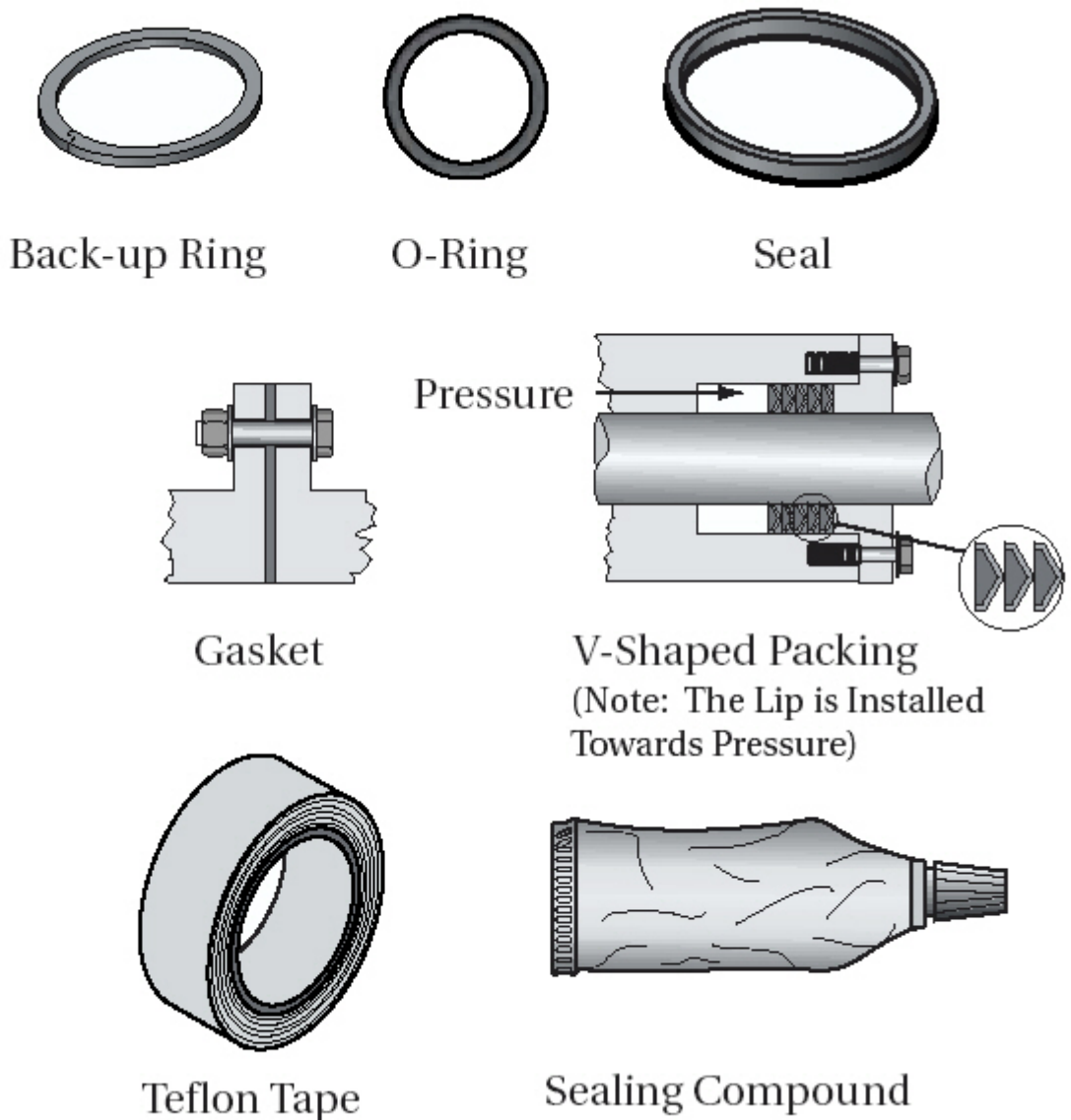
Back-up rings, depicted in Figure 2-6, are used in static or dynamic situations. When O-rings are used in systems where the fluid pressure is 1500 PSI or higher, it is necessary to put a back-up ring behind the O-ring to keep it from being extruded in the grooves. Backup rings used to be made of leather, but now are primarily made of Thero plastics or Teflon®. They are installed behind the o-ring on the opposite side of the pressure. In an actuator, the piston would have a back-up ring on both sides of the O-ring since the pressure can come from either direction.

## Gaskets

Gaskets, depicted in Figure 2-6, are only suitable for static applications. Gaskets are used in compression between two surfaces and seal by molding to imperfections between the two surfaces. Gaskets can be made from an array of materials and are available in multiple shapes and sizes.

## U- and V- Packings

U- and V-packings, depicted in Figure 2-6, are dynamic seals. They are made of leather, synthetic and natural rubber, plastic and similar. **THESE PACKINGS ARE INSTALLED WITH THE OPEN SIDE, OR LIP, TOWARD THE SYSTEM PRESSURE SO THE SYSTEM PRESSURE WILL PUSH THE LIP AGAINST THE MATING SURFACE.** This outward pushing will form a tight seal. These packings are made up of U- or V-shaped components.



**Figure 2-6** *Types of Sealing Devices*

### Cup and Flange Packings

Cup packings are dynamic seals. These are made of synthetic rubber, plastic or similar. Surfaces are sealed by expansion of the lip or beveled edge of the packing. The most common use is at cylinder pistons and piston rods.

### Sealing Compounds

**SEALING COMPOUNDS, SUCH AS THREAD LUBRICANTS AND TEFLON® TAPE SHOULD ONLY BE USED ON THE MALE THREADS OF PIPE FITTINGS AND ARE NEVER USED ON TUBING FITTINGS IN A HYDRAULIC SYSTEM.** Only the fluid in the system should be used to lubricate tubing fittings.

## 2-3 Fluids

### 2-3.1 Identifying

Hydraulic fluid is the medium by which power is transmitted from the pump to the mechanism that produces work. The fluid is one of the most important components of the hydraulic system. In fact, the majority of hydraulic system problems can be related to improper fluid use or fluid contaminants.

The system's hydraulic fluid is important because it transmits the force applied to it to create work. In addition, the fluid must be able to lubricate the moving parts of the system, be stable over long periods of time, protect the systems parts from rust and corrosion, resist foaming and oxidation, and be capable of separating itself from air, water, and other contaminants. Finally, it must maintain its ability to flow (maintain its viscosity) throughout a wide range of temperatures.

Viscosity is the most important property of a hydraulic fluid. If the viscosity is too low, the fluid will be thin and could pass through the seals of the system. If the viscosity is too high, the equipment will be sluggish and will not function properly.

Most fluids have a tendency to get thin as the temperature rises and thicken as the temperature lowers. Therefore, finding the correct balance of a hydraulic fluid's viscosity is important. The viscosity index helps individuals find the fluid that is balanced throughout a wide range of temperatures. Using a fluid with a high viscosity index will ensure the fluid is stable for a wide range of temperatures. The viscosity index is typically stated on the fluid container when it is purchased.

Some hydraulic fluids can handle the thrust pressures of the system better than others. **THEREFORE IT IS IMPORTANT TO USE ONLY HWH HYDRAULIC OIL.**

**Note: In an emergency call HWH Technical services before substitution any other oil.**

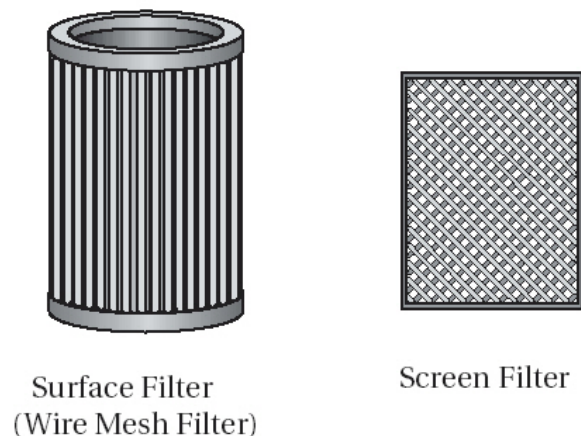


## 2-3.2 Filters/Screens

Servicing filters/screens are essential in keeping the hydraulic fluid in top condition. Dirt can be very harmful to a fluid because it acts as a catalyst for fluid decomposition and internal component wear. This is especially true if the dirt particles are ferrous, lead or copper. Filters or screens, depicted in Figure 2-7, usually remove a large percentage of dirt from a fluid stream. However, they do not remove all contaminants from the system; this is a maintenance function. One teaspoon of dust in 55 gallons of fluid is considered to be a dirty system. Even small amounts of contamination in a system can wear out a hydraulic components in just a matter of a few hours. Scored internal surfaces can result in excess leakage and poor performance of a component.

Some effects of contaminants in the hydraulic system:

- Reduced component life.
- Scored internal surfaces.
- Clogged internal passages and control valves.
- Clogged ports in cylinders and motors.
- Seized components
- Poor performance
- Improper check valve operation
- Improper or erratic operation
- Inability to maintain pressure



**Figure 2-7** Typical Filter Examples

## 2-4 Pumps

The pump is the primary component of the hydraulic system. The pump is what creates the flow of fluid and induces work as a result. All pumps create flow and operate on the principal of displacement. The fluid is taken into the pump, and displaced to another point.

To find out about a pump, you should always read its data plate. It may say “1 gal. per minute at 1200 rpm.” A positive displacement pump will be rated by its output at a given rpm. Usually, the pump is designed to run at this rpm or less. The data plate may also say “1500 PSI (10,000 kPa) rated” This means that the maximum pressure the pump is designed for is 1500 PSI (10,000 kPa) and it should be matched to a system that has a pressure relief setting at 1500 PSI (10,000 kPa) or less.

