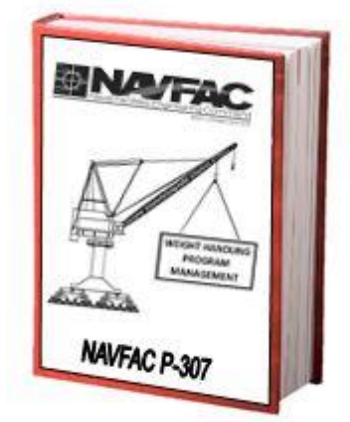
Navy Crane Center



NAVFAC P-307 Training

MOBILE CRANE MECHANIC

WEB BASED TRAINING STUDENT GUIDE

NCC-MCM-02

Naval Facilities Engineering Command
Navy Crane Center
Norfolk Naval Shipyard, Bldg. 491
Portsmouth, VA 23709-5000
Comm. Phone: 757.967.3803, DSN: 387
Fax: 757.967.3808
https://portal.navfac.navy.mil/ncc

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Introduction

Welcome

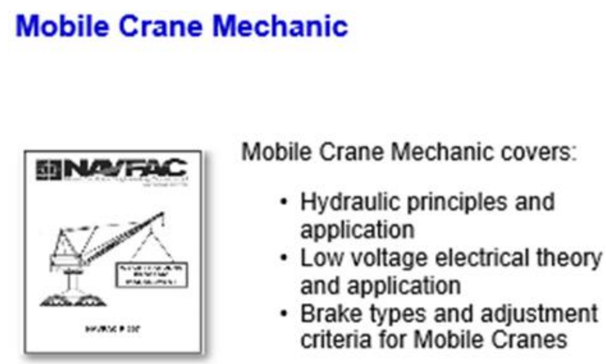
Welcome to the Crane Mechanic course.

Course Description

Mobile Crane Mechanic is designed to acquaint crane mechanics with Navy requirements for the safe mechanical maintenance of Navy cranes and provide a knowledge base on which to build with on-the-job experience.

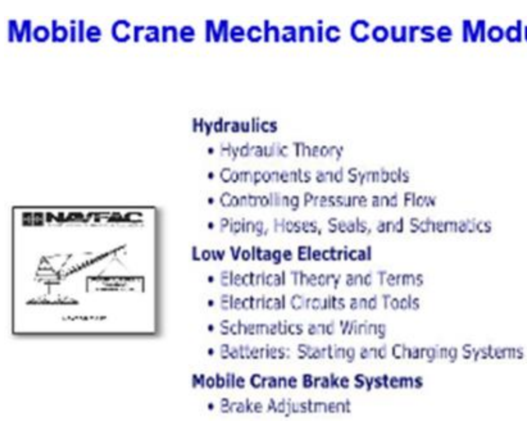
Topics Covered

In the Mobile Crane Mechanic course include basic hydraulic systems, low voltage electrical systems, and mobile crane braking systems.



Mobile Crane Mechanic Modules

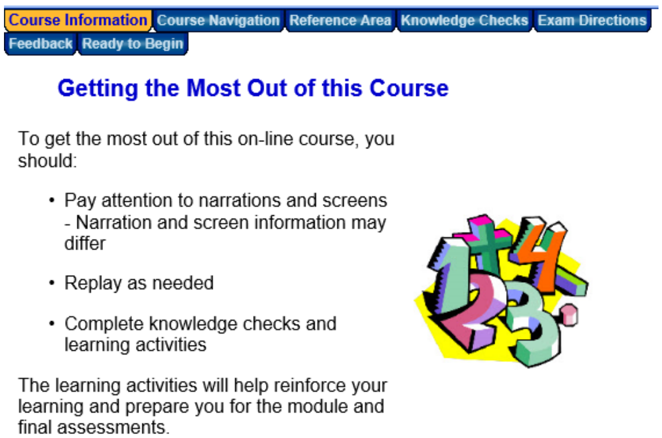
Here are the modules presented in the Mobile Crane Mechanic course.



Course Information and Navigation

These topics and screens are not needed for ILT.

These topics and screens provide guidance for trainees who take this training online.



Hazardous Energy Safety

Welcome

Welcome to the NAVFAC P-307 Mobile Crane Mechanic training module:

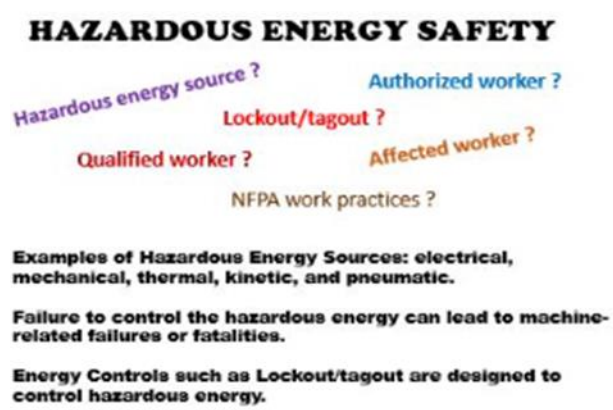
Introduction

Hazardous Energy Safety

What is hazardous energy? Hazardous energy is any source of energy (electrical, mechanical, thermal, kinetic and pneumatic) that can be hazardous to workers when discharged from a stored energy source. Failure to control the unexpected release of energy can lead to machine-related injuries or fatalities. The risk from these sources of energy can be controlled in a number of ways, including lockout-tagout policies and procedures.

Objectives:

Upon successful completion of this module, you will be able to define hazardous energy. You will know what questions to ask yourself to determine if you are fully trained and qualified to perform hazardous energy work. You will become familiar with several OSHA, NFPA, and Navy standard requirements. You will be able to explain the basic concepts of lockout-tagout. You will be able to define a qualified worker, authorized worker, and affected worker.



Job Work Hazards

How to identify the hazardous energy in your worksite?
Here are some examples, both general and specific, of the types of questions you may want to ask yourself before starting work.

Is there any electricity present? Is there pneumatic energy present? Is there kinetic (stored) energy present? Is there any other type of stored hazardous energy? If I disassemble this component, will there be any spring tension or pressure released? Before I release this brake is there an additional measure (second brake, tie back, bar in the drum, spud or wind lock, etc.) I can employ to prevent uncontrolled movement (of hoist, boom, rotate, etc.)? What could happen if I disassemble a component without control measures in place?

Is there any special PPE, tooling, guarding, training or procedures, supervision, etc. needed to mitigate the risks associated with accomplishing this type of work?

Qualified and Unqualified Persons

Crane mechanics work on many types of cranes. Most cranes have electrical systems that use either AC, DC, or both AC and DC. Mechanical personnel may work on mobile crane electrical systems. Most mobile cranes contain less than 50 volts. Regardless of the type of crane, work on any system 50 volts or greater, requires a qualified person (i.e., electrician). Crane mechanics working on cranes with 50 volts or greater are normally not qualified to perform work on these types of electrical systems. Working on systems with less than 50 volts does not require the same energy controls. You can refer to the NFPA 70E, article 130.2 (A) 3 for equipment operating at less than 50 volts. A qualified electrician is required when working on any electrical system that is 50 volts or greater. Your activity will determine who is qualified.

A qualified person is one who has received training in, and has demonstrated skills and knowledge of, the construction and operation of electrical equipment and installations and the hazards involved, and how to mitigate the electrical hazards of working on or near exposed energized parts.

An unqualified person is one who has received little or no training in these types of electrical hazards and does not possess the knowledge, skills, and abilities to work on these types of electrical systems.

Your activity determines who is qualified to perform work assignments.

Lockout/tagout (LOTO)

Lockout/tagout (LOTO) is a safety process used to secure potentially hazardous energy on machinery, equipment, or systems. It requires that hazardous energy sources be "isolated and rendered inoperative" to prevent the uncontrolled release of energy, prior to beginning maintenance or repair work. The hazardous energy sources are isolated, locked and tagged out in the proper position. The locks used identify with the worker that placed the lock on the isolation point. The worker holds the key to the lock and removes the lock when the work is complete. When lock(s) and tag(s) are removed, the system may be returned to normal operation. This prevents accidental release of hazardous energy or the potential start-up of a machine while maintenance is being performed.

Lockout/tagout is performed by authorized employees. Authorized employees are trained and knowledgeable on the equipment and system that they are working on. They understand the importance of lockout/tagout and they are authorized per the activity to install locks and tags. The activity determines who is an authorized employee.

What are affected employees?

Affected employees are those personnel who may be affected by the action of a lockout/tagout. This includes employees who normally operate or use the equipment or system that is going to be locked out or tagged out while maintenance is being performed. For example, personnel who use cranes as a tool to perform their everyday work and may be impacted (or affected) by a lockout/tagout.

Disconnecting or making the equipment safe involves the removal of all energy sources. This is commonly referred to as isolation. For example, mobile crane battery disconnects isolate the battery's energy from the crane's electrical system and may be considered an isolation point. The steps necessary to isolate equipment are often documented in an isolation procedure or a lockout tagout procedure. The isolation procedure generally includes the following tasks:

NOTE: The activity shall establish, document, and implement a lockout/tagout program.

• a. Announce shut off (warn affected employees)
• b. Identify the energy source(s)
• c. Isolate the energy source(s)
• d. Lock and tag the energy source(s)
• e. Prove that the equipment isolation is effective or it has reached a zero energy state.

Each activity shall establish, document, and implement a lockout/tagout program. The lockout/tagout program shall specify lockout/tagout procedures to safeguard workers from exposure to hazardous energy and the accidental release of these energy sources.

Standards and Procedures

There are several high level directives that must be followed which we will briefly discuss. Bottom line is that you will follow the local instructions, standard operating procedures (SOP), and original equipment manufacturer (OEM) manuals provided by your activity, etc.
The OSHA standard for the Control of Hazardous Energy (lockout/tagout) is found in 29 CFR 1910.147. This standard addresses practices and procedures necessary to disable machinery and prevent the release of potentially hazardous energy while maintenance or servicing activities are performed.

Other OSHA standards that contain energy control provisions are 29 CFR 1910.331, .332, and .333. In addition, some standards relating to specific types of machinery that contain de-energization requirements include 29 CFR 1910.179 (l) (2) (i) (c) which requires the switches to be "open and locked in the open position" before performing preventive maintenance on overhead and gantry cranes. The provisions of Part 1910.147 apply in conjunction with these machine-specific standards to assure that employees are adequately protected against hazardous energy.

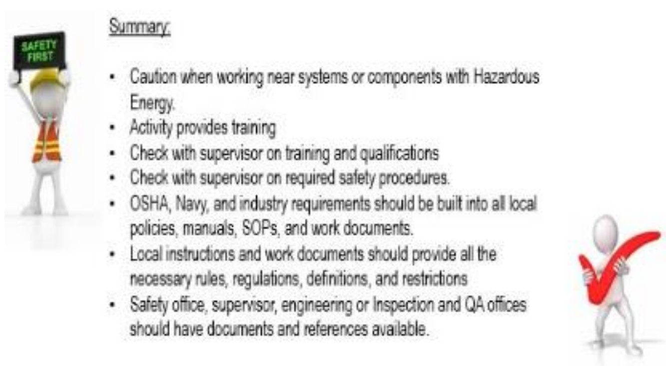
NFPA 70E addresses electrical safety work practices and is widely considered as the standard for Electrical Safety in the Workplace. This standard focuses on practical safeguards that also allow workers to be productive within their job functions. NFPA 70E Article 130.2(3) provides the work practices on systems or equipment with less than 50 volts.

The Department of the Navy issued OPNAVINST 5100.23, which includes Prevention and Control of Workplace Hazards, Energy Control Program (LOTO) and Weight Handling Equipment.

Summary

Use caution when working on or near systems or components that may contain hazardous energy.
Your activity provides the training necessary for employees to perform the work they are assigned. Always check with your supervisor to ensure you have the proper training, qualifications and tools to perform that work as well as any required safety checks and procedures.

Local safety policies, OEM manuals, SOPs, work documents, etc., developed by or for your activity will most likely have all the higher-level OSHA, Navy, and industry requirements built-in. Your local instructions and work documents should provide all the necessary rules, regulations, definitions, and restrictions that you need to know for the work you perform. Your safety office, supervisor, engineering or Inspection and QA offices should have these documents and references available.



NOTES:

HAZARDOUS ENERGY SAFETY OVERVIEW QUIZ AND SUMMARY

Knowledge Check

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select True or False.

Q: Failure to control the hazardous energy can lead to machine related failures or fatalities.

- ○ True
- ○ False

Check

Tries Remaining: 2

Select all that apply.

Q: Job work hazards include which of the following?

- ☐ Electricity
- ☐ Pneumatic
- ☐ Kinetic
- ☐ Spring tension

Check

Tries Remaining: 3

Select all that apply

Q: What are attributes of a qualified person?

- ☐ received training
- ☐ demonstrated skills and knowledge of equipment
- ☐ familiar with hazards involved
- ☐ activity will identify who is qualified

Check

Tries Remaining: 3

Select True or False.

Q: A unqualified person is one who has trained and possess knowledge, skills and abilities of the work that is being performed.

- ○ True
- ○ False

Check

Tries Remaining: 2

Select all that apply.

Q: Lockout/tagout (LOTO) is a safety process used to secure potentially hazardous energy...

- ☐ by preventing the uncontrolled release of energy, prior to beginning work
- ☐ when hazardous energy sources are isolated, locked and tagged in the proper position.
- ☐ and is performed by authorized employees.
- ☐ when locks and tags are removed, the system may be returned to normal operation.

Check

Tries Remaining: 3

Select True or False

Q: No activity shall establish, document, and implement a lockout/tagout (LOTO) program.

- ○ True
- ○ False

Check

Tries Remaining: 2

Select True or False

Q: Lockout/tagout (LOTO) programs shall specify LOTO procedures to safeguard workers from exposure to hazardous energy and the accidental release of these energy sources.