**IT IS ALSO VERY IMPORTANT THAT YOU UNDERSTAND THAT A PUMP DOESN'T PUMP PRESSURE. A PUMP PUMPS VOLUME.** In order to get pressure you have to restrict the output of the pump. Example: You hook a garden hose to the output of a pump. You tap a pressure gauge into the hose. You turn on the motorized pump and water flows out of the hose. The hose offers some restriction to the flow of water but for this lesson, the gauge reads zero. The pump is pumping so many gallons per minute, which is volume. Now put your thumb over the outlet of the hose and try to stop the water flow. The gauge is now reading pressure and the more you restrict the outflow the higher the pressure will go. The pump isn't doing anything different. It's still pumping out so many gallons per minute. The same thing is going to happen in the hydraulic system.

Displacement can be accomplished in one of two ways:

- Non-positive displacement
- Positive displacement

Most pumps used in hydraulic systems today are positive displacement pumps, as shown in Figure 2-8. Therefore we will not discuss non-positive displacement pumps. However, as a basic, a non-positive displacement pump, as shown in Figure 2-8, is a pump in which the inlet and outlet are hydraulically connected, so that the fluid can re-circulate in the pump when pressure builds. An example of a non-positive pump is a centrifugal water pump on a car's cooling system.

A positive displacement pump is a pump that has the inlet sealed from the outlet. This holds the fluid within a system as it moves. As the fluid flows out of the pump, it is sealed against back-up, so it can not be drawn back into the pump. This sealing is the "positive" part of displacement. Without this sealing, the fluid could never overcome the resistance of the other components in the system.

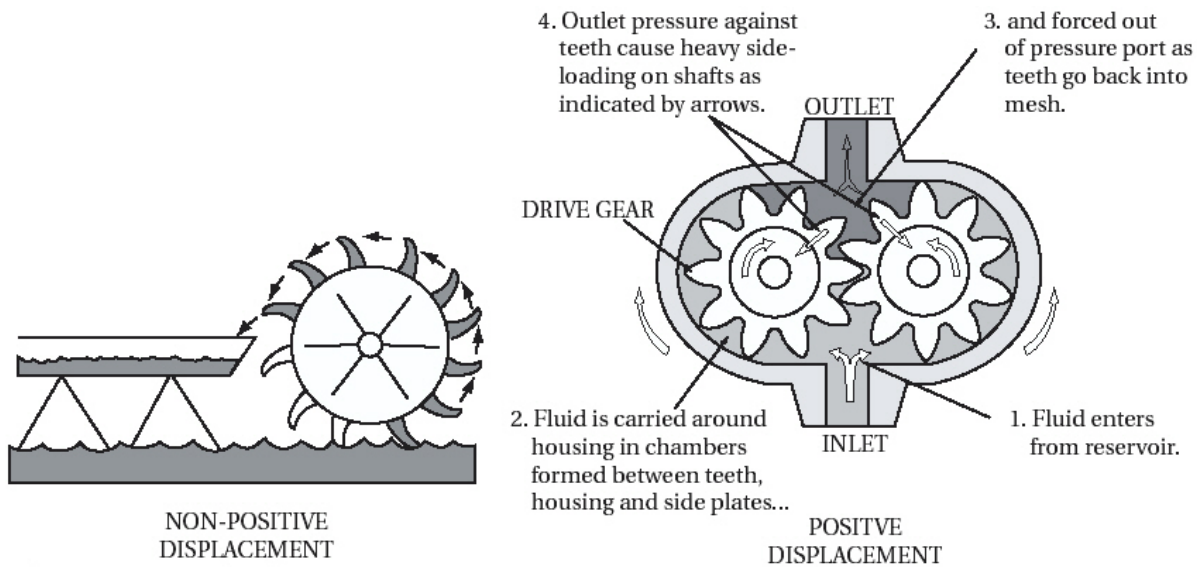


Figure 2-8 Hydraulic System Pumps

This pump will deliver fluid any time the inlet is kept supplied and the pump is driven. Positive displacement pumps must have a relieving device either internal to the pump or somewhere else in the system, or they will be damaged. This type of pump also has a pulsating type of output. The sealing mechanism of the positive displacement pump is primarily accomplished by the use of gears or pistons.

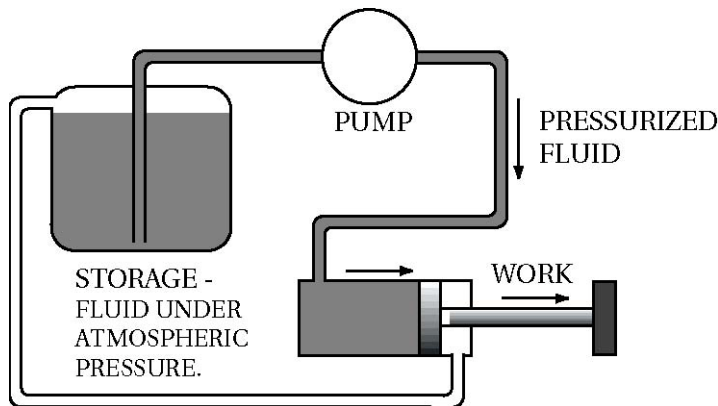


Figure 2-9 Pump Operation

## 2-4.1

### Types

The types of positive displacement pump are based on the sealing mechanism of the pump and how the positive displacement is accomplished. The basic types of positive displacement pumps are gear and piston pumps. Gear pumps are typically the only ones used in the RV industry.

#### 2-4.1.1 Gear Pump

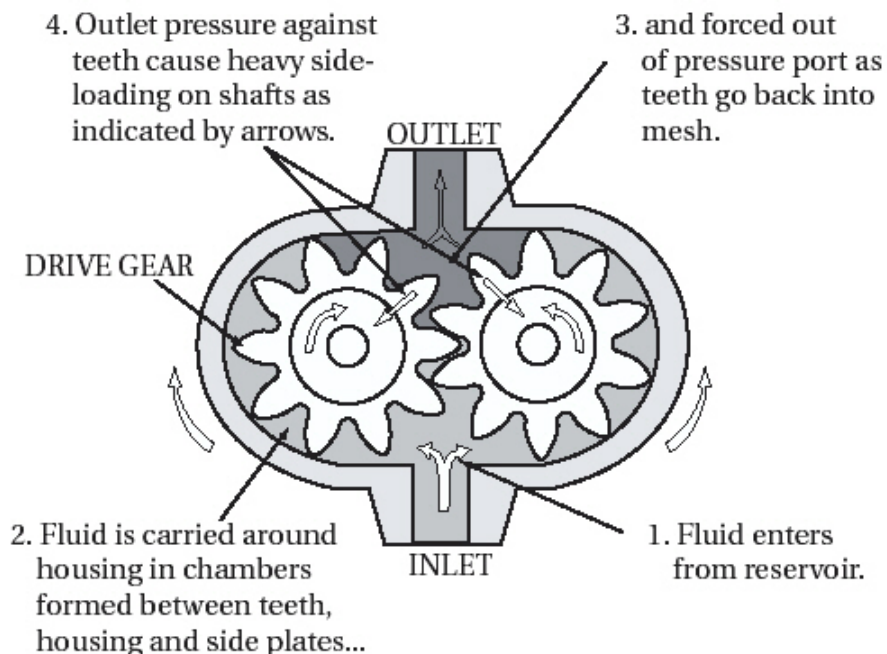
Gear pumps are the most commonly used pumps in the RV industry because they are simple and economical. The other types of pumps are generally cost prohibitive.

Gear pumps usually have two gears in mesh, closely fitted inside a housing. The drive shaft drives one gear, which in turn drives the other gear. Shaft bushings and machined surfaces or wear plates are used to seal in the working gears.

As the gears rotate and come out of mesh, they trap inlet fluid between the gear teeth and the housing. The trapped fluid is carried around to the outlet chamber. As the gears mesh again they form a seal which prevents fluid from backing up to the inlet. The fluid is forced out at the outlet port and sent through the system. This fluid is pushed out by the continuous flow of trapped fluid coming into the outlet chamber with each rotation of gears.

At the inlet side, gravity feeds in more fluid from the reservoir to replace that drawn out by the turning gears, as shown in Figure 2-10.

The main reason gear pumps are so popular is that they operate very smoothly.



**Figure 2-10** Gear Pump

## 2-5 Hydraulic Controls

Working energy transmitted hydraulically must be directed and under complete control at all times. If not under control, no useful work will be done or a machine might be destroyed. One of the advantages of hydraulics is that energy can be controlled relatively easily by using valves.

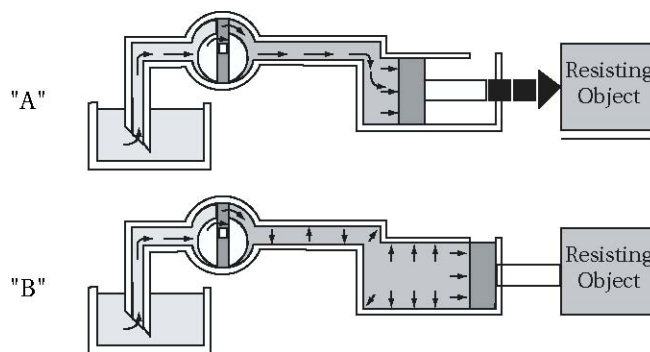
### 2-5.1 Valves

A valve is a mechanical device consisting of a body and an internal moving part which connects and disconnects passages within the body. The passages in hydraulic valves carry liquid. The action of the moving part controls maximum system pressure, direction of flow, and rate of flow.

### 2-5.2 Control of Pressure

Hydraulic energy can be applied to a piston type actuator, resulting in the performance of work. Once the actuator has reached full extension, the work is completed and there is no place for the fluid to go. **A POSITIVE DISPLACEMENT PUMP WILL CONTINUE TO TRY AND DELIVER IT'S RATED OUTPUT AND THE PRESSURE WILL RISE UNTIL DAMAGE IS DONE TO THE SYSTEM. A SYSTEM PRESSURE REGULATOR OR PRESSURE CONTROL VALVE MUST BE INCORPORATED IN THE SYSTEM TO PREVENT THIS FROM HAPPENING.**

Figure 2-11 shows an example of a pump supplying fluid to an actuator. In "A" the pressure in the system will be determined by the amount of resistance supplied by the object being moved. In "B" the pressure will be extreme because there is no pressure relief valve or a way for fluid to go back to the reservoir.



**Figure 2-11** *No Pressure Relief*

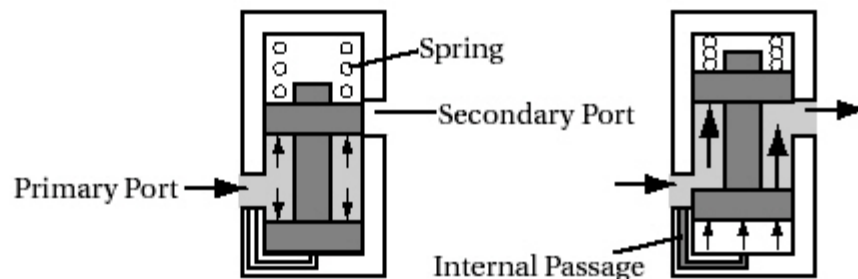
## 2-5.3 Pressure Control Valve

A pressure control valve has an internal moving part which is operated by pressure. When the pressure in a system reaches a certain level, the internal moving part connects or disconnects passages in a valve body, allowing the liquid to follow another path.

Many times, the internal moving part of a pressure control valve is a spool. In one extreme position, the spool connects the passages, allowing the fluid to flow through the valve. In the other extreme, the passages are disconnected and the flow path through the valve is blocked.

In pressure control valves, the spool is held biased in one extreme position by a spring. If the passages are disconnected and the flow path through the body is blocked in its normal condition, the valve is designated a normally non-passing pressure control.

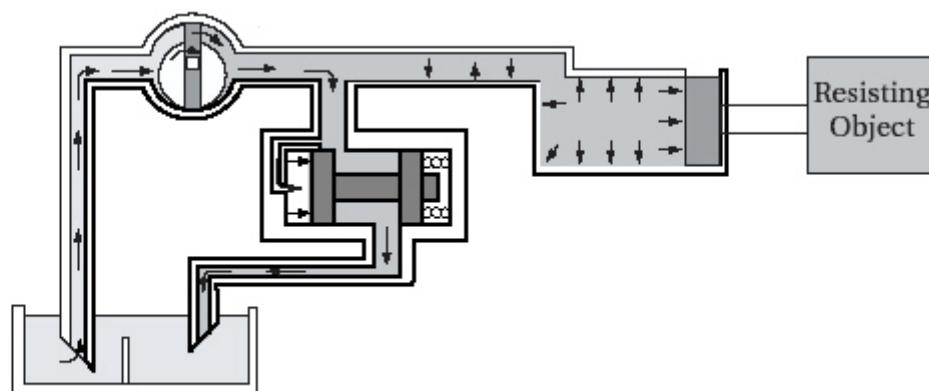
Pressure is sensed at the bottom of the spool by an internal passage connected to the primary passage. When system pressure overcomes the force of the spring, the spool moves and the passages are connected. Fluid is free to flow through the valve, see Figure 2-12.



**Figure 2-12** *Pressure Relief Valve*

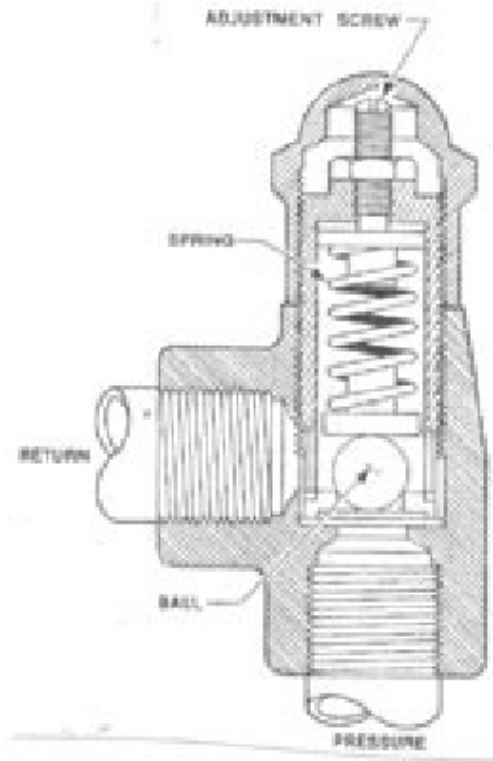
**Note:** The fluid pressure used to operate the spool is known as pilot pressure. Pilot pressure is a common way of operating many types of hydraulic valves.

If the primary ports of this type of pressure valve were connected to the system, and the secondary port was connected to the reservoir, the flow from the pump could be directed back to reservoir when pressure applied to the pump becomes excessive. A normally non-passing pressure valve used in this manner is called a relief valve, as shown in Figure 2-13.



**Figure 2-13** *Pressure Relief in Hydraulic System*

**Note: Most pressure relief valves are adjustable by increasing and decreasing the spring tension as shown in Figure 2-14.**



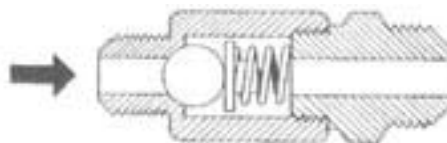
**Figure 2-14** *Pressure Relief Valve Adjustment*

## 2-5.4 Flow Control Valves

Flow control valves are used to route the fluid in the desired direction in a system to perform the work required. They can also be used to control the rate of flow in the system.

### 2-5.4.1 Check Valves

Figure 2-15 shows a one way valve, better known as a check valve. It consists of a body with a ball and a spring. In the direction you desire the fluid to flow, the fluid will move the ball back against the spring and uncover the passage. In the other direction the fluid and the spring will keep the ball on its seat, to block the flow.



**Figure 2-15** *Check Valve*

2-5.4.2

*Orifice Check Valves*

Figure 2-16 shows an orifice check valve. These valves are similar to a check valve except they usually have a cone instead of a ball. The cone has a drilled orifice that will allow free flow in one direction and restricted flow in the other. An orifice check valve could be installed in a leveling system where you want the jack to extend quickly and retract slowly, as shown in Figure 2-17.



Figure 2-16 Orifice Check Valve

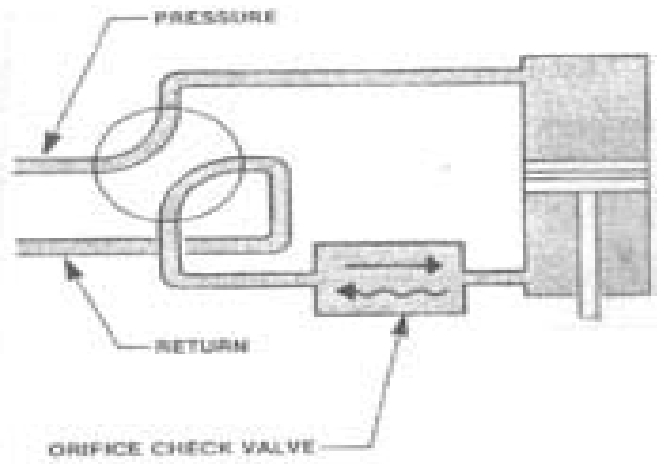


Figure 2-17 Orifice

2-5.4.3

*Variable Restrictors*

Figure 2-18 shows a variable restrictor. A floor jack is a common example of a variable restrictor. The tapered valve can be screwed down on its seat to block the flow completely or the valve can be slowly moved off its seat to allow as much flow as desired.

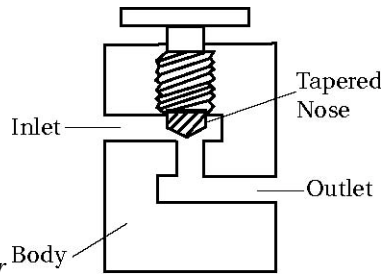


Figure 2-18

Variable Restrictor

#### 2-5.4.4

#### *Sequence Valves*

Sometimes it is necessary to make sure one component works prior to another to avoid damage. An example might be insuring the leveling jacks on a motor home swing down from the horizontal position before they extend. This would be accomplished by the use of a sequence valve. See Figure 2-19.

Fluid from the outlet port would go to the “extend” side of the jack actuator and is blocked in view “A.” When the jack swings all the way down, it bumps a component and mechanically pushes the plunger in. The ball comes off the seat and allows fluid pressure to extend the jack actuator. This valve insures the jack has swung all the way down before it will extend.

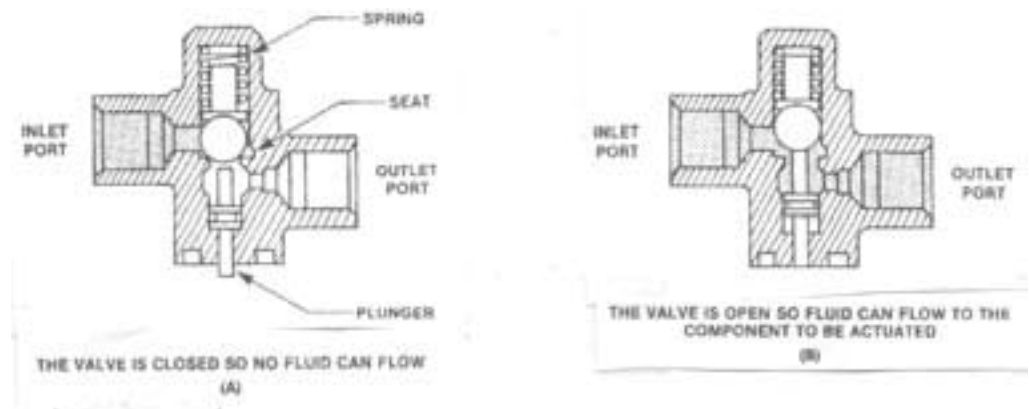


Figure 2-19

*Sequence Valve*

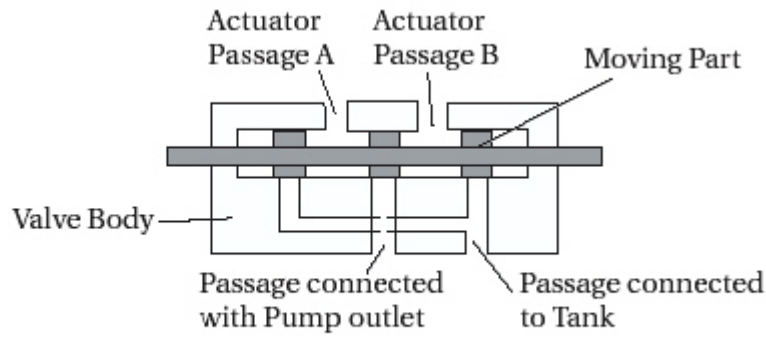
Some sequencing valves are operated by hydraulic pressure and are called priority valves. They are complex and won't be covered in this book.