- ○ True
- ○ False

Check

Tries Remaining: 2

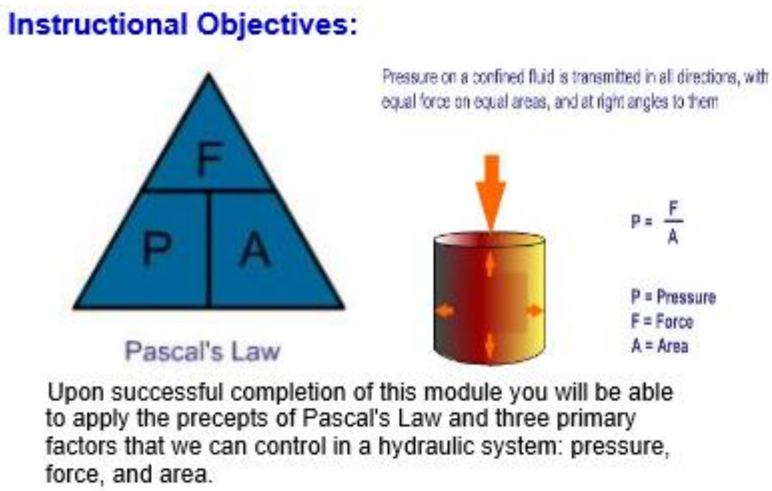
Hydraulic Theory

Welcome

Welcome to Hydraulic Theory

Instructional Objectives

Upon successful completion of this module, you will be able to apply the precepts of Pascal's Law and the three primary factors that we can control in a hydraulic system: pressure, force and area.



Hydraulic History & Theory

Hydraulic theory, dates back to the French Mathematician, Blaise Pascal. He discovered the principle of the hydraulic lever from which the science of pressure hydraulics is derived.

Joseph Bramah developed the original hydraulic press, using water as a lever. Today, hydraulic applications are limitless and hydraulic power is the work horse of many industries.

In this module, we will review basic hydraulic theory and application while focusing on the field of mobile crane hydraulics.

Control of Hydraulic Energy

There are three primary factors that we can control in a hydraulic system; the pressure in the system; volume of flow in the system and the direction of flow in the system.

Pressure

Pressure defines how much force is exerted against a specific area. An example is the air in your tires. The more air you squeeze in, the greater the pressure becomes.

The technical definition of pressure is force per unit area and is expressed as pounds per square inch or PSI. This is a measure of the force in pounds exerted against the area in square inches.

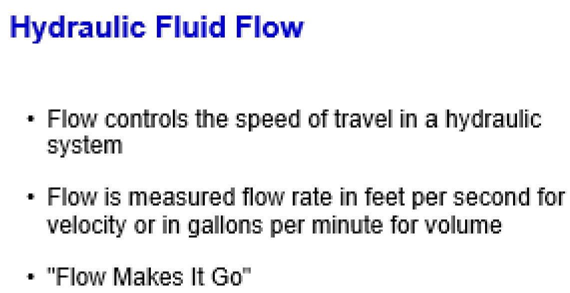
In hydraulic systems, pressure results when there is a resistance to the flow of hydraulic fluid. If there is no resistance to flow there will be very little pressure.

Hydraulic Fluid Flow

Flow controls the speed at which a component in a hydraulic system travels.

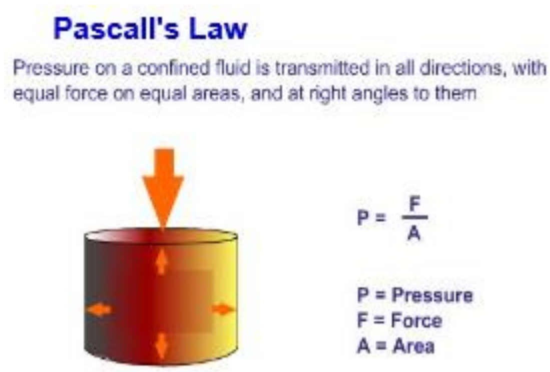
Flow is measured two ways. They are velocity, which is the speed of the fluid, usually measured in feet per second (FPS) and flow rate defined as the volume of liquid that passes a given point, and is usually measured in gallons per minute (GPM).

Remember: Flow makes it Go!!!



Pascal’s Law

Pascal’s Law states that “Pressure applied on a confined fluid is transmitted undiminished in all directions, and acts with equal force on equal areas, and at right angles to them.”



Hydraulic Lever

The principal of leverage in a hydraulic system is much the same as it is in a mechanical system, but instead of the difference in the length of the lever on either side of the fulcrum determining the multiplication of force, the difference in the areas of the two pistons determines the multiplication of force.

In this example, you have 5 pounds of force being exerted on a 1/2 square inch area. Using Pascal's Law, to determine pressure you would divide 5 by point 5 for a result of 10 pounds per square inch or 10 psi. To determine the amount of force the other end of the lever would develop, you multiply 10 psi of force by 10 square inches of area which results in 100 pounds of force.

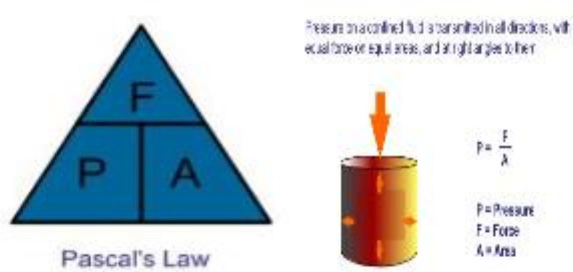
Hydraulic Lever

The difference in the areas of the two pistons determines the multiplication of force.

Summary and Review

In this module we have discussed Pascal's Law and the three primary factors that we can control in a hydraulic system: pressure, force and area. We also discussed the hydraulic lever and the multiplication of force.

Summary and Review



In this module we have discussed Pascal's Law and three primary factors that we can control in a hydraulic system: pressure, force, and area. We also discussed the hydraulic lever and the multiplication of force.

HYDRAULICS AND HYDRAULIC THEORY OVERVIEW QUIZ AND SUMMARY

Knowledge Check: Introduction

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

Note

KNOWLEDGE CHECK

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: Which of the following are not one of the three primary factors that can control in a hydraulic system?

- ○ Force
- ○ Volume of Flow
- ○ Pressure
- ○ Direction of Flow

Check

Tries Remaining: 3

Select the best answer.

Q: The speed at which a hydraulic cylinder travels is determined by what controllable hydraulic factor?

- ○ PSI of pressure
- ○ G.P.M. of flow
- ○ Pounds of force
- ○ Foot pounds of torque

Check

Tries Remaining: 3

Select all that apply

Q: What are two ways Hydraulic Flow is measured?

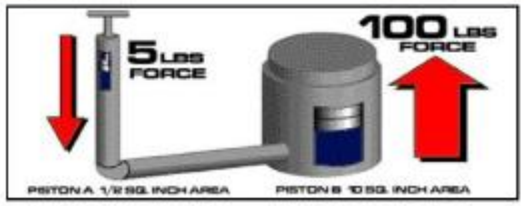
- ☐ Velocity measured in feet per second (FPS)
- ☐ Speed rate measured in Revolutions per minute (RPM)
- ☐ Flow rate measured in gallons per minute (GPM)
- ☐ The amount of force required in pounds per square inch (PSI)

Check

Tries Remaining: 3

True or False

Q: The principle of leverage in a hydraulic system is much the same as it is in a mechanical system, but instead of the difference in the length of the lever on either side of the fulcrum determining the multiplication of force, the difference in the areas of the two pistons determines the multiplication of force.



- ○ True
- ○ False

Check

Tries Remaining: 2

True or False

Q: Pascal's Law states that "Pressure applied on a confined space is transmitted in all directions with equal velocity on all areas, and at right angles."

- ○ True
- ○ False

Check

Tries Remaining: 2

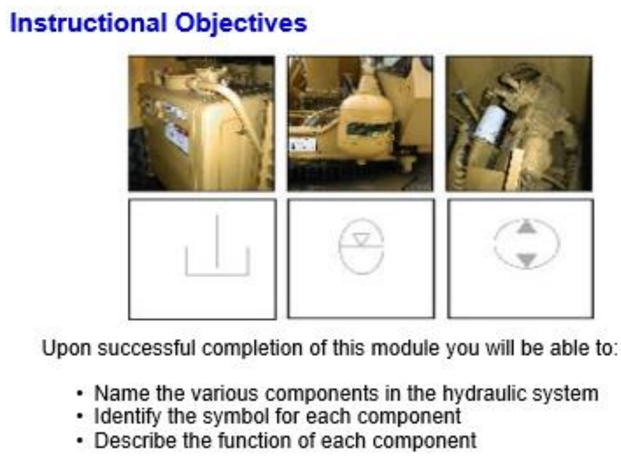
HYDRAULICS COMPONENTS SYMBOLS AND SCHEMATICS

Welcome

Welcome to Hydraulics - Components and Symbols.

Instructional Objectives

Upon successful completion of this module, you will understand the function of each component of a typical mobile crane hydraulic system and how the components interact to produce lifting capabilities. Also, the symbol used to identify components on a hydraulic schematic will be presented with their respective illustration.

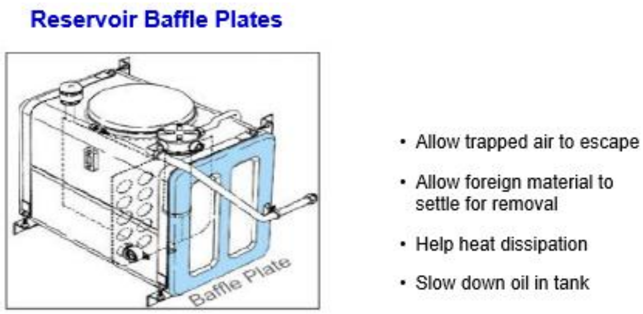


Reservoirs

A reservoir is a storehouse for the hydraulic fluid until needed by the system. A vented breather cap, containing air filtering material, is used on unpressurized reservoirs. On pressurized reservoirs, a breather is not used but is replaced by an air valve to regulate the pressure in the tank within preset limits. The symbols for typical reservoirs are noted.

Reservoir Baffle Plates

An important feature of a reservoir is the baffle plate. Baffle plates separate the reservoir outlet from the reservoir inlet so that the same fluid cannot continuously recirculate. Baffle plates provide a means for air to separate from the fluid, permit particulate contaminants to settle for easy removal, and help control/reduce fluid temperature. Instead, the fluid must take a slower, more meandering route through the tank.



Filters and Strainers

Filters and strainers keep the fluid in the system clean and are rated by micron size. The smallest particle an eye can see is 40 microns. When a filter/strainer is specified in microns, it refers to its nominal rating. A filter nominally rated at 10 microns, for example, would trap most particles 10 microns in size or larger. Its absolute rating, however, would be a somewhat higher size and in effect would be the size of the largest opening, possibly 25 microns. Absolute rating is important when particulate size is critical to the proper circulation of the system.

Filters and strainers may be located on the suction side, pressure side or return side of the system. If located on the suction side, they must be checked regularly to prevent pump cavitation. Cavitation will be discussed later. If on the pressure side, the housing must be adequate to withstand system pressure. If located on the return side the user must be aware that they do not protect system components.

Accumulator

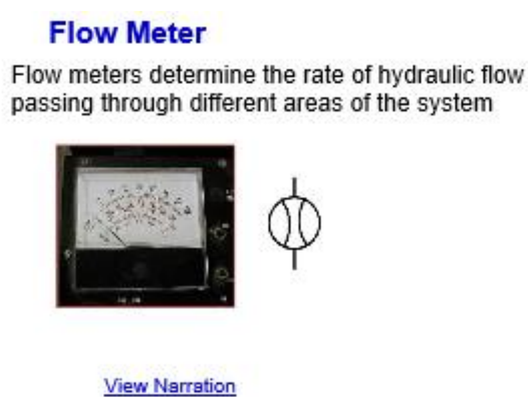
An accumulator provides a means of storing a non-compressible fluid under pressure. They also serve as a safety device on mobile cranes, allowing the crane to lower if the engine shuts down. Since they retain pressure even when the crane is shut down, the system must be bled before any work can be done.

The gas charged accumulator is the most commonly used type and is pre-charged with an inert gas, usually dry nitrogen.

Accumulators must be pre-charged while empty of hydraulic fluid and in accordance with manufacturer's requirements. They may also be installed to absorb shock or pressure surges due to the sudden stopping or reversing of oil flow.

Flow Meter

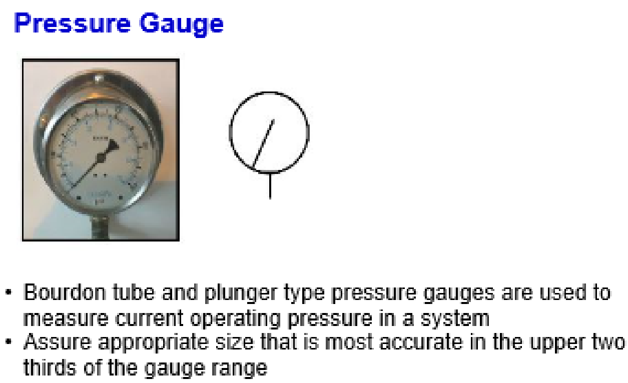
Flow meters are used to determine the amount of flow in gallons per minute passing through different areas of the hydraulic system. They are generally used to troubleshoot problems relating to pump output. Flow meters are seldom permanently mounted in a mobile crane system. A common mistake during use is measuring flow in the wrong direction.



Pressure Gauge

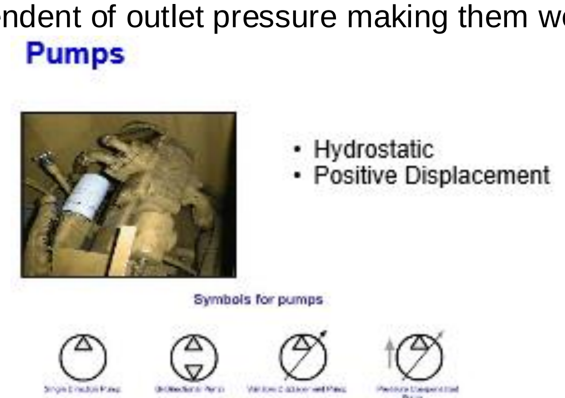
Two of the most commonly used pressure gauges are the bourdon tube and the plunger type. They are used to measure system pressure.

Pressure gauges must be sized appropriately for the system in which they are used. An example is a gauge with a maximum range of 1500 psi that should not be installed in a hydraulic system that normally operates at 1500 psi. A system operating at 1500 psi would require a gauge with an upper limit of 2,000 or 3,000 psi. The most accurate portion of a gauge is the upper two thirds of the scale.



Pumps

A pump takes the mechanical force provided by the prime mover and turns it into hydraulic flow and pressure. Hydrostatic or positive displacement pumps provide a given amount of fluid for every stroke, revolution, or cycle. Their output, except for leakage losses, is independent of outlet pressure making them well suited for use in the transmission of power.