#### 2-5.4.5

#### *Selector Valve (Directional Control Valve)*

A selector valve, connects and disconnects internal passages within the valve body, which results in a control of fluid direction. This valve is used to determine which actuator(s) are going to move and in what direction. The selector valve spool can be moved either manually or electrically. In the manual mode there would be a lever attached directly or through linkage that the operator would move. The level might be labeled “UP” or “DOWN,” “IN” or “OUT.” In the electrical mode the spool would be moved by a solenoid. A typical selector valve or directional control valve is shown in Figure 2-20. The body of the valve has four port connected to internal passages. In the figure shown, the spool (dark portion) is in the neutral position and fluid from the pump is blocked. If the spool is moved to the right, the pump outlet passage is ported to passage “A” and fluid will flow to one side of an actuator. As the piston in the actuator moves, fluid is forced out to the return passage “B” which is now ported in the selector valve to return to return to the tank. If the spool is moved to the left, port “B” will be the pressure port and the actuator will move in the opposite direction. The hydraulic lines connected to ports “A” and “B” will alternate from pressure lines to return lines and will be known as working lines in the system.



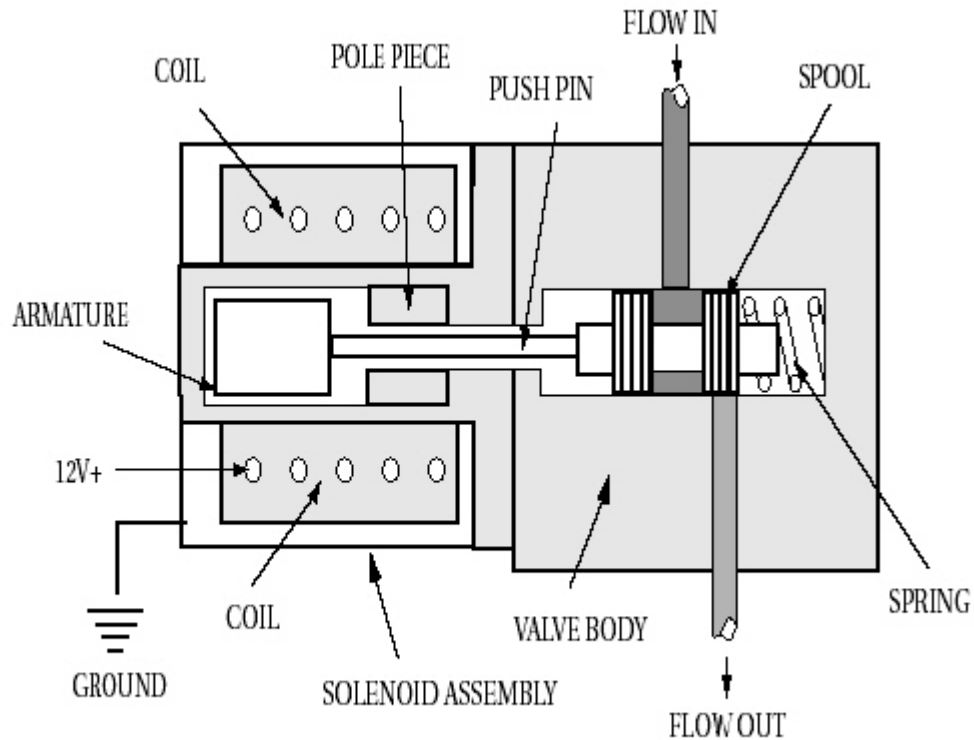


**Figure 2-20** *Selector Valve*

**2-5.4.6**

***Solenoid Valve***

Solenoid valves are operated electrically and are used to move a spool valve in a body, such as a selector valve or at as an “ON,” “OFF” valve. Figure 2-21 shows a solenoid valve in the de-energized or off position. The spool is in the spring loaded position shutting off the outlet passage. When voltage is applied to the coil, it becomes an electromagnet which causes the ferrous armature to be pulled toward the pole piece, sliding the spool and opening the passage. Solenoids are used extensively because they can be installed remotely and only require a switch in the panel for the operator.



**Figure 2-21** *Electric Solenoid*

## 2-6

# Actuators or Cylinders

The actuator does the work of the hydraulic system. It converts the fluid power from the pump to linear mechanical power. Actuators are the “arms” of the hydraulic system. Piston-type, linear actuators are the most common type used in recreation vehicles, and therefore will be the only type discussed herein.

### 2-6.1

## Piston-Type Actuators

There are two basic types of piston-type actuators. They are single-acting and double-acting, linear actuators.

#### 2-6.1.1

### *Single-Acting Actuators*

These type of actuators only apply force in one direction. The hydraulic fluid passes through a manual or electrically operated selector valve under pressure and enters into one end of the actuator. This causes the piston to move, extending the ram, and work is performed. See Figure 2-22. Once the pressure is released, an outside force such as a spring or gravity would be used to return the cylinder to its starting position, as shown.

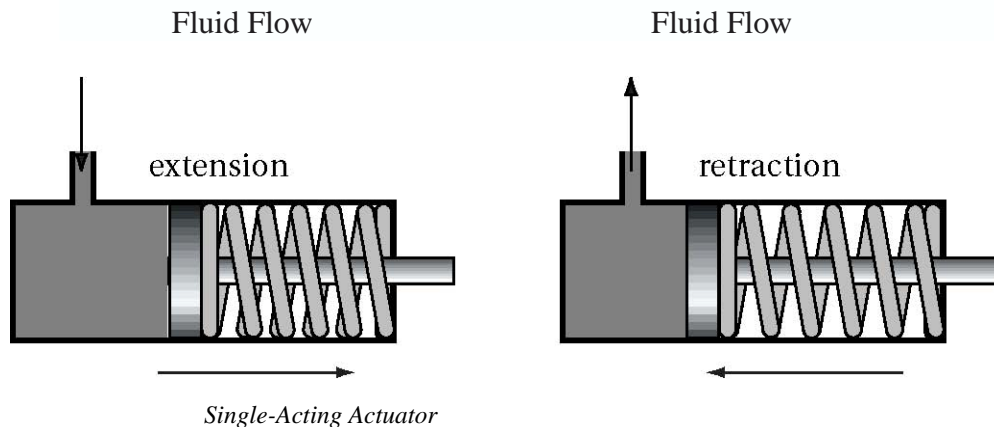


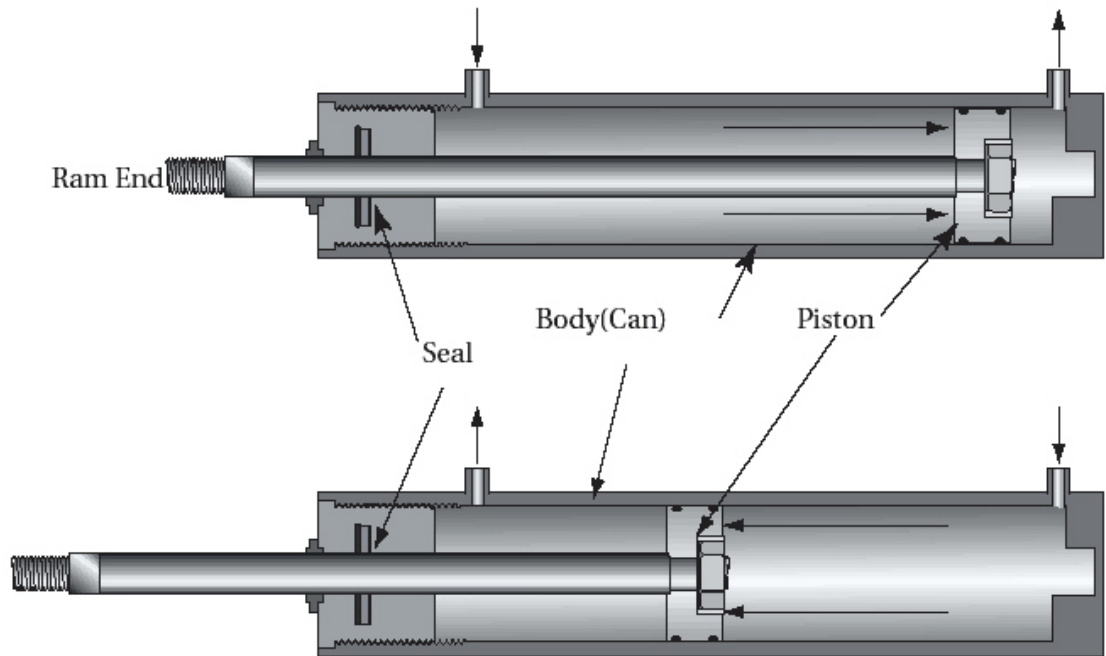
Figure 2-22

*Single-Acting Actuator*

#### 2-6.1.2

### *Double-Acting Actuators*

These type of actuators apply force in both directions. The hydraulic fluid passes through a manual or electrically operated selector valve under pressure and enters into one end of the actuator. This causes the piston to move, extending the ram, and work is performed. See Figure 2-23. As the piston moves, fluid is forced out of the other end and is returned through the selector valve back to the reservoir or tank. When this selector valve is switched, fluid enters the other end of the actuator and the procedure is reversed. This allows two-way power.