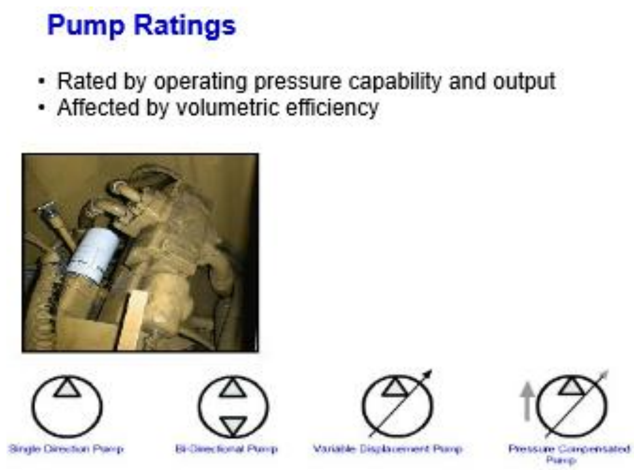
NOTE: Use extreme caution when operating a positive displacement pump with the discharge blocked or closed. The flow will go to zero and the discharge pressure will increase to its maximum for that pump. This is called the 'shut-off-head' (the highest point the pump will lift liquid and at which point the pump will pump zero gallons per minute). The pressure will continue to rise to a point where the integrity of the pump and the safety of personnel may come into question.

Pump Ratings

Pumps are generally rated by their maximum operating pressure capability and their output in gallons-per-minute at a given drive speed.

Volumetric efficiency is the percentage of theoretical output lost because of internal leakage or slippage and is equal to the actual output divided by the theoretical output.

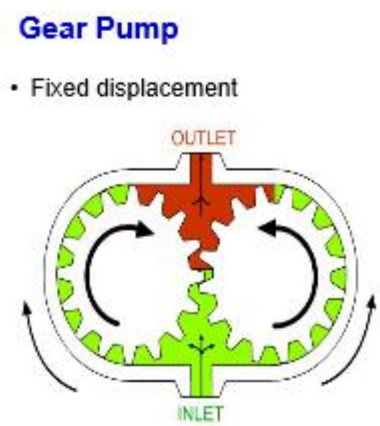
The symbols for pumps show the operating characteristics, but do not identify the construction of the pump.



Gear Pumps

Gear pumps consist of two shaft-mounted gears which turn in a housing. One shaft is driven by the prime mover of the hydraulic system (usually a diesel or gasoline engine). The gear attached to this shaft turns the gear on the idler shaft. When the gears turn, a low pressure area is created as the teeth separate and atmospheric pressure on the fluid in the reservoir forces the fluid into this area. The hydraulic fluid is carried around in the pump casing until it reaches the point where the teeth come together and then the fluid is forced out of the pump.

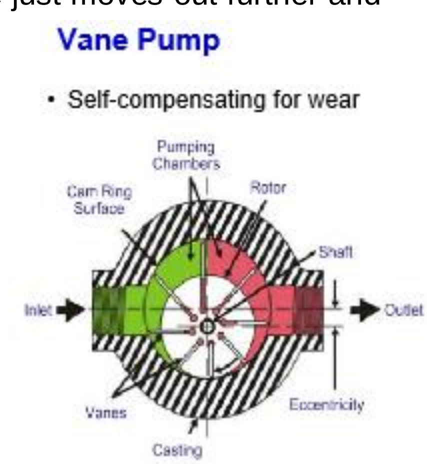
Most gear type pumps are fixed displacement. This means that for every rotation of the pump a set amount of fluid comes out. They range in output from very low to high volume.



Vane Pumps

The vane pump consists of a slotted rotor which turns inside of a ring. Flat plates, called vanes, fit into slots in the rotor and when the rotor spins they create a series of chambers in which the oil is carried around.

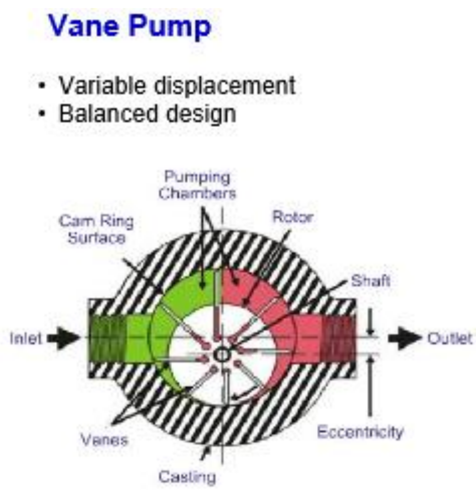
Vane pumps are self-compensating for wear, which means that as the tip of the vane wears down from rubbing against the outer ring, the vane just moves out further and there is no loss of efficiency as there is when a gear pump wears.



Vane Pumps (Continued)

Vane pumps can be manufactured to have variable displacement by making the outer ring shift back and forth under spring pressure so that the degree of eccentricity to the rotor and therefore the displacement can be varied. This type of pump can be used instead of having the full volume of a fixed displacement pump go over the relief valve in applications which need closed center valves.

Vane pumps are also manufactured in a balanced design with the rotor rotating in an elliptical chamber. This design is much easier on the shaft bearings because there is no side loading.



Piston Pumps

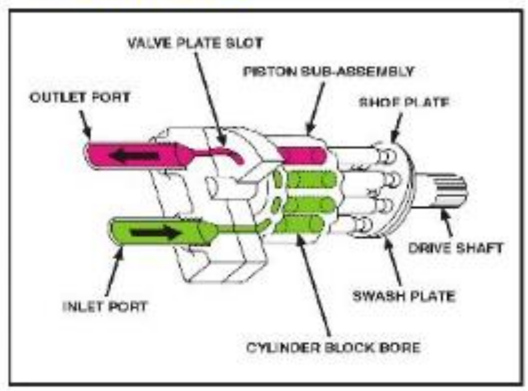
Piston pumps are manufactured in axial piston and radial piston configurations.

Axial piston pumps, as shown in the illustration on the screen, have pistons which move parallel to the axis of rotation and are more common in crane applications. They have a cylinder barrel with bores in it for the pistons. On the back end of each piston is a shoe assembly which rides on a swash plate as the barrel rotates. The angle of the swash plate determines how far the piston will travel in the bore. The greater the angle of the swash plate, the greater the displacement of the pump.

Radial piston pumps, not illustrated, have pistons which move perpendicular to the axis of rotation.

Due to the close tolerances in piston pumps, they produce high pressures and require very clean fluid to limit heat rise.

Piston Pumps



- Axial
- Radial

Pump Suction

Proper pump suction is vital for an efficient hydraulic system. Atmospheric pressure charges the pump suction. If the pump suction is above the tank level, there must be a vacuum equivalent to the height of oil to lift the oil. If the vacuum is too high on the suction side the oil will vaporize, causing gas bubbles to form and collapse in the oil with considerable force when exposed to load pressure at the outlet. This problem is called cavitation.

Cavitation can cause damage that will impair pump operation and reduce its life. If fittings leak at the inlet, air at atmospheric pressure can be forced into the system. This air-oil mixture also causes a condition called aeration, which is different than cavitation. Excessive lift must be avoided and pump inlet lines should permit the oil to flow with minimum resistance.

Actuators

Actuators take the hydraulic flow and pressure and convert it into mechanical force to lift a load or turn a wheel and can be either linear or rotary

Linear actuators such as cylinders and rams give us force and motion outputs in a straight line.

Rotary actuators, or motors, produce torque and rotating motion.

Cylinders

The most common type of actuators are cylinders which are constructed of a barrel or tube, a piston and rod, two end caps, and suitable oil seals. The barrel is usually cast or seamless steel tubing and the interior is finished true and smooth. The piston rod is highly polished, usually hard chrome plated to resist pitting and scoring and is supported in the end caps by a bushing or polished surface. The cylinder's ports are built into the end caps. End caps may be threaded, welded, bolted, or flanged onto the ends of the tubes. Cylinders are rated by size and pressure capacity. Size includes the bore or piston diameter and the stroke length.

Cylinders

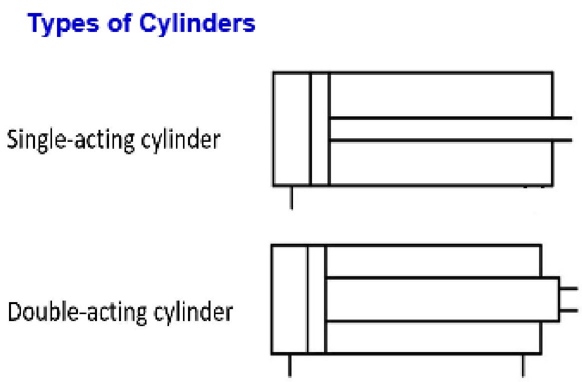
- Most common type of actuator
- Rated by size and pressure capacity

Types of Cylinders

There are several types of cylinders.

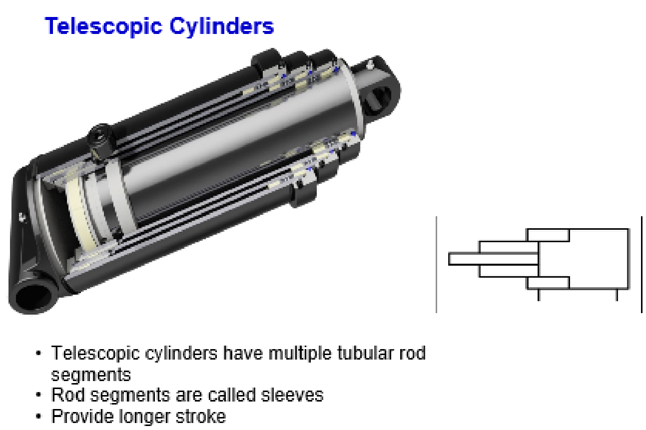
The single acting cylinder, also known as the ram type cylinder exerts force in only one direction. It is usually mounted vertically and retracts by the force of gravity on the load. In the ram type cylinder the piston and rod are all one piece of the same diameter.

The double-acting cylinder is operated by hydraulic fluid in both directions. It is classed as a differential cylinder because it will have more force extending than retracting due to the larger area of the piston. However, it will retract faster because the same volume of fluid is acting against a smaller area.



Telescopic Cylinders

Telescopic cylinders are equipped with tubular rod segments called sleeves. These sleeves work together to provide a longer stroke than would be possible with a standard or single rod cylinder of the same length. Maximum force is achieved when the telescopic cylinder is in the collapsed position. When the telescopic cylinder is fully extended the force is equal to the smallest sleeve.



Hydraulic Motors

Hydraulic motors are constructed much the same as hydraulic pumps except that instead of turning mechanical force into hydraulic flow and pressure, the motor converts hydraulic flow and pressure into mechanical force and motion. They are typically used on cranes in the hoist circuits, where the motor powers the winch, and in the swing circuit, where the motor rotates the upper works.

Motors can be either gear, vane, or piston type. The vane type motor must have a positive means of pushing the vanes out against the ring. The vane type pump uses centrifugal force to keep the vanes against the ring.

The symbol is the same as the pump symbol, except that the arrows point inward instead of outward.

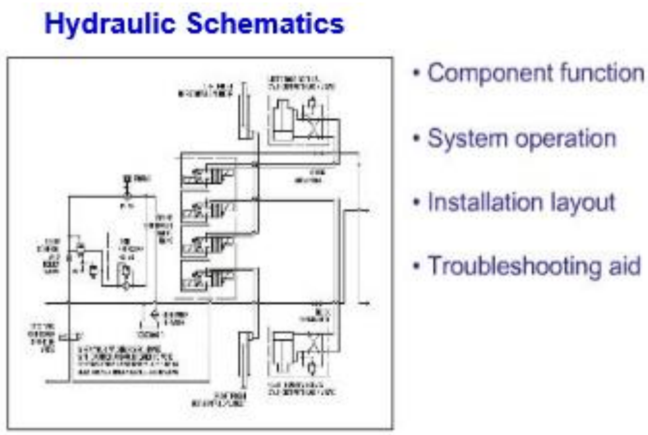
Hydraulic Motors

- Constructed like hydraulic pumps
- Gear, vane, and piston types

Bi-directional motor

Hydraulic Schematics

Similar to electrical schematics, hydraulic schematics, or circuits, identify the component and function in the circuit. Information essential to understanding the operation of the system, component relationships and general installation arrangements can also be found on the schematic. The schematic can serve as a trouble shooting guide. By tracing a given path, it is possible to see the affected valves and hoses and narrow the trouble down to the part or parts that might be causing the problem. The most typical type of hydraulic schematics use standard graphic symbols, with no attempt to show shape, internal construction or the exact location of the components. However, some are more complex and also show the construction and operation of the components. Hydraulic graphic symbols were previously reviewed in Hydraulic Components and Symbols. The schematic shown is a typical mobile crane schematic.



Review

In this lesson we found that the principal components in a hydraulic system are the reservoir, the accumulator, the pump, the motor and the actuator.

We also learned the function of each of these critical components and identified their standard symbol for identification on a hydraulic schematic.

HYDRAULICS COMPONENTS AND SYSTEMS OVERVIEW QUIZ AND SUMMARY

Knowledge Check: Introduction

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Choose all that apply.

Q: Baffle plates in fluid reservoir tanks allow:

- [ ] trapped air to escape
- [ ] heat to dissipate
- [ ] pressure buildup
- [ ] contaminants to settle

Check

Tries Remaining: 3

Select the best answer.

Q: What device changes mechanical force and motion into fluid power?

- ○ hydraulic line
- ○ pump
- ○ cylinder
- ○ reservoir

Check

Tries Remaining: 3

Select the best answer.

Q: Which component is self-compensating for wear?

- ○ relief valve
- ○ filter
- ○ vane pump
- ○ actuator

Check

Tries Remaining: 3

Select the best answer.

Q: An actuator changes hydraulic energy into mechanical force and motion. Which component shown below is a good example of an actuator?

- ○ gauge
- ○ cylinder
- ○ reservoir
- ○ relief valve

Check

Tries Remaining: 3

Select the best answer.

Q: Which item stores excess oil for the system allowing it to cool down, contamination to settle, and air to escape?

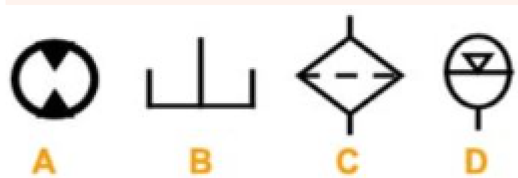
- ○ motor
- ○ reservoir
- ○ cylinder
- ○ filter

Check

Tries Remaining: 3

Select the best answer.

Q: Identify the correct symbol for a filter or strainer.



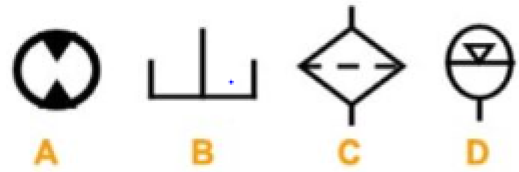
- ○ A
- ○ B
- ○ C
- ○ D

Check

Tries Remaining: 3

Select the best answer.

Q: Identify the correct symbol for a motor.



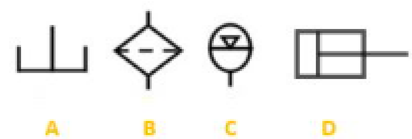
- ◯ A
- ◯ B
- ◯ C
- ◯ D

Check

Tries Remaining: 3

Select the best answer.

Q: Identify the correct symbol for a cylinder.



- ◯ A
- ◯ B
- ◯ C
- ◯ D

Check

Tries Remaining: 3

Select the best answer.

Q: What provides information essential to understanding the operation, general installation arrangement and troubleshooting of a hydraulic system?

- ◯ Schematic
- ◯ Operator log
- ◯ Crane nameplate
- ◯ Work schedule

Check

Tries Remaining: 3

NOTES:

CONTROLLING HYDRAULIC PRESSURE AND FLOW

Welcome

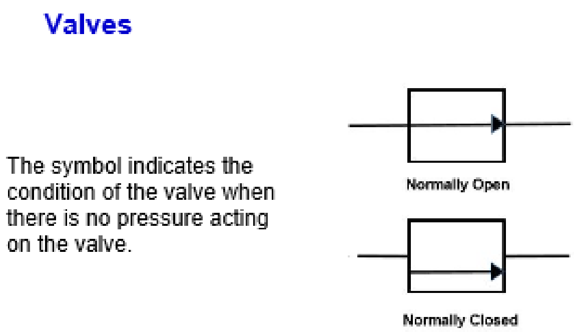
Welcome to Controlling Hydraulic Pressure and Flow

Instructional Objectives

At the end of this lesson, you will be able to identify the various means of controlling pressure and flow in a hydraulic system. Also, the symbol used to identify components on a hydraulic schematic will be presented on their respective illustration.

Controlling Pressure and Flow-Valves

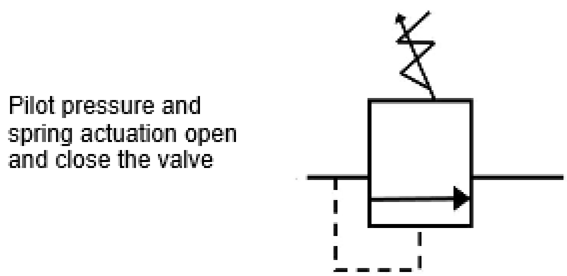
When valves are drawn schematically, the basic symbol is usually a box. Within the box will be an arrow representing the path of the flow of oil and lines indicating either a normally open or normally closed valve. This is the condition of the valve when there is no pressure such as pilot pressure acting on the valve.



Pilot Operated Valves

Pilot pressure is an auxiliary pressure used to actuate or control hydraulic components. On hydraulic diagrams pilot lines are indicated with a long dashed line. Pilot pressure often works against a spring force to open or close (pilot-to-open, pilot-to-close) a flow control valve. The internal component in the valve that the pilot pressure acts on is typically a pilot piston. In the diagram shown the squiggly line represents a spring and the diagonal arrow across it indicates that the valve is adjustable.

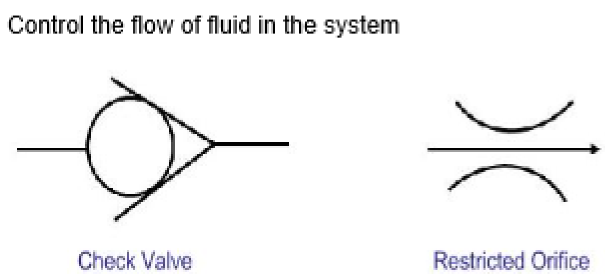
Pilot Pressure Valves



Flow Control Valves

Flow control valves control the flow of fluid in the system. There are various types of flow control valves, which are named according to the method by which they control the flow, as indicated here by the symbols for a check valve and a restricted orifice.

Flow Control Valves

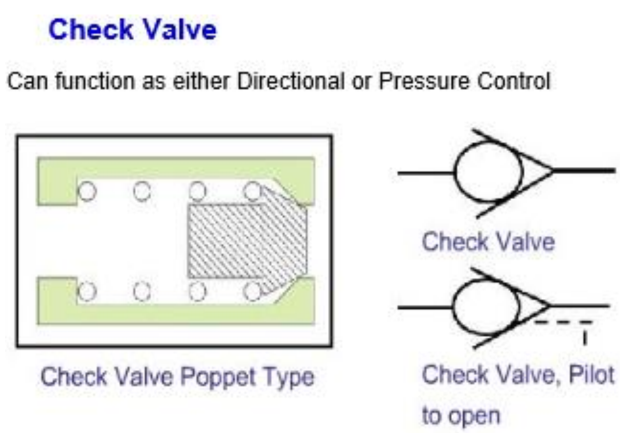


Check Valve

A check valve can function as either a directional control or pressure control valve.

A pilot operated check valve allows free flow in one direction. In the opposite direction, flow may only pass when pilot pressure unseats the valve's poppet.

Pilot operated check valves may be used as holding valves on some circuits. A good example of this is on a vertical outrigger cylinder circuit.



Restricted Orifice

A restricted orifice is a reduced opening in the fluid's flow path. They may be of fixed size, or they may be adjustable. A needle valve is an example of an adjustable orifice.

An orifice may be used to control the speed of a certain component in a system. These type of circuits are referred to as meter-in or meter-out circuits depending upon which side of the circuit the orifice is located.

Restricted orifices may be configured to be pressure compensated. Pressure compensated needle valves, for example, once set for a certain flow, will only flow that amount regardless of the pressure on the upstream side of the system.

Pressure Control Valves

Pressure control valves perform functions such as limiting maximum system pressure regulating reduced pressure in certain portions of a circuit, and other functions caused by a change in operating pressure.

Their operation is based on a balance between pressure and spring force. Most are infinite positioning because they can assume various positions between fully open and closed depending on flow rate and pressure differential.

They are classified by type of connection, size and pressure operating range and may be named for their primary function, such as relief valve, sequence valve, brake valve, etc...

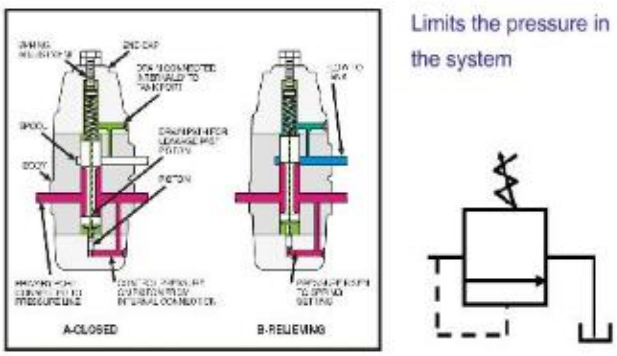
Relief Valve

The relief valve is found in virtually every hydraulic system. It is a normally-closed valve connected between the pressure line (pump outlet) and the reservoir. Its purpose is to limit the pressure in the system.

The pressure at which the valve first begins to divert flow is called the cracking pressure. Full flow pressure is when the valve inlet is passing its maximum volume.

The symbol for a typical, normally closed, infinite positioning Relief Valve with a pilot line is shown.

Relief Valve

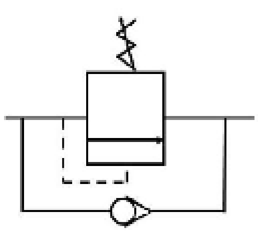


Counterbalance Valve

A directly operated counterbalance valve, positioned downstream from a cylinder supporting a heavy load, balances out the weight of the load. If the load tries to move faster than the fluid flow, the pressure will drop off in the upstream cylinder line as well as in the pilot line. The valve will close and allow the flow to catch up.

Counterbalance Valve

Balances the weight of the load



Brake Valve

A brake valve is a normally closed pressure control valve with both direct and remote pilots connected simultaneously for its operation. This valve is frequently used with hydraulic motors instead of a directly operated counterbalance valve.

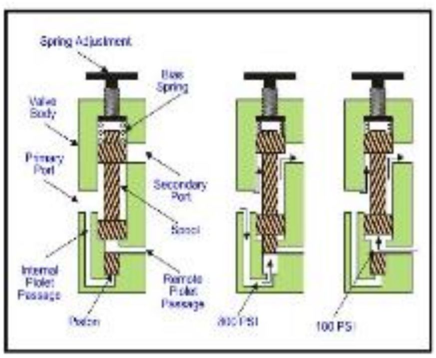
How A Brake Valve Works

In this cut-away drawing, you see the internal parts of a brake valve.

Assume that the spring biasing the spool is adjusted for 800 psi direct operation. When pressure in the internal pilot passage reaches 800 psi, the piston moves up, pushes the spool, and opens a passage through the valve. If the pressure falls below 800 psi, the valve closes. This operates as a directly operated counterbalance valve.

The piston on which the internal pilot pressure acts has much less cross sectional area than the spool. With the remote pilot connected to the opposite motor line a pressure of only 100 psi is needed to open the valve since it acts on the bottom of the spool with eight times more area than the piston.

How a Brake Valve Works



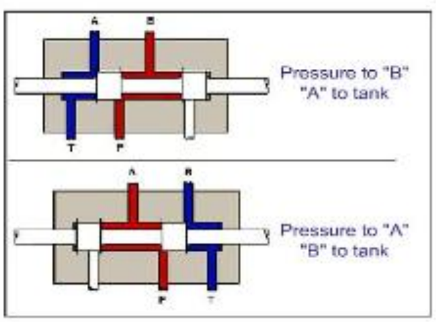
Directional Control Valves

Directional control valves are used to control the direction of flow. They vary considerably in construction and operation, and are classified according to the following principal characteristics: the type of internal element such as a piston or ball poppet and rotary or sliding spool; the method of actuation such as cams, plungers, manual lever, solenoid, pilot-operated hydraulic pressure, or any combinations of these; the number of flow paths; the nominal size of pipe connections to the valve or its mounting plate; rated gallon-per-minute flow; and/or the type of connection including pipe threads, straight threads, flanged, and back-mounted, which is sometimes referred to as gasket or sub-plate-mounted.

How a Directional Control Valve Works

This picture shows the basic operation of a directional control valve. The body of the valve is machine bored with several connecting passages. The spool diameters are precision ground to slide within the body with very little clearance. When spools cover a passage, no oil can flow past. The spools are undercut and as they slide, selected passages are uncovered. The oil is allowed to flow through the undercut areas and provide the required pressure or is routed back to the reservoir. Spool valves depend on metal to metal contact for sealing. The clearances are small and the sealing surfaces are very susceptible to damage from impurities in the system. Spool valves are not positive sealing valves.

How a Directional Control Valve (DCV) Works



Directional Control Valve Symbols

The directional control valve symbol is one of the most complex of the hydraulic symbols. It identifies many things about the directional control valve and how it works.

The first consideration is how many positions the valve will actuate. This valve is a three position valve. The position that the valve will be in when it is not being operated is called the center position. The lines outside of the boxes, which represent the connections to other parts of the system, will be connected to this box.

The next consideration is how many connections there are to the valve. This valve has 4 connections, which are often referred to as “ports” or “ways”. “P” is the pump connection. “T” is the tank or reservoir connection. “A” and “B” represent the connections to an actuator, like a cylinder or a motor.

Types of Directional Control Valves

There are two basic types of directional control valves: finite and infinite positioning. Most are finite positioning and control the path of the oil by opening and closing flow paths in specific valve positions. The symbol for a finite positioning directional control valve contains a separate envelope, or square, for each finite position, showing the flow paths in that position. Infinite positioning directional control valves have many positions between fully open and fully closed spool center conditions. Most three-position valves are available with a variety of interchangeable spools. Four-way spools provide identical flow patterns in the shifted positions, with different centered conditions. The symbols for infinite positioning direction control valves have lines over and under the boxes.

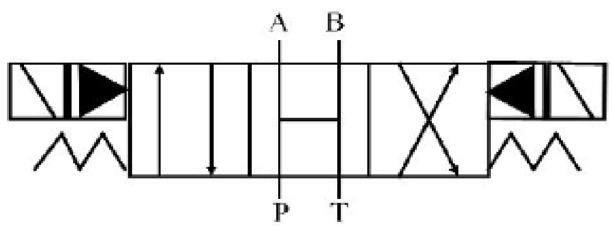
Directional Control Valve – Methods of Actuation

Directional Control Valve – Methods of Actuation
In this illustration we see the many ways in which a directional control valve can be actuated and their respective symbols. These symbols will be attached to the side of the directional control valve symbol. The actuation methods include push button, hand lever, foot pedal, mechanical, hydraulic pilot, solenoid, manual and spring operated.

Directional Control Valve – Consolidated Symbol

Putting it all together, the valve shown here is a three-position, four-way directional control valve with an open center condition, which is solenoid controlled, pilot-operated and has a spring return.

Directional Control Valve - Consolidated Symbol



Consolidated Symbol

Review and Summary

During this module, you learned how to identify the various means of controlling pressure and flow in a hydraulic system. Also, you learned how to identify components on a hydraulic schematic by use of standard symbols.

Controlling Hydraulic Pressure and Flow Overview Quiz and Summary

Knowledge Check: Introduction

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: What system component commonly controls pressure and flow in a hydraulic system?

- ○ Valves
- ○ Pilot spring
- ○ Hydraulic fluid
- ○ Hoses

Check

Tries Remaining: 3

Select the best answer.

Q: Which valve operates on a balance between pilot pressure and spring force?

- ○ Accumulator
- ○ Relief
- ○ Flow control
- ○ Directional Control

Check

Tries Remaining: 3

Select the best answer.

Q: Which system component limits the system operating pressure?

- ○ Directional control valve
- ○ Accumulator
- ○ Relief valve
- ○ Pressure control

Check

Tries Remaining: 3

Select the best answer.

Q: Which of the valves listed below control the flow of fluid in the system?