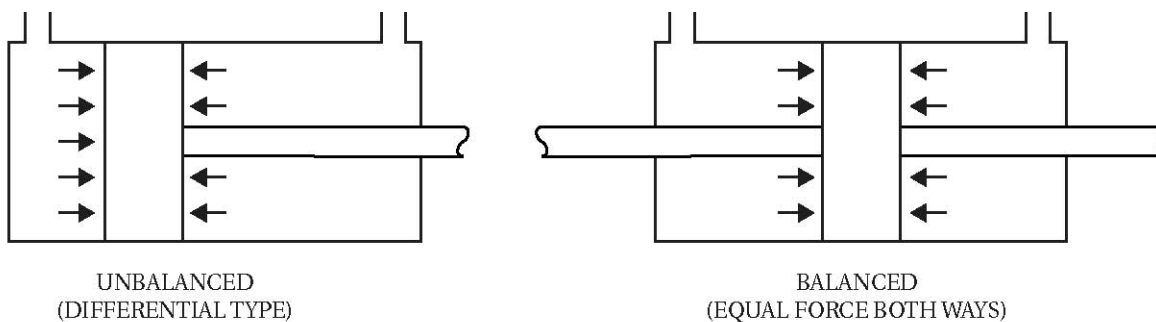


**Figure 2-23** *Double-Acting Hydraulic Cylinder*

### Types of Double-Acting Cylinders

A balanced double-acting cylinder has an equal area on both sides of the piston upon which the fluid (pressure) acts. Usually, the piston rod extends through the piston head on both sides. This gives equal working area on both sides of the piston and balances the working force of the cylinder whether it is extending or retracting, see Figure 2-24.

An unbalanced, or differential type, double-acting cylinder has unequal areas of force on each side of the piston, as shown in Figure 2-24. Typically, the rod side of the piston has less force than the “blank” side of the piston. This is because the rod fills up some of the volume not exposed to pressure. This type of cylinder is usually designed for a slower, more powerful stroke when it extends, and for a faster, less powerful stroke when it retracts. This application is the type found on RVs.



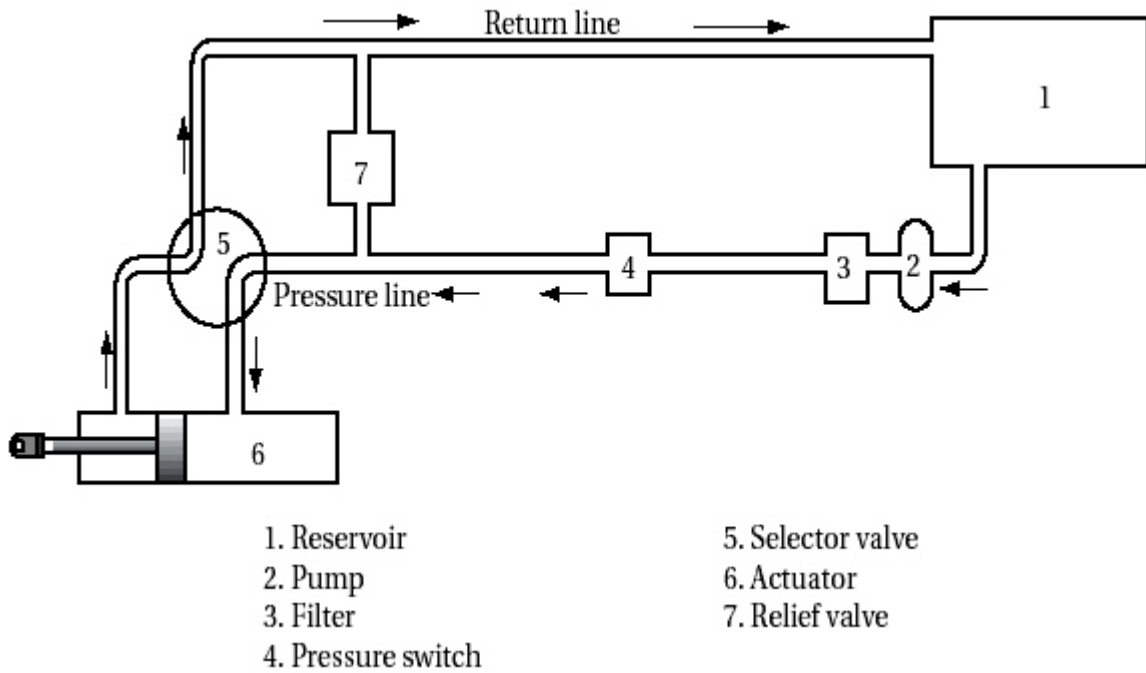
**Figure 2-24** *Double Acting Cylinders*

## **Basic Information for Performing Hydraulic System Maintenance**

- Identify hazards and safety requirements of hydraulic systems (pinch points, leaks, etc.).
- Identify basic hydraulic symbols specific to RV schematic symbols.
- Route hydraulic hose and piping.
- Identify common pump symbols.
- Identify valve, cylinder and accessory symbols (RV specific).
- Troubleshoot, clean, repair or replace leveling systems.
- Troubleshoot, clean, repair or replace lines, connectors and fittings.

### **3-1 How a Hydraulic System Works**

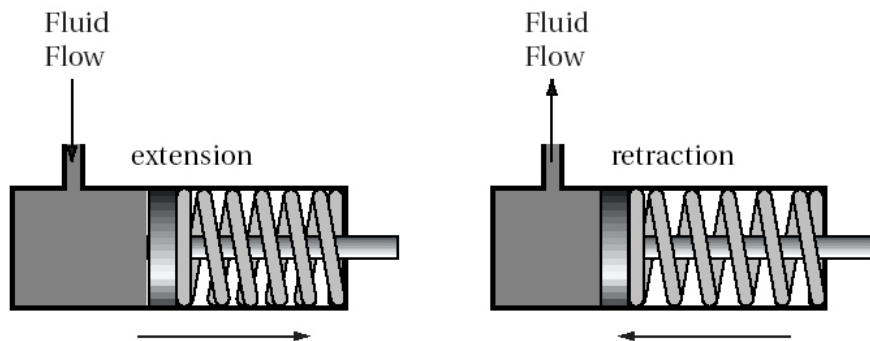
Using the Figure 3-1, we can see the components and how they relate to each other to form a dual-acting hydraulic system. There is a supply line from the reservoir (1) through a filter (2) to the inlet of the pump (3). A pressure line comes out of the pump and goes through a pressure switch (4) to the selector valve (5). The lines going to and coming from the selector valve to the actuator (6) are going to alternate between pressure and return and therefore will be called the working lines. There will be pressure lines in one direction of the actuator and return lines in the other. The line going from the selector valve to the reservoir is always a return line. Remember, pressure lines are always pressure lines and return lines are always return lines, working lines alternate between pressure and return. Working lines are sometimes names by what they do when they are under pressure. “Up line,” “Down line,” “Extend line,” “Retract line,” etc.



**Figure 3-1** Typical Dual-Acting Hydraulic System (Pictorial Schematic)

1. The electrically driven pump (3) starts turning and draws fluid from the reservoir (1) and pushes it out into the system through the selector valve (5). Keep in mind that the system is already full of fluid. Since fluid is incompressible, pressure will start to build and the actuator (6) will start to move immediately to the left.
2. The fluid leaving the actuator (6) will go right back through the selector valve (5) to the reservoir (1).
3. The fluid entering the pump (3) also goes through a filter (2) to keep debris out of the system.
4. The actuator (6) is moving a heavy object. The pressure in the system will only be as high as it takes to move the object. The heavier the object the higher the pressure.
5. As soon as the actuator reaches it's full travel, the fluid will have no place to go, so the pressure will build up immediately.
6. The pressure reaches 1200 PSI and triggers the pressure switch relief valve (7).
7. The pressure relief valve (7) set at 1200 PSI would function and bypass fluid back to the reservoir, to prevent damage to the system.

This is close to a typical system found in an RV.



**Figure 3-2** Single Acting System

### 3-1.1 REVIEW OF IMPORTANT CONCEPTS

- 1 A PUMP DISPLACES VOLUME AND DOES NOT CREATE PRESSURE. WHEN ACTUATORS ARE MOVING, THE SYSTEM PRESSURE WILL ONLY BE AS HIGH AS IT TAKES TO DO THE WORK. WHERE MUST BE NO AIR IN THE SYSTEM. AIR IS COMPRESSIBLE. IF AIR IS IN THE SYSTEM, THE SYSTEM WILL BE SPONGY AND MAY CAUSE CAVITATION. LOW HYDRAULIC FLUID MAY ALSO CAUSE CAVITATION BECAUSE LOW FLUID WILL ALLOW AIR TO ENTER THE LINES.
- 2 ON DUAL-ACTING SYSTEMS, WORKING LINES ALTERNATE BETWEEN
- 3 PRESSURE AND RETURN. THE WORKING LINES
- 4 ARE USUALLY NAMED BY WHAT THEY DO UNDER PRESSURE (I.E., RETRACT OR EXTEND).
- 4 MOISTURE CONTAMINATES HYDRAULIC FLUID LEADING TO RUST AND PREMATURE WEAR OF COMPONENTS.

### 3-2 Schematic Symbols

Figure 3-3 depicts symbols that will be used to identify components on some manufacturer’s schematics

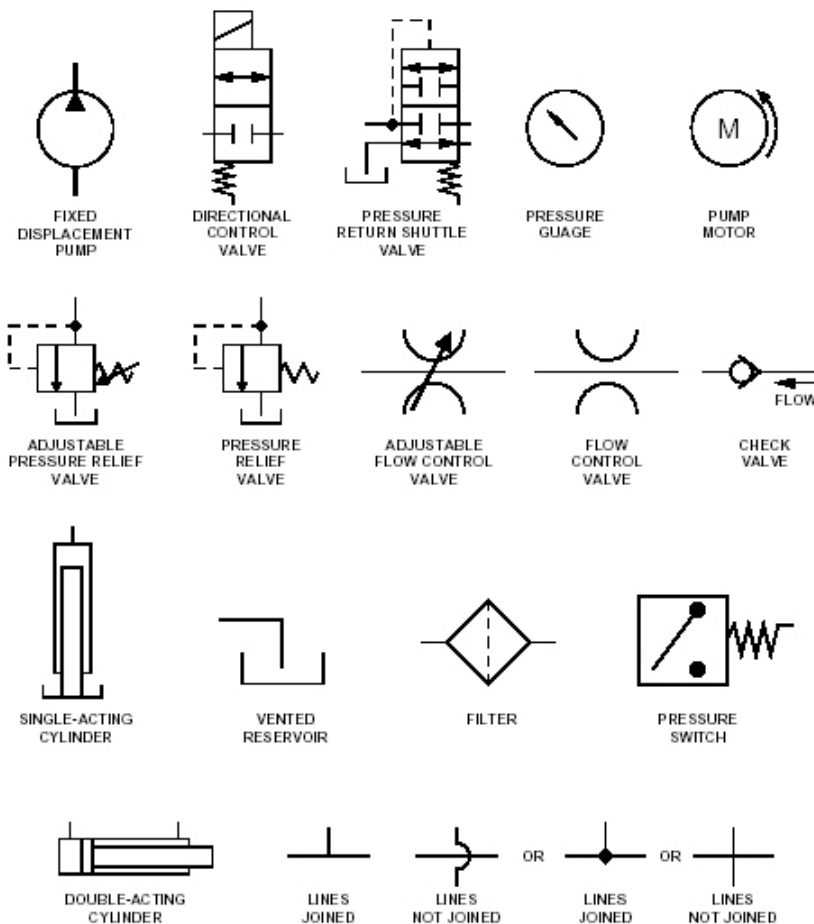


Figure 3-3 Schematic Symbols

## 3-3

## Safety

### 3-3.1

### Personal Protection Equipment

Safety glasses need to be worn at all times when working on a hydraulic system. This is to protect eyes from dirt, metal chips, high pressure fluid leaks, etc. Additional personal protection equipment should be worn in accordance with OSHA or local government requirements.

### 3-3.2

### Hydraulic Systems Safety Procedures

When a leak is noted, stop the equipment, relieve the pressure and repair the leak(s) as quickly as possible.

When routing or re-routing hydraulic hoses and related electrical wires, be sure they are not exposed to engine exhaust or any high-temperature components of the vehicle. Hoses must be kept away from heat source. If that is not possible, an adequate heat shield must be used. Hoses and electrical wires must be protected from sharp edges and other sources of chaffing. Avoid kinking and twisting of hoses.

**Note:** Never place your hand or other parts of your body over or near a hydraulic leak. Hydraulic fluid under pressure may cut and penetrate the skin, causing injury or even death.

Do not over-extend any cylinder of the RV leveling system. If the weight of the vehicle is removed from one or more wheels it places all the vehicle's weight on the hydraulic cylinder(s). This may cause cylinder failure and/or instability of the RV leading to personal injury or vehicle damage.

Operate all control levers or mechanisms to insure that the hydraulic system has been completely relieved of pressure.

Components subjected to excessive pressure may fail.

Loosen lines and components in a hydraulic circuit slowly to relieve any trapped pressure.

Accidental or intentional release of trapped fluid in hydraulic circuits may cause components or the RV to malfunction or fall suddenly.

Leveling systems are not designed for supporting the weight of the RV for servicing. Never work under an improperly supported RV, adequately rated jack stands must be used.

**Note:** Many hydraulic fluids are extremely flammable. Do not smoke around or work around hydraulic fluid near an open flame.

**Note:** Some hydraulic fluids can irritate or burn when they come into contact with the skin or eyes.

Be aware some levelers may swing up or down abruptly, when a footpad clears the ground or when extending.

**NOTE: BLOCK THE FRAME AND TIRES OF THE RV SECURELY BEFORE CRAWLING UNDER A VEHICLE. DO NOT USE A LEVELING SYSTEM OR AIR SUSPENSION TO SUPPORT VEHICLE WHILE UNDER THE VEHICLE OR WHILE CHANGING TIRES. THE VEHICLE MAY DROP OR MOVE WITHOUT WARNING, CAUSING INJURY OR DEATH.**

### **3-3.3 Test Pressures vs. Materials**

All hydraulic system components need to meet the requirements outlined in the component manufacturers installation instructions.

## **3-4 RV Hydraulic Leveling Systems**

The hydraulic leveling system for RVs is a hydraulic system that uses the basic components we discussed at the beginning of this chapter. The leveling system has a reservoir, a pump, selector valves and actuators. As the fluid is pressurized, the actuator extends and works to level the RV.

### **3-4.1 Necessary Cylinder Capacity**

Pivoting and straight-acting cylinders are available in capacities ranging from 4,000 lbs. (1818 kg.) per cylinder up to 24,000 lbs. (11000 kg.) per cylinder. Consult HWH specifications to determine the best combination of leveling cylinders for the application.

### **3-4.2 Proper Cylinder Leg Locations**

The leveling units should be mounted as close as possible to the front and rear axles. Check leveling unit and chassis manufacturer installation specifications for exact mounting position requirements.

Kick-down levelers must be positioned so that they swing up toward the rear when retracted. This allows the legs to kick up when the vehicle moves forward.

Each leveler must be mounted so that when it is in a vertical retracted position (not extended) there is adequate clearance between the ground and the footpad. Adequate clearance should be provided in accordance with component manufacturers specifications. Measurements should be determined when the vehicle is loaded to the stated GVWR.

### **3-4.3 Proper Mounting Height/Brackets**

The kick-down type of levelers is much easier to mount than the straight-acting leveler, especially in tight situations. Kick-down levelers are rarely damaged if the RV is inadvertently moved with the levelers down. The straight-acting levelers have a much larger footpad for greater stability. Make sure installations are done not only according to the component manufacturer's instructions, but also chassis manufacturer's recommendations.

The side of the frame is the best place to mount the levelers. Mounting brackets should be placed on the frame to allow cylinder adjustment upward or downward. It is important to place the bracket at the proper height to give the system maximum ground clearance.



If a suitable mounting position cannot be located on the outer side of the frame, a special mounting adapter may be fabricated that fastens to the inside of the vehicle frame before the mounting bracket is welded or bolted on.

### 3-4.4 Proper Bracket Welding Procedures

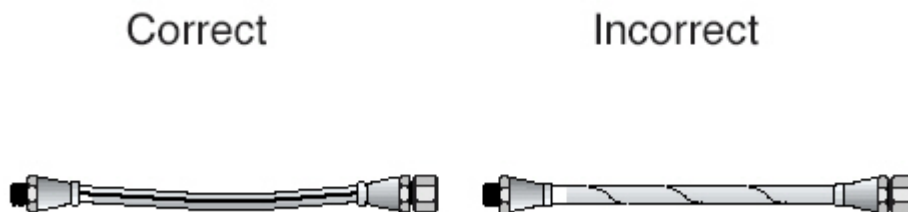
- **DO NOT WELD ON VEHICLE UNLESS APPROVED BY MANUFACTURER.**
- All batteries must be disconnected prior to welding in accordance with standard battery welding procedures.
- When the mounting bracket is welded to the frame, use caution to avoid all wiring, fuel lines or brake lines.
- Welds should not be made within 1/2 inch radius of the chassis frame rail.
- Check all chassis manufacturer and installation manual specifications for welding on chassis frame rails.
- Connecting welding ground to the part to be welded will minimize electronic failures.

### 3-4.5 Proper Bolt On Procedures

- Mounting brackets often bolt right in, using holes provided by the chassis manufacturer.
- If drilling is required, use caution to avoid all wiring, fuel lines or brake lines.
- Bolt size and grade must meet or exceed leveler manufacturers specifications.
- Tightening of bolts should meet all manufacturers installation and torque specifications.

### 3-4.6 Routing of Hydraulic Hoses

- In installations where the hose ends do not move in relation to each other, there needs to be slack in the hose to prevent strain. Hoses installed where they are tight or stretched tend to bulge and weaken under pressure.

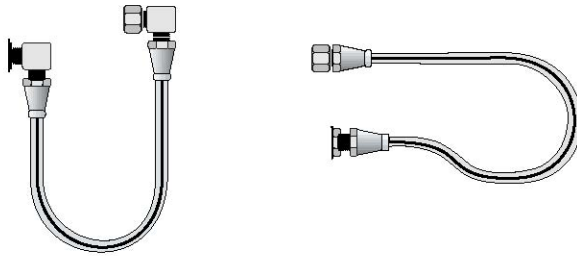


**Figure 3-4** *Avoid Taut Hose*

- Prevent long loops by using angled fittings at the termination points. This helps to cut down on the length of hose needed. It also helps make a neater, overall installation. Pre-manufactured hose excess should be installed in a secure manner to prevent kinking.

Correct

Incorrect

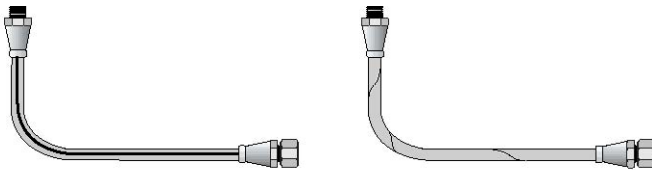


**Figure 3-5** *Avoid Loops*

- Twists in the hosing can restrict the flow of hydraulic fluid and can cause the hose to weaken. Twists can also lead to loosened fittings. These situations can happen during installation or during equipment usage. Back-up wrenches must be used to avoid twisting of the hose during installation.