- ◯ Accumulator
- ◯ Pressure control
- ◯ Directional control
- ◯ Flow control

Check

Tries Remaining: 3

Select the best answer.

Q: Which valve controls the direction of the fluid flow in a hydraulic system?

- ◯ Pressure control valve
- ◯ Accumulator valve
- ◯ Directional control valve
- ◯ Flow control valve

Check

Tries Remaining: 3

HYDRAULIC LINES, SEALS AND FLUIDS

Welcome

Welcome to Hydraulic lines, Seals, and Fluids.

Instructional Objectives

Upon successful completion this lesson, you will be able to state the proper installation techniques for hydraulic system pipes, tubes, hoses and other critical system components. Also, you will learn how to correctly size and select an O-ring, state the precautions for proper storage and handling of hydraulic fluid, and, through the use of a schematic, be able to trace the flow of hydraulic fluid and troubleshoot system problems.

Hydraulic Lines

There are three types of lines used to move hydraulic fluid in a hydraulic system. These are steel pipe, steel tubing and flexible hoses.

Hydraulic Pipe and Tubing

Seamless steel pipe, or tubing, and high pressure synthetic hose, or tubing, are two products with sufficient design and material composition to handle the demands of conveying hydraulic fluid safely through a hydraulic system while avoiding the concerns associated with galvanized or copper lines. Galvanized pipe and fittings should be avoided because zinc can flake and contaminate the fluid and can react chemically with some oil additives. Copper tubing should be avoided because vibration in the hydraulic system can work-harden the copper and cause cracks at the flares. Also, copper decreases the life of the oil.

Helpful Hints for Lines

Dirty oil is a major cause of failure in hydraulic systems. As integral and vital components of any hydraulic system - piping, tubing, hoses and fittings must be kept very clean. These items must remain free of contaminants such as rust, dust, dirt and scale while in storage, during installation or when undergoing maintenance and repair work.

Hydraulic lines are susceptible to vibration and shock from sudden reversal of fluid flow. Damaged lines and loose connections can cause leakage, overheating and loss of hydraulic power. Replace damaged lines immediately and re-install all brackets and supports.

The function of a line can require specific precautions. For example: the pump inlet port, which is usually designed to be larger than the outlet port, should have a supply line equal in diameter to that of the port. Additionally, the supply line should be as short as possible and contain the minimum number of bends and fittings necessary to make the connection.

Hydraulic Hoses

Hoses offer flexibility and ease of installation. However, they sometimes wear more quickly and are more easily damaged than pipe or tubing. Replacement hoses may be manufactured on site by a qualified technician or they may be purchased to specification from the OEM or other approved vendor.

Why Do Hoses Fail?

Hose failure can result from many different causes. The root cause in most cases is improper routing which results in twisting, abrasion, heat damage, kinks and sharp bends. Care must be taken to install the proper length of hose in a path free of potential heat or rubbing damage. In addition, look for signs of cracking, splitting, pin hole leaks in the outer cover and incorrect hose or fittings. Finally, a noisy pump, lack of pressure, “spongy” operation, or no action at all, and may indicate a collapsed suction line. This occurs when the inner layer of the suction hose collapses sealing off flow through the line.

Replacement Hoses

Ensure that replacement hoses are properly rated and that the hydraulic fittings are compatible. Hydraulic fittings should be steel, except for inlet, return and drain lines, where malleable iron may be used. A good way to assure compatibility is to purchase the hose and fittings from the same manufacturer. Replacement hoses should be pressure tested. Also, they should be inspected before installation for loose bits of rubber remaining from the hose assembly process that can obstruct pilot passages and cause the system to malfunction. Swivel end connections will often provide for easier installation in tight places and reduce the potential for damage due to twisting.

Hose Installation

Proper hose installation techniques will help ensure long hose life. Avoid taut or stretched hoses that may cause swelling or weakening under pressure. Some slack in the hose will relieve strain and permit absorption of pressure surges.

Avoid twisted hoses that may weaken the hose and cause fittings to become loose. A stripe on the hose is provided to easily identify twisting. Avoid long loops that may expose hoses to interference with moving parts. Avoid sharp bends or kinks. Hose manufacturers provide a recommendation for the minimum bend radius.

Avoid heat and rubbing by routing hoses away from hot spots or moving parts. If they cannot be avoided, use appropriate protective shields and guards.

Hydraulic Fittings

Proper selection and installation of hydraulic fittings is critical to providing a clean, leak-free system. There are many different configurations of hydraulic fittings. Use manufacturer criteria to help you correctly identify fittings. Assure fittings and hoses are compatible. A good way to assure compatibility is to purchase the hose and fittings from the same manufacturer. Whether the fitting is a male or female fitting, it will usually have an angled seat. The most common fittings in hydraulic systems are 37-degree fittings. Pay particular attention not to mistake a 45-degree fitting with the same threads for a 37-degree fitting. Use manufacturer supplied gauges to determining fitting angles. Fluid piping systems in the United States are measured by dash numbers and are universal abbreviations for the size of the component. The dash number will be the numerator of the fraction with the denominator always being sixteen. For example, a dash-four port is four-sixteenths or one-quarter inch.

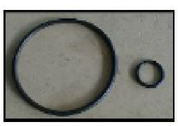
Hydraulic Seals

A well designed, correctly installed hydraulic system still depends on good seals to operate properly. Hydraulic seals are used to prevent fluid leakage within pressurized hydraulic systems, and to keep foreign material from entering systems when non-positive sealing (metal to metal contact) is ineffective. Hydraulic seals are principally used in two types of applications. One - they are used as static seals against non-moving parts, and two – as dynamic seals with parts in motion. Two examples of dynamic seals include the reciprocating motion of a piston to barrel seal in a cylinder and the rotary motion of a motor shaft.

O-Rings

One of the most popular hydraulic seals is the O-ring. An O-ring is generally made of synthetic rubber and is used in both static and dynamic applications. It is placed in a groove slightly less than the cross section of the O-ring and compressed between two surfaces as a method of closing off a passageway and preventing the unwanted loss or transfer of fluid.

O-Ring Selection Criteria



- Made of synthetic rubber
- Used in both static and dynamic applications
- Placed in a groove and compressed
- Prevents loss of fluid

O-Ring Selection Criteria

In order to determine the size of an O-ring, you must determine the cross sectional diameter and the inside diameter. This can be measured with a scale or caliper. However, due to the elasticity of the material, getting an accurate measurement is difficult. An O-ring cone, like the one shown, is much easier to use and results in a more accurate measurement. O-ring cones can be purchased from most hydraulic supply companies. O-ring material must be compatible with the fluid used in the system to avoid damage from corrosion, cracking or swelling during operation. Also, material hardness is important, especially in dynamic applications, in preventing damage from abrasion. Consult the fluid or O-ring manufacturer for further compatibility and selection information.

How to Size an O-ring

NAVFAC P-307 appendix M provides procedures for third party certifications performed by Navy Crane Center on Navy owned cranes, derricks, container spreaders and below-the-hook lifting devices. This includes a documentation review, condition inspection, load test, and the satisfactory completion of local certification requirements. NAVFAC P-307 section 4 provides additional certification information.

O-Ring Installation Tips

When installing O-rings, remember these tips: avoid rolling or twisting the O-ring when putting it in place; keep the position of the O-ring mold line constant; never force an O-ring over sharp edges such as corners, key-ways, slots, splines, or ports; and consider using a thin wall metallic sleeve, such as shim stock, for O-ring installation.

There are tools specifically made for the purpose of O-ring installation. These are normally made of brass or some other soft material. Special tools can also be made to suit specific purposes. Some suggested materials are Teflon, hardwood, hard plastic, or soft metal, such as brass.

T-Seals

T-seals are T-shaped as the name indicates and are reinforced with back-up rings on each side. They are used extensively in reciprocating dynamic applications like cylinder pistons and piston rods.

Lip Seals

A lip seal is a very popular dynamic seal, used primarily on rotating shafts. The sealing lip provides a positive seal against low pressure and is installed in the direction of the pressure source. The lip seal is not recommended for high pressure applications because it does not have the back-up support found in other seals. The part number is often embossed on a thin metal backing.

Piston Rings

The piston rings in a hydraulic system are used to seal pressure at the end of a piston in much the same way that they do in an automobile engine. They offer less resistance to movement than cup seals therefore keeping friction wear to a minimum. While they are good for high pressure applications, piston ring seals are not necessarily a positive seal and are more effective when used in combination with other similar seals. They are designed to allow some leakage for lubrication.

Packing

Packing can be used in either static or dynamic applications, but in many cases, has been replaced by other more effective types of seals. Packing is a twisted, woven, or molded material which is “packed” between two parts being sealed. Most molded packing is molded into either “u” or ‘v’ shaped rings with a diagonal split located somewhere on the ring (like a split lock-washer). When used in a stack, these cuts, or splits, should be staggered to form a good seal. If the packing gland is adjustable, it should be adjusted somewhat loosely at first so that the packing can wear-in. Adjusting packing too tightly can bind up the shaft, or cause premature wear.

Seal Life

Control over system operating conditions can be very important to seal life. These are some key operating factors that can help improve seal function:

Avoid Contamination: An atmosphere contaminated with moisture, dirt or any abrasive material shortens the life of shaft seals and piston rod seals exposed to the air. Protective devices should be employed in contaminated atmospheres. Equally important is clean fluid to avoid damage to internal seals.

Fluid Compatibility: Some fluids attack and disintegrate certain elastomer seals. Few seals, in fact, are compatible with all fluids.

Temperature: At extremely low temperatures, a seal may become too brittle to be effective. At too high a temperature, a seal may harden, soften, or swell. The operating temperature should always be kept well within the temperature range of the seals being used.

Pressure: Excess fluid pressure from overloads puts an additional strain on oil seals and may "blow" a seal causing a leak.

Lubrication: No seal should ever be installed or operated dry. All seals should be lubricated or they will wear quickly and leak. Leather seals should be soaked in fluid before installation.

Hydraulic Fluid

Hydraulic fluid has four primary purposes: power transmission, lubrication, sealing and cooling. In most hydraulic components, internal lubrication is provided by the fluid. Use fluids recommended by the crane manufacturer or as indicated by the activity engineering organization.

Proper Storage of Hydraulic Fluid

Store drums on their sides. If possible, keep them inside or under a roof. Before opening a drum, clean the top thoroughly so no dirt can get in. Use only clean containers, hoses, etc., to transfer the fluid from the drum to the hydraulic reservoir. An oil transfer pump equipped with 25 micron filters is recommended. Provide a 200 mesh screen in the reservoir filler pipe.

Review and Summary

During this lesson, you learned the proper installation techniques for hydraulic system pipes, tubes and hoses and other critical system components. Also, you learned how to correctly size and select an O-ring, understand the precautions for proper storage and handling of hydraulic fluid.

NOTES:

HYDRAULIC LINES, SEALS, AND FLUIDS OVERVIEW QUIZ AND SUMMARY

Review and Summary

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

True or False

Q: Check all hydraulic lines and other system components before installation to be sure they are clean inside.

- True
- False

Check

Tries Remaining: 2

True or False

Q: There is no need to clean the pipes or other hydraulic lines again after completion of cutting threads or flaring.

- True
- False

Check

Tries Remaining: 2

True or False

Q: Long, rigid hydraulic lines are susceptible to shock and vibration and should be supported.

- True
- False

Check

Tries Remaining: 2

True or False

Q: The O-ring material must be compatible with fluid in the system.

- True
- False

Check

Tries Remaining: 2

Select the best answer.

Q: Always store barrels in what position to prevent water from accumulating on the barrel top, potentially contMCM LSEnating the oil?

- ○ On the bottom
- ○ On the top
- ○ Upright
- ○ On the side

[Check]

Tries Remaining: 3

Select the best answer.

Q: When transferring fluid from one container to another, what precaution should be made with hoses and funnels?

- ○ They should be rubber.
- ○ They should be clean.
- ○ They should be new.
- ○ They should be synthetic.

[Check]

Tries Remaining: 3

Select the best answer.

Q: What area of the container should always be clean before opening a drum or other container of hydraulic fluid?

- ○ Bottom
- ○ Top
- ○ Sides
- ○ Nameplate

[Check]

Tries Remaining: 3

Low Voltage Electrical Overview

Welcome

Welcome to Low Voltage Electrical Overview

Instructional Objectives

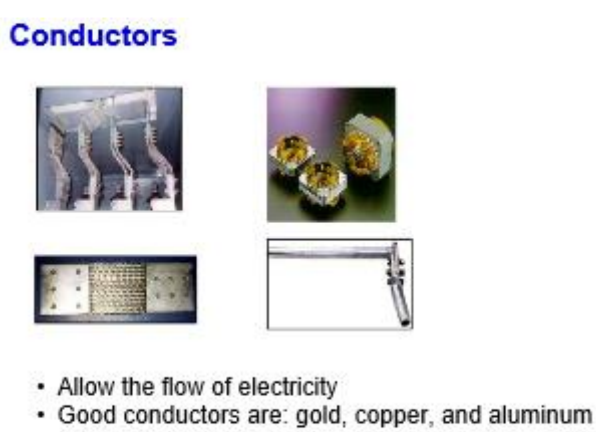
Upon successful completion of this module, you will be able to define electrical terms, determine if a material is a conductor or a non-conductor, and have an understanding of Ohm's Law.

Why Do Mechanics Need to Know Electrical Concepts?

Why does a crane mechanic who works with hydraulic, pneumatic and other mechanical systems need to know electrical concepts? The answer to that question lies in the fact that most mobile cranes have low voltage electrical systems, and the mechanic is often responsible for the electrical work on these systems. Also, a knowledge of correct wire sizes and crimping techniques ensures proper repair and installation. Finally, knowledge of electrical concepts and the ability to read schematics will aid the mechanic in troubleshooting.

Conductors

Conductors are materials which allow the flow of electricity. Examples of good conductors are gold, silver, copper and aluminum.



Non-Conducting Insulators

Insulators don't allow the flow of electricity. Examples of good insulators are plastic, glass and rubber.

Resistance - Ohms

Resistance in an electrical circuit is the opposition to the movement of electrons and can be thought of like an orifice installed in a hydraulic line. Resistance is measured in ohms. Resistors are devices made of materials that have specific ohm ratings and provide a consistent opposition to current flow. They are designed to allow an exact amount of resistance to be built into a circuit. Resistance in a circuit may also be the result of corrosion between connections. High resistance is especially problematic in low voltage circuits.