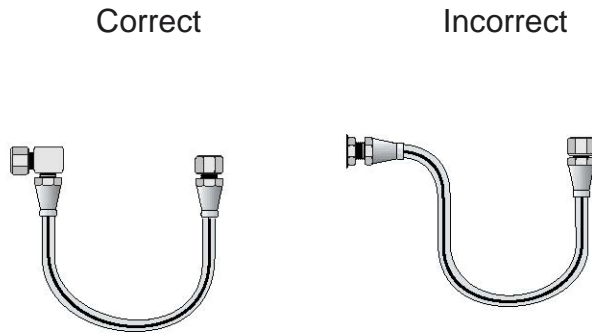
Correct

Incorrect



**Figure 3-6** *Avoid Twisting*

- Hoses should always be routed away from moving parts or sharp edges where they can rub or chafe. In some cases, protective clamps, brackets, or grommets may be needed to keep the hoses in their proper position(s).
- When routing hydraulic hoses, be sure they are not exposed to engine exhaust, or any high temperature components of the vehicle. It is recommended that hoses be located away from any heat source. If separation is not possible, you may need to construct a baffle with heat resistant material between the hose and heat source to protect the hose.
- The bend radius of a hose depends on the hose's construction, size, and pressure. Hose manufacturers typically provide a minimum radius. Sharp bends in the hose can limit the system pressure, reduce the work force available, and can lead to hose rupture or other type of failure.



**Figure 3-7** *Avoid Sharp Bends*

- Support long runs of hydraulic hoses. This will also help protect the fittings from excessive strain. Ensure installation of hose support brackets meet manufacturers specifications.
- Ensure proper clearance is provided for all hoses during operation cycle (i.e., slide room extension and retraction).

### 3-4.7 Routing of Electrical Wires

Route and connect all system wiring as required by the device's installation instructions and applicable code specifications.

Use the correct tools for all crimping operations and correct gauge wire for all extension splices. Exercise care when removing cable jackets and insulating coverings to insure wires are not damaged.

When routing electrical wires, be sure they are not exposed to engine, exhaust, high-temperature components, or any sharp edges on the vehicle.

### 3-4.8 Pump Manifold Assembly Location

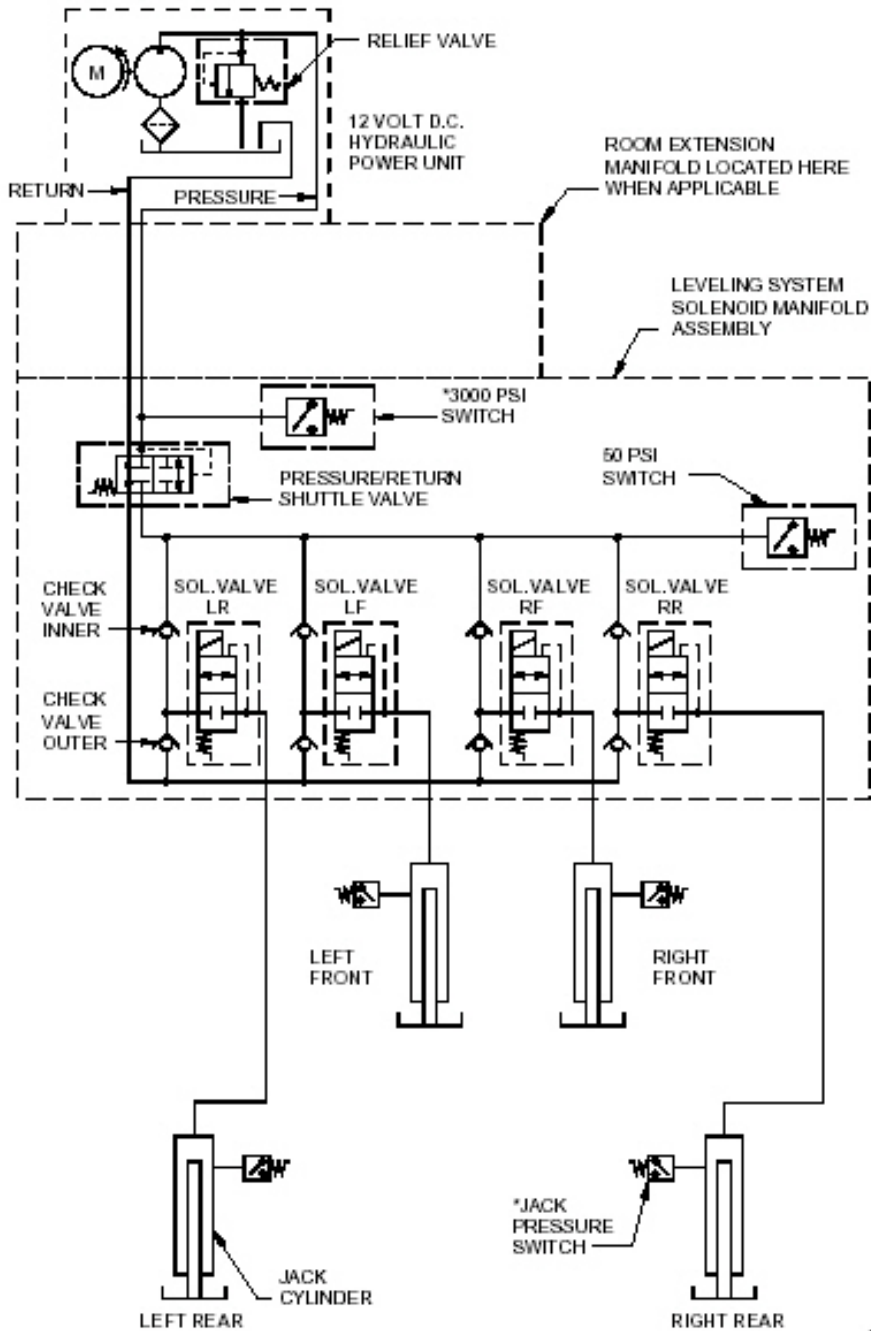
Pump manifold assembly must be located in an area protected from the elements and high temperature components (i.e., exhaust). Location must be capable of supporting the weight and accessible for service.

It is recommended to have the pump as close to the power source as possible.

Figure 3-10 shows a typical schematic using hydraulic symbols. Notice the cylinders are plumbed in parallel, which is more normal. The dual cylinder portion of the schematic, shows a synchronizing valve in the system to cause the actuators to move together. In some systems the synchronizing valve is called a proportional valve. The cylinder extend and retract valves are solenoid selector valves discussed previously.

### 3-5 Hydraulic Room Extensions

#### HYDRAULIC SCHEMATIC BI-AXIS LEVELING WITH STRAIGHT-ACTING JACKS



\* USED ON AUTOMATIC SYSTEMS ONLY

MP65.601C  
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Figure 3-9 Typical Hydraulic Leveling System Symbol Schematic.

# Chapter 3 Basic Information for Performing Hydraulic System Maintenance

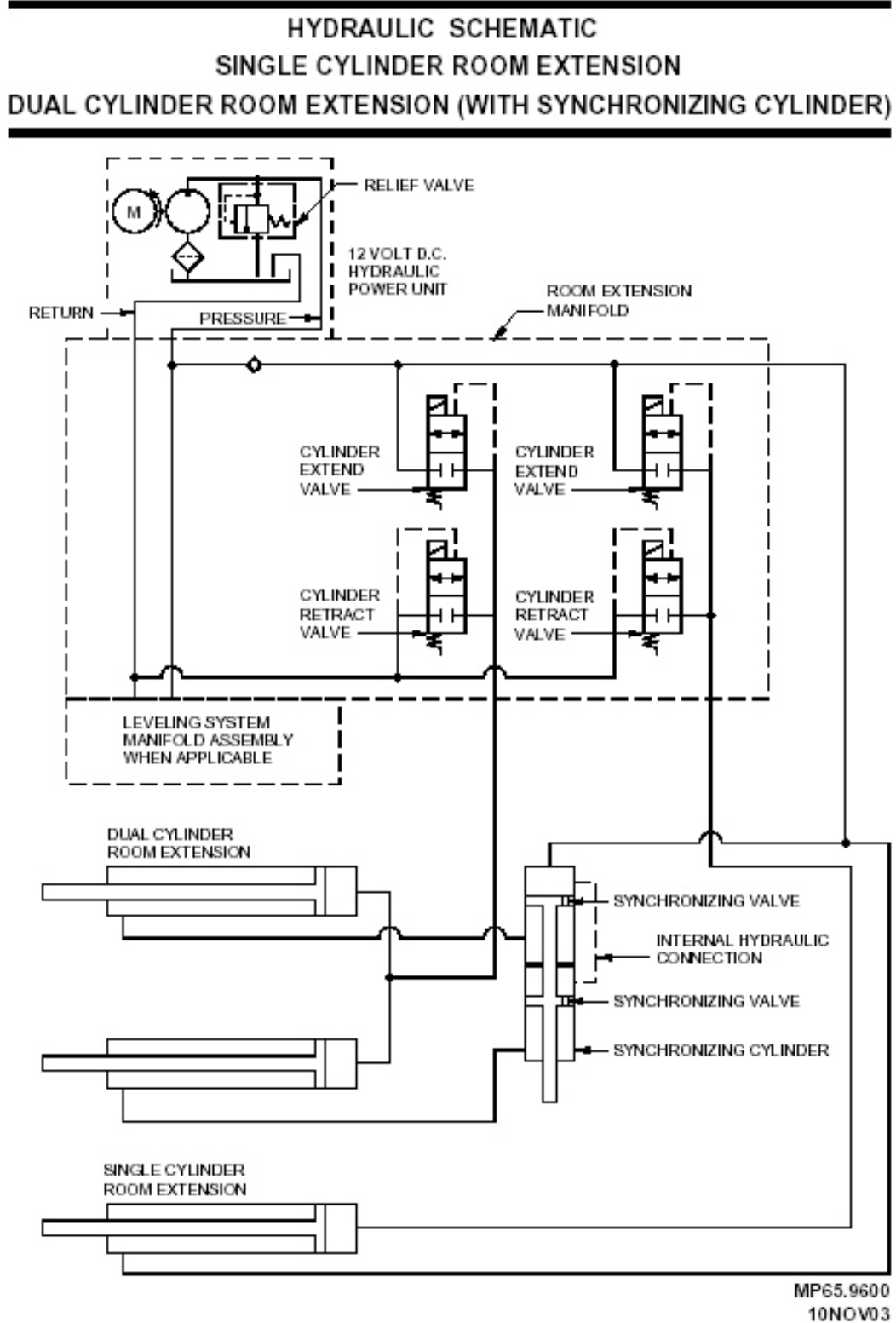


Figure 3-10 Typical Hydraulic Room Extension Symbol Schematic.