Voltage – Electromotive Force

Voltage, or electromotive force, is the difference in potential between two points. This potential is like “electrical pressure" that pushes electrons from the negative pole to the positive pole. Voltage can be compared to the pressure, or head, that causes water or gas to flow through a pipe. Electromotive force is measured in volts. One volt will cause one amp to flow through one ohm of resistance.

Current – Amps

Current, measured in amps or amperes, is the rate at which electrons flow when a potential difference exists between two points in an electrical circuit. It can be compared to the amount of water or gas that flows through a pipe in a given time period. In its simplest form, it is direct current and always flows in one direction. In order for current to flow, certain conditions must be present. First, a complete electrical circuit must be in place. Next, the circuit must be made up of materials which are good conductors. Finally, there must be a potential difference. For instance, the negative terminal of a battery has a surplus of electrons, while the positive terminal lacks electrons. This creates a difference of potential which will cause current to flow. Current flow is the amount of electrons flowing through a point in a period of time.

Ohm’s Law

In the early nineteenth century, George Ohm, pictured here, proved that a precise relationship exists between current, voltage, and resistance. This relationship is called Ohm’s Law. As shown here, “I” is current, “E” is voltage (which may also be represented by “V”), and “R” is resistance. So, if voltage is doubled and resistance stays the same, the amperage will double. Using Ohm’s Law, to determine volts you would multiply amps times ohms, to determine ohms you would divide volts by amps, and to determine amps you would divide volts by ohms. Ohm’s law simply states that “one volt will cause one amp of current flow through one ohm of resistance”.

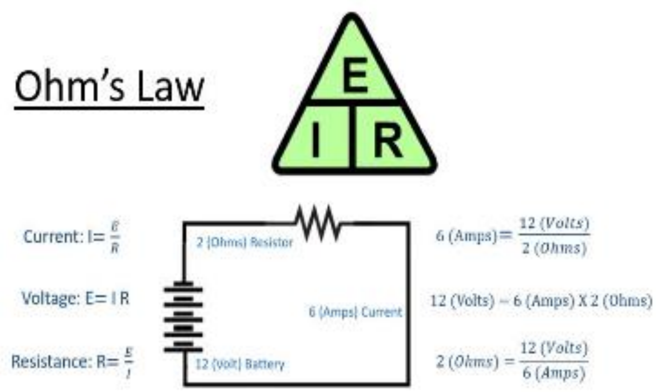
Ohm’s Law

Here is a simple battery circuit to show how to calculate for Current, Voltage and Resistance using Ohm’s Law.

To find Current (Amps) in this circuit we know it has 12 volts and 2 ohms of resistance. Per Ohm’s Law we have to divide the voltage (12) by the resistance in ohms (2), which equals 6 Amps.

To find the voltage in this circuit we know it has 6 amps and 2 ohms of resistance. Per Ohm’s Law we have to multiply the Amps (6) times the resistance in ohms (2), which equals 12 volts.

To find the Resistance in this circuit we know it has 12 volts and 2 amps. Per Ohm’s Law we have to divide the voltage (12) by the Amps (6) which equals 2 ohms of resistance.



Review and Summary

In this lesson, we learned that because many mobile cranes have low voltage electrical systems, it is important for mechanics to have a basic understanding of electrical concepts. You learned which materials are good conductors and insulators of electricity. Finally, you learned the basic precepts of Ohm’s Law and how to apply it.

NOTES:

Low Voltage Electrical Overview Quiz and Summary

Knowledge Check: Introduction

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: What term is used for the rate at which electricity flows?

- Electricity
- Resistance
- Voltage
- Amperage

Check

Tries Remaining: 3

Select the best answer.

Q: What term is used for the opposition to the flow of electricity?

- Resistance
- Amperage
- Electricity
- Voltage

Check

Tries Remaining: 3

Select the best answer.

Q: What term is used for the difference in potential between two points?

- Resistance
- Voltage
- Amperage
- Electricity

Check

Tries Remaining: 3

Select the best answer.

Q: What is defined as the basic unit of electrical current flow?

- ◯ ohm
- ◯ volt
- ◯ electron
- ◯ amp

Check

Tries Remaining: 3

True or False.

Q: A non-conductor is material which allows the flow of electricity.

- ◯ True
- ◯ False

Check

Tries Remaining: 2

True or False.

Q: Mechanics must have a fundamental knowledge of low voltage electricity and the equipment to effectively troubleshoot and maintain mobile cranes.

- ◯ True
- ◯ False

Check

Tries Remaining: 2

Select the best answer.

Q: You have a circuit with a 12 volt battery and a 4 ohm resistor. Using the principles of OHM's Law, what would the current flow be through this circuit?

- ◯ 6 amps
- ◯ 12 amps
- ◯ 3 amps
- ◯ 2 amps

Check

Tries Remaining: 3

LOW VOLTAGE ELECTRICAL CIRCUITS AND TOOLS

Welcome

Welcome to Low Voltage Electrical - Electrical Circuits and Tools

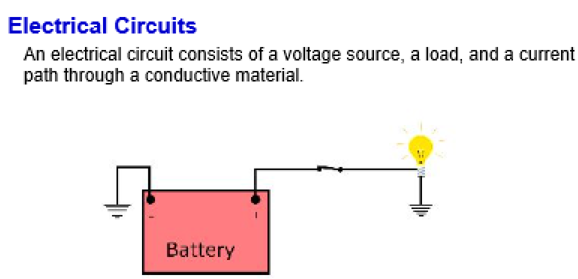
Instructional Objectives

Upon successful completion of this module you will understand the basic construction of series and parallel circuits. You will also be able to describe the proper operation of electronic testing and measuring instruments, including voltmeters, ohmmeters, ammeters, carbon piles and multi-meters.

Electrical Circuits

Every electrical system requires a complete circuit for it to function. A complete electrical circuit consists of a voltage source, a load, and a current path through a conductive material.

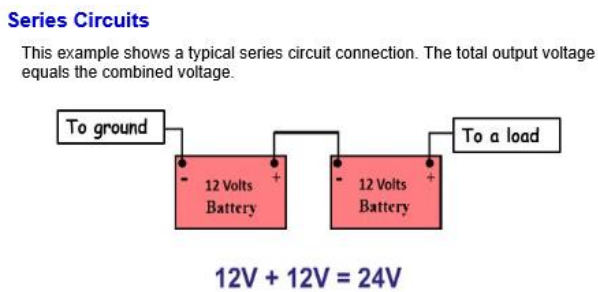
A complete circuit is simply an uninterrupted path for electricity to flow from its source through all the electrical components and back to its source.



Series Circuits

There are two basic electrical circuits, they are series and parallel. A series circuit is a closed circuit which allows the current to follow a single path. A parallel circuit divides the current flow into two or more paths.

Shown here is an example of two batteries connected in series. The positive pole of the battery on the left is connected to the negative pole of the battery on the right. The negative pole of the battery on the left goes to ground. The positive pole of the battery on the right will go to a load. The total output voltage will be the voltage of each battery individually and then added together. So, if each battery is 12 volts, the combined voltage will be 24 volts.

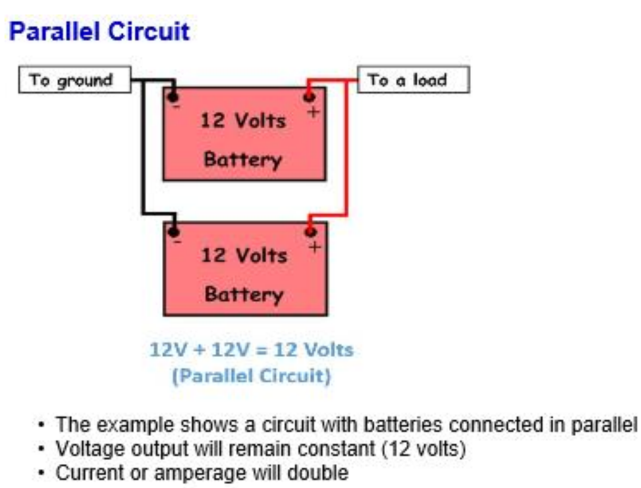


Parallel Circuits

Here is an example of a parallel circuit using two batteries.

The positive pole of the battery on the bottom is connected to the positive pole of the battery on top, and the negative pole of the battery on the bottom is connected to the negative pole of the battery on the top. The negative connections of the batteries go to ground. The positive connections of the batteries will go to a load.

When connecting a circuit in parallel the total output voltage will be the same as the individual battery voltage. So, if each battery is 12 volts, the combined voltage will still remain 12 volts, but the amperage output will be double.



Circuit Problem Areas

Short circuits, open circuits, and grounded circuits are three common problems found in malfunctioning electrical circuits. Understanding the causes of these problems will assist greatly in troubleshooting mobile crane low voltage systems.

Short Circuits

A short circuit is a failure in an electrical circuit which allows the current to bypass a part of the normal path.

Circuit Problem Area – Open Circuits

An open circuit is caused by an interruption, or break, in the continuity of the circuit, thereby preventing current flow. For a circuit to be complete, there must be a continuous flow to and from the electrical source.

Circuit Problem Areas – Grounded Circuits

A grounded circuit is a condition which allows current to return to ground before it has reached its intended destination. In circuit wiring that uses the frame of the equipment as a circuit conductor, a grounded circuit and a short circuit are basically the same.

Testing Instruments

Because you cannot see electricity, much of the troubleshooting of circuits must be done with testing and measuring instruments. Grabbing a wire to see if it’s energized is not smart . . . and not allowed. Test instruments will help you gather the information you need to safely and accurately maintain and troubleshoot electrical circuits.

Examples of information that can be found using test instruments are: evidence of current flow, the amount of voltage, and the amount of resistance present in a circuit.

Remember that safety of equipment and personnel is always a primary concern when working around equipment. This especially applies to operating equipment and systems with potential energy.

Voltmeters

Voltmeters are used to measure the potential voltage or the voltage drop in a circuit.
Voltmeters are always connected in parallel with the circuit being tested.
Voltmeters may be analog or digital type.

Ammeter

An ammeter is an instrument used for measuring electric current in amperes. It consists of a low voltage resistance shunt which is connected in series with the circuit and a parallel circuit which functions similarly to a voltmeter. The meter section samples the current flowing through the series shunt and indicates the current in the circuit.

The ammeter shown here is a clamp-on type that uses the magnetic field around a conductor to measure the amount of current flowing.

Carbon Pile

A carbon pile is used to place a variable load on a circuit. It is frequently used to put an alternator under a load or to load a battery to check for output. The resistance of the carbon pile can withstand high current loads and can be adjusted for the amount of current.

Some carbon piles, such as battery testers have an ammeter and a voltmeter so that the voltage can be monitored while specific amperage loads are applied to the battery.

A carbon pile is connected across the output of a battery or generator.

Multimeter - Volt-Ohm-Meter (VOM)

The multimeter, or volt-ohm meter, is an instrument that reads and measures the values of several different electrical parameters such as current, voltage, and resistance. It is one of the most useful electrical test instruments for the mechanic. A multimeter combines the functions of several meters in one device. Multimeters come in two major configurations: the analog type, which has a dial face, and the digital type, which features LCD readout. These meters can come in small sizes, which are easily carried in a tool bag.

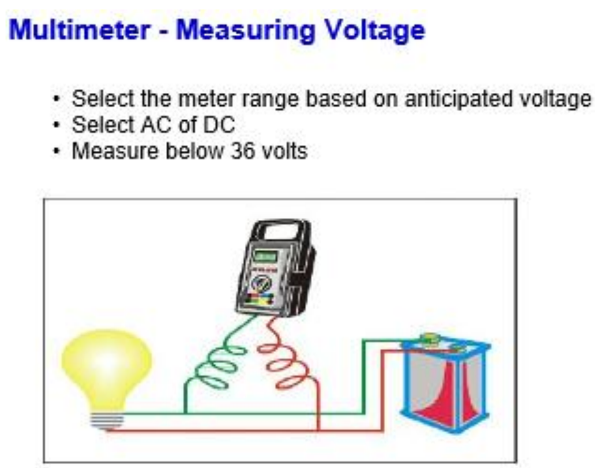
Using a Multimeter

There are a few precautions that should be observed when taking readings using a multimeter. Always consult the multimeter OEM manual before use. First, care should be taken to avoid using the ohmmeter section of the device on live circuits. Failure to observe this precaution may result in damage to the meter. Also, the meter must always be turned off or switched to the volt scale (as applicable) when not in use, because the ohmmeter portion is powered by batteries, it may run down if left on.

Multimeter - Measuring Voltage

Measuring voltage with a multimeter is a skill any mechanic who is going to work on electrical systems should know. When measuring voltage with a multimeter, the operator should first select the range of the meter which corresponds to the anticipated voltage to be measured. If unsure, always select a higher voltage than you expect to encounter. You must also select AC or DC. If it is coming out of a battery it will be DC, if out of a wall plug it will be AC.

Note: Mechanics should only be measuring DC voltage less than 36 volts.



Multimeter - Measuring Resistance

When measuring resistance with a multimeter, the meter will be supplying its own power, so never check an energized circuit with the meter set to the Ohms scale. To measure resistance with a multimeter, set the meter for the Ohms scale. The meter can also check a circuit for continuity on this setting. For most direct current, low voltage, mobile cranes applications, the resistance values should be fairly low, so you will normally use the lowest settings on the scale.

Review and Summary

In this module, you received a basic understanding of electrical circuits and their importance in maintenance and troubleshooting. Also, you learned the basic construction of series and parallel circuits. Finally, you learned the proper operation of basic electronic testing and measuring instruments, including voltmeters, ohmmeters, ammeters, carbon piles and multimeters.

LOW VOLTAGE ELECTRICAL CIRCUIT AND TOOLS OVERVIEW QUIZ AND SUMMARY

Knowledge Check

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

Note

KNOWLEDGE CHECK

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

True or False

Q: The multimeter or VOM can be used to measure current, resistance and voltage values.

- True
- False

Check

Tries Remaining: 2

True or False

Q: The carbon pile is the most accurate way to measure resistance.

- True
- False

Check

Tries Remaining: 2

Select the best answer.

Q: What is the correct instrument to check the voltage of a starting system?

- Carbon pile
- Ohmmeter
- Ammeter
- Voltmeter

Check

Tries Remaining: 3

Select the best answer.

Q: What is correct instrument to measure the resistance of a spark plug wire?

- ◯ Ammeter
- ◯ Carbon pile
- ◯ Ohmmeter
- ◯ Voltmeter

Check

Tries Remaining: 3

Select the best answer.

Q: What is correct instrument to test the output of a battery?

- ◯ Carbon pile
- ◯ Voltmeter
- ◯ Ammeter
- ◯ Ohmmeter

Check

Tries Remaining: 3

LOW VOLTAGE ELECTRICAL SCHEMATICS AND WIRING

Welcome

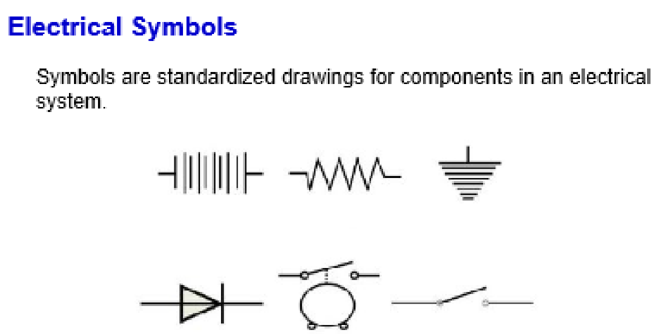
Welcome to Low Voltage Electrical, Schematics and Wiring.

Instructional Objectives

Upon completion of this module, you will be able to interpret electrical schematics and answer questions related to them. Also, you will learn how to identify the different types and sizes of electrical wire. Finally, you will be able to state the requirements for selecting wire lugs and how to crimp them.

Electrical Symbols

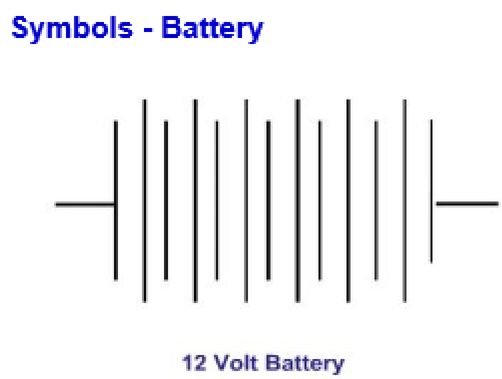
Electrical symbols are standardized drawings for components and devices in an electrical system. They are used in electrical schematics instead of using drawings or pictures of the actual objects. While there are many standard symbols, it is important for you to be able to recognize the most commonly used symbols.



Symbols-Battery

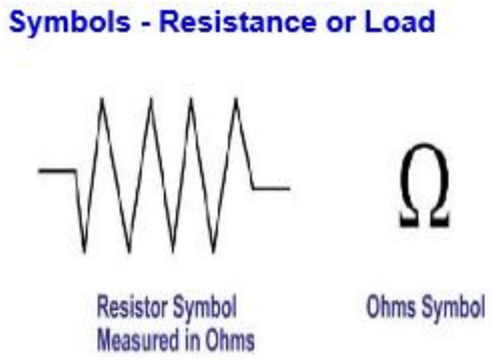
This is the symbol for a battery. Each short and long line pair represents a cell in the battery.

This picture identifies a 12 volt battery.



Symbols – Resistance or Load – Ohms

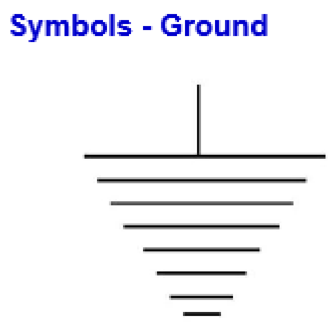
This is the symbol for resistance or load. Resistance is measured in ohms and is indicated by the Greek Letter Omega. Resistors are added to a circuit to reduce current to certain pieces of equipment. Some types of resistors can have a variable value. The dimmer switch for the dash board lights on your car is a variable type resistor.



Symbols - Ground

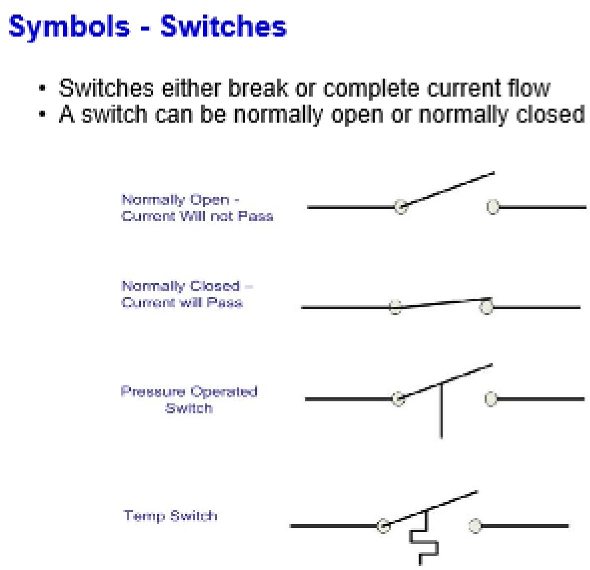
This is the symbol for Ground. There may be several of these symbols in a schematic to indicate where the circuit goes to ground.

In a low voltage, DC system, found in most mobile cranes, one side of the battery will be grounded. Also, the frame will be a common ground for the entire system.



Symbols – Switches

Electrical switches are used in an electrical circuit to either allow or interrupt the flow of current. A switch can either be normally open or normally closed. They may be operated manually or by changes in temperature, pressure or by other means. The symbols shown here illustrate both conditions. That is, a normally open switch that will not allow current to flow until it is closed, and a normally closed switch that continues to allow current to flow until it is opened.

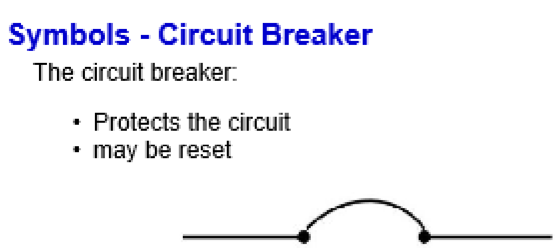


Circuit Breaker

Shown here are the symbols for a circuit breaker and a fuse.

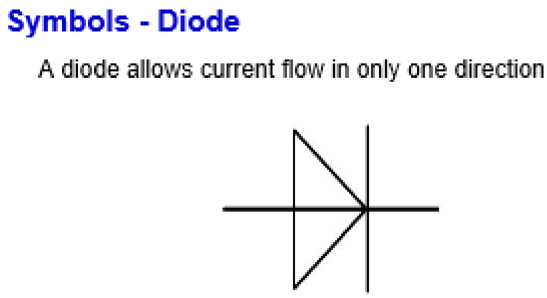
Fuses and circuit breakers are used to protect circuits from overload.

Circuit breakers are similar to fuses in that they open the circuit (or disrupt current flow) when overheated. They differ in that they can be reset; fuses must be replaced.



Symbols - Diodes

This is the symbol for a diode. A diode is an electrical check valve which allows current flow in one direction, but does not allow flow in the other direction. A diode may fail in two different ways. A “blown” diode will not conduct current in either direction, while a “shorted” diode will allow current to flow in either direction. Both faults will require replacement of the diode.



Symbols - Devices

Electrical devices also have symbols. Shown here are symbols for some common devices that can be seen on mobile crane electrical schematics. As an example, the motor symbol shown here would be an electric motor that might power a fan. The light could be a headlight, dome light, or even an indicator light on a dashboard. There are many different types of relays on cranes. Relays are used to control devices which have a high current draw, without having to have the full current load pass through the switch. For example, if the full current draw of a starter went through the ignition switch, the switch would have to be very large and expensive. By using a series of relays to control starting, the switch in the dashboard can be much smaller.

Schematics and Wiring Diagrams

Electrical schematics and wiring diagrams, similar to the ones shown here, are maps of the electrical circuits that make up a system. There are different types of diagrams that a mechanic should be familiar with when troubleshooting mobile cranes. The wiring diagram shows the actual components displayed, by means of symbols, and all connections are illustrated. In the schematic, the positive and the negative sides of the circuits are displayed as vertical lines running on either side of the drawing, and the different circuits run between them through the various switches, relays, and devices which are powered by the system. There are advantages and disadvantages to both ways of showing the wiring. The wiring diagram actually shows the physical relationship of the wire locations and by doing so makes locating the components easier. The schematic diagram, on the other hand, while it doesn’t show the actual layout of the wires, shows how the current flows, and makes troubleshooting easier.

Wiring

The electrical system in any piece of equipment is dependent upon the proper selection and installation of the wiring used to connect the various components and devices. Wiring must be selected with its intended application in mind. Wiring should be properly sized with sufficient capacity to carry the expected system load while retaining flexibility. It should be properly insulated to suit environment and load conditions and installed properly, using the correct tools and connectors, to prevent concerns such as overheating, shorts, grounds and corrosion.

Types and Sizes of Wire

Electrical wires may be a single strand or a number of smaller wires run together to form a stranded wire. Stranded wires offer more flexibility. Wire diameter is specified in gauge size, with the smaller numbers being the larger wires. Wiring on a crane would normally be in the 12 to 14 gauge size for low voltage, low amperage applications. Larger sizes like zero and double-zero are used for large amperage applications, such as battery cables. Very small components, such as indicator lights, would use wires in the 18 to 22 gauge range because of the very small current draw. The diameter of the wire will depend on how much current has to be supplied and the length of the wire to be run. Remember that the smaller the wire diameter, the greater the resistance, and the larger the diameter, the less resistance, all other things being equal.

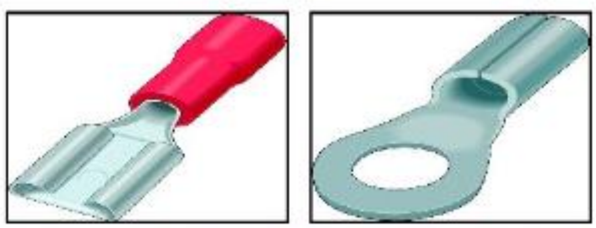
Insulation Materials

Electrical wiring insulation prevents or reduces the passage of electricity between wiring and other conductive materials in and around an electrical system. Insulation materials vary, but the most common types are rubber and plastic. In the dirty working environment of most crane operations, a wire insulation which is resistant to the effects of grease and oil should be chosen.

Types and Sizes of Lugs

Wire lugs are the end connections used to attach wiring to electrical components and devices. There are different types and sizes of lugs and selection of the correct lug is important for personnel safety and proper operation of the components. First, the lugs must be matched to the gauge of the wire. Generally, lugs will span two gauge sizes of wire, for instance ten twelve, fourteen sixteen, and so forth. Never put an oversized lug on a wire smaller than it is designed to accept nor try to fit a large wire into a smaller lug by shaving a solid wire or cutting off individual strands of wire. Overheating can easily result from these actions. The lug size will generally be imprinted on the lug. Lugs may also be insulated or non-insulated as shown in these pictures. Here we see an insulated lug on the left and a non-insulated lug on the right.

Types and Sizes of Lugs



Wire lugs connect wiring to electrical components and devices.

Wire Lug Crimping Tools

Wire lug crimping tools are used to secure the lug to the wire end ensuring a good connection. Always use the proper crimper for the type and size of lug being used. Shown here is a typical multi-purpose crimping tool that can used to crimp many common lug sizes and types. The multi-purpose tool can be used on insulated lugs and non-insulated lugs and includes a stripper section for removing the insulation from different sizes or gauges of wire. You may encounter connections that require special crimping tools which are available from most electrical supply outlets.

Wire Lug Crimping Tools

Crimping tools are used to secure the lugs to the wire ensuring a good connection

Using the Crimping Tool

Shown here are pictures of the basic steps in properly crimping a wire end connection. Read the manufacturer's manual before using any new multi-purpose or specialty tool. First, measure the wire to determine the correct size lug and how much insulation to be stripped from the wire. Next, only strip enough insulation to assure that the end of the wire will be flush with the barrel of the lug when it's pushed in. To prevent damaging the wire, assure that you use the correct size opening for the wire being stripped. Once the wire is stripped, check for cuts on the wire. Place the lug in the proper section of the crimper for either the insulated or non-insulated type. Push the wire into the lug until the end of the wire is flush with the barrel of the lug. Apply enough pressure to completely attach the lug to the wire or until the tool "bottoms out".

Summary and Review

During this module, you learned how to identify and interpret electrical symbols used to identify components and devices on electrical schematics. You learned how to identify the different types and sizes of electrical wire. You learned about insulation and how it is used to prevent or reduce the passage of current between wiring and other conductive materials. Finally, you learned how to properly size wire lugs and how to use a multi-purpose crimping tool to install them.

NOTES:

Low Voltage Electrical Schematics and Wiring Overview Quiz and Summary

Knowledge Check

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: Standard representations of individual components and devices in an electrical drawing are referred as __________.

- symbols
- graphics
- pictures
- schematics

Check

Tries Remaining: 3

Select the best answer.

Q: What is the most appropriate wire size or gauge to use to connect a battery to a starter?

- 00
- 12
- 18
- 16

Check

Tries Remaining: 3

True or False

Q: The larger the diameter the wire, the more resistance there is.

- True
- False

Check

Tries Remaining: 2

Select the best answer.

Q: What determines the style of crimper to use on a lug?

- ○ The type of the lug
- ○ Whether the lug is insulated or non-insulated.
- ○ All are correct
- ○ The size of the lug

Check

Tries Remaining: 3

Select the best answer.

Q: What determines the size of the lug?

- ○ The size of the wire
- ○ What's available
- ○ The type of wire
- ○ The crimper to be used

Check

Tries Remaining: 3

Low Voltage Electrical Batteries, Starting Systems and Charging Systems

Welcome

Welcome to Batteries, Starting Systems and Charging Systems.

Instructional Objectives

Upon successful completion of this module, you will be able to identify the individual components of, and troubleshooting techniques for, lead acid batteries, charging systems, and starting systems.

Battery

The storage battery, or secondary cell, which can be recharged by reversing the chemical reaction, was invented in 1859 by the French physicist Gaston Planté. Planté's cell was a lead-acid battery, the type widely used today in mobile cranes, automobiles, trucks, aircraft, and other equipment. Its chief advantage is that it can deliver a strong current of electricity for starting an engine. Its disadvantage is that it runs down quickly. The battery is a very important part of a crane's low voltage DC electrical system. It is an electrochemical device that stores chemical energy which can be released as electrical energy. When a battery is connected to an external load such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

Functions of the Battery

The three main function of a battery are:

1. Supply power to the starter and other electrical systems so the crane's engine can crank and the electrical systems can operate.