### 3-5.1

## Adjustment of Extension Cylinders

All adjustments or reinstallation of cylinders must be made in accordance with manufacturers specifications. Improper alignment of a cylinder may cause damage of the room or cylinder.

### 3-5.2 Proper Room Sealing

The room extension mechanism is critically important. If the adjustment of a room are even slightly off, the room may not seal completely in the extended or retracted position.

### 3-5.3 Cantering of Room

Cant is the leaning or tilt of an object, especially sideways. It is caused by improper alignment of cylinders, rails and extensions caused by poor installation or wear and tear. Some room extensions may require periodic adjustment. Check manufacturer specifications for correcting this condition.

### 3-6 Bleeding the System

Bleeding of the system is the process of removing all air from the system and replacing it with appropriate hydraulic fluid. Air in cylinders and hydraulic lines will cause erratic system operation.

Prior to initiating the bleeding process, verify that all the fittings on the cylinder(s) and the manifold have been tightened to manufacturers specifications. The entire system must be filled with hydraulic fluid during the bleeding process. Check that the cylinders are fully retracted and fill the reservoir. **IT IS IMPORTANT TO FOLLOW PROCEDURES OUTLINE IN HWH SERVICE MANUALS FOR A SPECIFIC SYSTEM.**

**NOTE: DO NOT RUN THE PUMP WITHOUT FLUID AS DAMAGE TO THE PUMP MAY OCCUR. DO NOT ENGAGE THE PUMP MOTOR FOR PERIODS GREATER THAN THIRTY (30) SECONDS AS PUMP DAMAGE MAY OCCUR.**

## 3-7 Servicing and Maintaining the Hydraulic System

Hydraulic systems should be routinely checked as part of a regular scheduled vehicle maintenance program. It is recommended that the system be checked twice a year: in the spring, prior to the heavy travel season, and in the winter, prior to storage.

**Note:** During periods of vehicle inactivity and/or storage, the hydraulic system should be activated and cycled through the extending/ retracting procedures on a monthly basis to keep the actuators in good operating condition.

- Make sure the actuators are in the retracted position, remove the breather cap on the reservoir and check the fluid level in the reservoir.
- Clean dirt off breather caps, filler plugs and surrounding areas prior to opening the system.
- Use clean, lint-free towels to wipe off dip stick. The fluid level should be approximately 1" below the top of the reservoir or as indicated by the dip stick.
- This standard provides an adequate amount of fluid for the actuators to operate efficiently.
- If the fluid is below this level, add a sufficient amount to bring the level up to the operating standard.

**Note: Do not mix fluid types.**

- Check the wiring and wire connections throughout the system; these should be tight and secure. Repair and replace as necessary.
- Check the valve manifold for any evidence of hydraulic fluid leakage. Replace any seals as necessary.
- Check the hydraulic cylinders, hoses and assemblies for any damage and/ or leakage. Replace and/or repair as necessary. Verify that all mounting bolts have been tightened to manufacturers specifications.
- Keep the work area clean. This is especially important when disassembling components.
- Clean components prior to installing or reinstalling them in the system.
- To help prevent corrosion when left exposed to the atmosphere, lightly coat with lubricant as necessary.
- Inspect all pivot points and lubricate as necessary.

## Troubleshooting

- Troubleshoot, clean, repair or replace other hydraulic RV components.
- Verify source voltage to pump and controls.
- Verify and maintain fluid level.
- Verify adequate ground.

### 4-1 RV Hydraulic Systems

**Table 4-1 Troubleshooting RV Hydraulic Systems**

Problem	Probable Cause	Testing Procedures
No actuators/cylinders will extend or retract	Improper operating procedures	Check operating manual for proper settings and procedures of ignition, emergency brake, transmission and other options.
	Improper DC voltage	Check for required 12 VDC as per manufacturers specifications at source, pump, solenoids and controls.
	Improper DC ground	Check all connections for good ground.
	Low fluid level	Check that the reservoir is full and the jacks are in the retracted position.
	Directional flow control valve blocked	Check flow control for foreign object obstructing the valve itself.
	Pump malfunction	Check for proper manufacturers operating pressure.



**Table 4-1 Troubleshooting RV Hydraulic Systems**

Problem	Probable Cause	Testing Procedures
One actuator/cylinder will not extend/retract	Improper DC voltage at solenoid	Check voltage at appropriate directional control valve.
	Bent or restricted cylinder	Check for damaged cylinder.
	Kinked or restricted hose	Check hose and fittings.
	Defective solenoid	Check solenoid operation.
	Defective retraction spring	Check spring tension and mounting brackets per manufacturer's specifications.
	Low fluid level	Check reservoir fluid level with cylinders retracted.
		Check for system leaks.
Actuators/cylinders operate slowly	Low fluid level	Check reservoir fluid level with cylinders retracted.
		Check for system leaks.
	Air in the system	Check system for proper bleeding procedures.
		Check for air leak between pump and reservoir.
	Improper DC voltage	Check for required 12 VDC as per manufacturer's specifications at source, pump, solenoids and controls.
	Improper DC ground	Check all connections for good ground.
	Kinked or restricted hose	Check hose and fittings.
	Filter or screen restricted	Check system filter and screen.
	Pressure relief valve stuck open	Check pressure relief valve.
One cylinder will not remain extended	The extend manual or solenoid valve is leaking.	Check valve.
	Cylinder has an internal leak.	Check cylinder seals.

**Table 4-1 Troubleshooting RV Hydraulic Systems**

Problem	Probable Cause	Testing Procedures
	Manifold check valve is leaking.	Test check valve.
	External fluid leak	Check for visual leaks.
	Foreign debris in system	Clean, flush and test system.
Room extension cylinder(s) creeps out	Thermal expansion	Check room locks.
	The extend manual or solenoid valve is leaking.	Check valve.
	Cylinder has an internal leak.	Check cylinder seals.
	Manifold check valve is leaking.	Test check valve.
	External fluid leak	Check for visual leaks.

## Glossary of Hydraulic Terms

**Accumulator:** A device for storing hydraulic energy.

**Actuator:** A device that converts hydraulic energy into mechanical energy. (e.g., cylinders, motors.)

**Aeration:** Air in the fluid.

**Cant:** The leaning or tilt of an object, especially sideways.

**Cavitation:** Air bubbles or pockets created in hydraulic lines and components by the turbulent flow of hydraulic fluid.

**Cylinder:** An actuator that converts hydraulic energy into linear or rotary mechanical energy. (NOTE: Rotary cylinders usually rotate less than one full revolution.)

**Displacement:** The volume of fluid is transferred from the pump inlet to the outlet during one revolution of the pump. Displacement is expressed in cubic inches per revolution.

**Energy:** The capacity for doing work.

**Filter:** A device that removes contaminants from the hydraulic fluid and is rated in microns.

**Flash Point:** The lowest temperature at which vapors from a volatile liquid will ignite.

**Force:** A push or pull that is exerted on an object in order to change its position or direction of movement.

**Fluidity:** Fluidity is the ability of the fluid to take the shape of the container it is in.

**Horsepower:** 1 Horsepower = 33,000 foot-pounds/one minute or 1 Horsepower = 550 foot-pounds/one second

**Hydraulics:** The study of fluids in motion or at rest.

**Hydrodynamics:** Devices or systems that use the impact or kinetic energy in the liquid to transmit power.

**Hydrostatics:** Devices or systems that use force applied to a confined fluid. Pressure is distributed over the area exposed to the fluid and is expressed in force per unit area (PSI).

**Incompressible Fluid:** A fluid which is not reduced in volume by an increase in pressure.

**Laminar Flow (Streamline):** The smooth and efficient flow of hydraulic fluid through hydraulic lines and components.

**Line:** A tube, pipe or hose for conducting a fluid.

**Liquid:** A fluid that is relatively incompressible. (NOTE: A gas is a fluid which is very compressible).

**Mass:** Represents the amount of matter in an object, and its inertia or resistance to movement.

**Micron:** A measure of size equal to one millionth of a meter, or approximately 0.000039 inch. Micron size is often used to describe the size of particles that a filter will remove from the fluid. For example, a 20 micron absolute filter is said to remove all particles greater than 20 microns.

**Motor:** An actuator that converts hydraulic energy into rotary mechanical energy.

**Non-positive displacement pump:** A pump in which the inlet and outlet are hydraulically connected, so that the fluid can re-circulate in the pump when pressure builds.

**Pascals law:** Pressure in an enclosed container is transmitted equally and undiminished to all parts of the container and acts at right angles to the enclosing walls.

**Positive displacement pump:** A pump that has the inlet sealed from the outlet.

**Power:** An amount of work (foot-pounds) done in a given amount of time (seconds or minutes).

**Pressure** The force exerted over a surface divided by its area.

**Pump** A device that creates the flow of hydraulic fluid. (NOTE: A pump converts mechanical energy into hydraulic energy.)

**Radial piston pump:** Where the pistons are set perpendicular to the pump's center, like sun rays.

**Reciprocating motion:** The movement of hydraulic fluid back and forth in cylinder bores through the use of pistons.

**Reservoir:** A container for keeping a supply of working fluid in a hydraulic system.

**Specific gravity:** The density or mass of a liquid. The specific gravity (SG) of a liquid is also its weight as compared to the weight of water in the same amount and at the same temperature.

**Thermal expansion:** The dimensional changes in increased volume exhibited by solids, liquids, and gases for changes in temperature while pressure is held constant.

**Valve:** A device that controls either pressure of fluid, direction of fluid flow, or rate of flow.

**Viscosity:** A measure of the fluid's resistance to flow.

**Weight:** A result of the gravitational force or pull on the object.

**Work:** Takes place when a force (in pounds) is moved through a distance (in feet).