2. Supply extra power, as required, when the crane's electrical load exceeds the capability of the charging system.

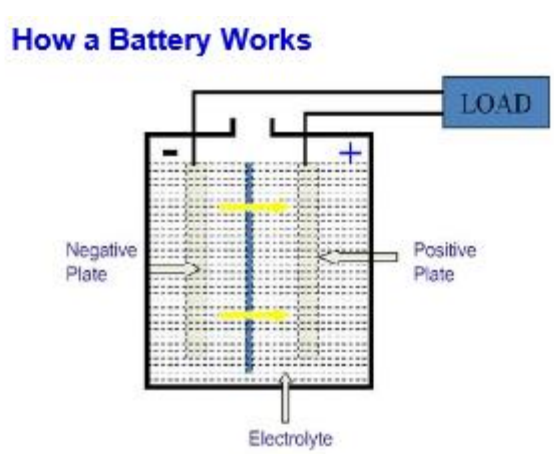
3. Act as a stabilizer in the electrical system by absorbing voltage surges which could otherwise damage components. The battery smoothes out, or temporarily reduces, voltage surges in the electrical system.

Parts of a Battery

Shown here are the basic parts of a typical crane battery. The case of the battery is a one piece container molded from polypropylene, hard rubber, or other plastic-like material. It has partitions which separate the cells from one another. The bottom portion of the cells have raised rests which keep the plates off the bottom so that settling material does not form an electrical path which could short-circuit the plates. Each cell of the battery contains one element which consists of a stack of alternating positive and negative plates with separators between them. Each set of plates is connected by means of a plate strap: one for the positive plates and one for the negative plates. These plate straps also connect the plates in series with the plates from the other cells and with a battery terminal or post. Finally, batteries have vents, not visible in this picture, that allow excess gas to escape the battery case while retaining the electrolyte.

How a Battery Works

The battery has three active components in each cell: the negative plates, which are made of sponge lead; the positive plates, which are made of lead peroxide; and the electrolyte, which is a mixture of sulfuric acid and water. When the battery discharges, the chemical reaction changes the composition of the positive and negative plates to lead-sulfates. This reaction makes the acid weaker in the electrolyte, and the water which is formed by the reactions on the plates further dilutes the electrolyte. When the cell is being recharged, the chemical reactions described above are reversed until the chemicals have been restored to their original condition. Sometimes, at the end of the charging process, if the battery is being charged at a higher rate than it can accept, the water in the electrolyte will decompose resulting in the release of hydrogen gas that is very explosive. Select a charger that adjusts the charge rate to compensate for the state of the charge of the battery. Always take necessary precautions and wear proper personnel protective equipment.



Testing Specific Gravity

Battery electrolyte is a mixture of sulfuric acid, which has a specific gravity of one-point-eight- three-five, and water, which has a specific gravity of one. In a fully charged battery, the specific gravity, corrected to eighty degrees Fahrenheit, is one-point-two-six-five. The fully charged electrolyte has thirty-six percent sulfuric acid by weight (or twenty-five percent by volume). The remainder is water.

The most common test for a battery is to measure the specific gravity of the battery's electrolyte. This is done by using a hydrometer. A hydrometer measures the ratio of the density of the liquid to the density of water. It is based on the hydrostatic principle that the weight loss of a body in a liquid equals the weight of the liquid displaced. It is a bulb-type syringe used to extract electrolyte from a battery cell. It contains a weighted float, and measures the level to which the float will rise in the electrolyte to determine the specific gravity. Hydrometers are calibrated to give a correct reading at a specific ambient temperature. Therefore, the reading indicated must be corrected to compensate for the difference in temperature from the temperature standard. A false reading may occur if readings are taken immediately after adding water to a cell, or after prolonged cranking of the battery. Always wear personal protective equipment when checking battery specific gravity.

Load Testing a Battery

A battery can be load tested to determine if it has sufficient charge to crank an engine. Typically, a carbon pile type tester is connected to the battery and a load of fifty percent of the rated cranking performance is applied for 15 seconds. The voltage is read after 15 seconds with the load applied and the reading is compared to a chart for minimum required voltage.

Battery Performance

One of the hardest jobs that a battery is called upon to perform is cranking an engine in cold weather while still providing other systems with adequate power. "Cold cranking", as it is called, involves a high discharge rate of amps over a very short period of time. Batteries are rated, for "Cold Cranking Amps". This rating is defined as the amps which a battery can deliver, at zero degrees Fahrenheit, for a period of 30 seconds, while maintaining a minimum of one-point-two volts per cell (or higher). Most passenger car batteries, for example, have a "Cold Cranking Amp" rating of 300-600 amps. Industrial, commercial and heavy duty applications are usually much higher. The graph illustrates how a fully charged battery's cranking power declines in relation to decreases in ambient temperature.

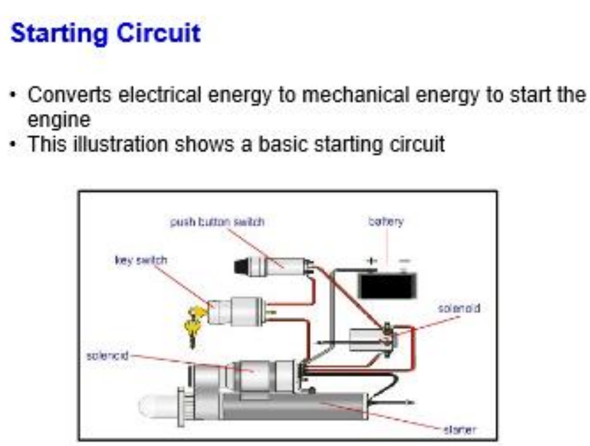
Battery Safety

Safety precautions must be taken when working around batteries. Be aware of your local emergency procedures for chemical or explosive accidents and seek medical attention immediately when needed.

Batteries contain sulfuric acid which can burn eyes and skin. Goggles, gloves, aprons and other personnel protective equipment should be worn when handling or servicing batteries. Batteries can emit an explosive mixture of hydrogen and oxygen, especially when charging, and any source of spark or flame should be kept away. Special care should be taken during “jump-starting” operations to assure you connect the ground cable to the frame, rather than to the battery post. To avoid the potential for an explosion, Ni-cad batteries and lead acid batteries should not be emptied or stored in the same container.

Starting Circuit

The starting circuit is designed to convert the electrical energy provided by the battery into mechanical energy utilizing the cranking motor. The basic starting circuit consists of a battery, a starting switch (key or push button), a solenoid switch, and the cranking motor, along with the required wiring. In addition to the basic portions of the starting circuit, there may also be a neutral safety switch, a safety circuit override, or a series-parallel switch in the starting circuit as well.



Starter Switches

The master switch is generally on the ground side of the circuit. It opens the circuit, thereby preventing current flow. The switch can handle the entire amperage requirements for the equipment. The starter switch may be a spring-loaded switch, a key switch, a push button, or a combination of a key switch and a push button. Shown here are examples of typical key and push button switches. These switches handle only enough current to energize the solenoid(s) for starting. In many cases, there is an override switch which will by-pass a failure circuit until the oil pressure comes up, thus allowing the engine to start.

Starter Solenoids and Relays

Solenoids and relays play an important part in the starting system.

The solenoid in a starter circuit, in many cases, not only closes the contacts to power the cranking motor, but also shifts the cranking motor pinion inward to mesh with the engine flywheel ring gear. The advantage of having a solenoid for cranking a motor is that the wiring to the start switch does not have to carry the full load of the cranking motor.

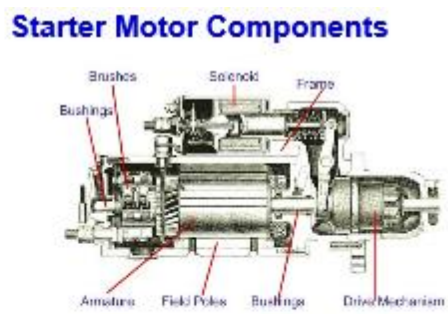
There are many different types of relays in cranes. They are used to control components which have a high current draw without passing the full current load through the switch. For example, if the full current of a starter went through the ignition switch, the switch would have to be very large. By using a series of relays to control starting, the starter switch can be much smaller.

Starter Motor

The starter or cranking motor is the most important part of the starting system. Rotation of the armature causes the cranking motor drive pinion or Bendix, to rotate, engaging the drive pinion gear or Bendix, with the teeth of the flywheel ring gear, causing the engine to crank and start. A cranking motor is designed to produce very high torque and therefore requires very high current. As a result, there is a potential for excessive heat if the motor is run for an extended period of time.

Starter Motor Components

Shown here is a cut-away view of a typical starter motor revealing the internal components. It consists of motor brushes, field poles, and an armature, which rotates on a center shaft supported by bearings and bushings at either end of the frame. Also seen here is the drive mechanism that mechanically cranks and starts the engine. Finally, some cranking motors have a solenoid switch that opens and closes the circuits between the battery and the cranking motor, and engages the drive pinion. As current enters the motor through the field windings it flows to the brushes. The brushes ride on the armature commutator. Current then passes through the armature windings in such a way that two strong magnetic fields are created which oppose each other in such a way that the armature is forced to rotate.



Starting System Troubleshooting

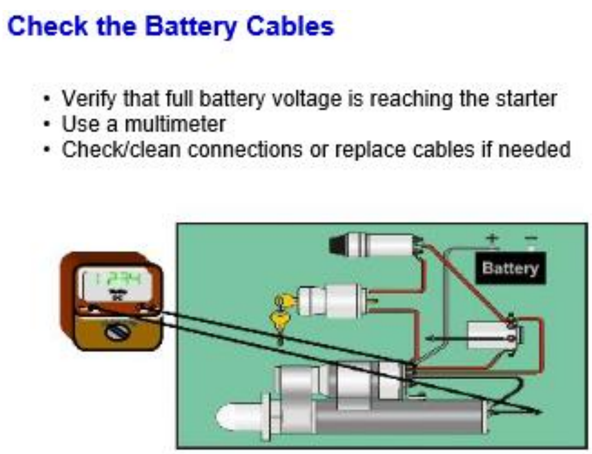
Starting System Troubleshooting Effective troubleshooting is important to solving starting system problems. During any troubleshooting evolution, it is important to work in a series of logical steps to eliminate possible problem areas one by one. You should never assume that a component is either good or bad. A good example of this would be assuming that the battery is good because it was just replaced last week. The battery may have run down due to a short or ground, the alternator may not be charging, or battery simply may be faulty. You should verify that the battery is supplying sufficient cold cranking amperes for starting. Finally, don't overlook the obvious. Identify when the last repair or service was performed to assure a mechanic has not inadvertently disconnected a wire or damaged a component.

Check the Battery Voltage

When troubleshooting a starting circuit, if other tests are inconclusive, verify that the battery has the required voltage. This can be done by using a multimeter. If correct voltage is available, proceed to the next step. If not, ensure that the battery gets fully charged before proceeding.

Check the Battery Cables

When troubleshooting a starting circuit, if other tests are inconclusive, verify that full battery voltage is reaching the starter. Use a multimeter to read the voltage at the battery cable connection on the starter. If the voltage is the same as the battery voltage, proceed to the next step. If the voltage is lower than battery voltage by more than one-half volt, the cable should be checked for excessive resistance or bad connections.



Check the Starter

When troubleshooting a starting circuit, if other tests are inconclusive, check for proper operation of the starter to determine if the problem is in the starter or somewhere else in the circuit. To do this, by-pass the starting circuit and jumping the starter solenoid directly from the battery terminal to the starter lug using a remote start switch. If the starter does not operate correctly, remove it and perform other checks. If the starter operates correctly, the problem lies in the circuitry between the starter solenoid and the battery. The individual components such as the start switch and the relays will have to be checked, as will the wiring.

Check the Starter Wiring

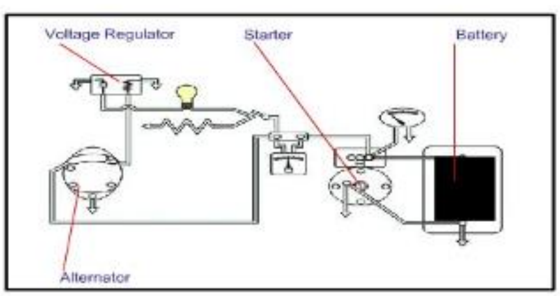
When troubleshooting a starting circuit, if other tests are inconclusive, the circuit wiring must be checked. This can be done either by taking voltage readings on both the input and output terminals of each switch, or by disconnecting the battery ground and checking the continuity between each connection point. In most cases, taking voltage readings is both faster and easier. Following is one example of how to troubleshoot, with a multimeter, in a logical, systematic, fashion so that every switch and section of wire is inspected. First, assure that voltage is reaching the relay and the key switch, indicating that there is voltage at both places when the battery is connected. Next check for voltage with the key switch in the “on” position, indicating that voltage is going through the switch. Also, check the downstream side of the push button with the button pushed and the key switch on. If there is no voltage here, you should inspect the switch and the wiring between the key switch and the push button to assure they are good. Finally, check the solenoid and the connection to the solenoid with only the key switch “on” and the button pushed. If there is no voltage here, check the solenoid.

Charging Circuit

The charging circuit charges the battery to assure uninterrupted voltage to the starting system and other important parts of the electrical system of the crane. Typically, it consists of the battery, a belt-driven alternator (AC or DC), a regulator (either internal or external to the alternator), and the accompanying wiring. This schematic shows the wiring for the basic charging circuit, and includes the wiring from the alternator to the battery by way of the starter. It also shows the alternator light and wiring for the amp and volt gauges.

Charging Circuit

- The charging system charges the battery
- This illustration shows a basic charging circuit



Generators

A generator is a mechanical device that converts mechanical energy supplied by the engine into electrical energy. It may be either AC or DC. The primary difference between AC and DC generators is one of construction. Both, however, operate on the same basic principle that a conductor connected to a completed circuit will have an induced current when it moves through a magnetic field. AC generators, or alternators as they are called, are increasingly more popular than DC generators for several reasons. First, the alternator can provide higher current at lower engine speeds. It can safely rotate in either direction and at higher speeds. The output voltage and current of the alternator can be controlled easily. Finally, it has longer service life.

Alternator Construction

The AC generator is constructed differently from the DC generator. An alternator handles the problem of current reversal in a different way. The field windings are the portions that rotate in an alternator. The current generated is alternating, but it is rectified into DC by a set of diodes. Because the field is the rotating portion, the brushes have a much smaller electrical load to handle. They run on continuous slip rings instead of a segmented commutator so wear is greatly reduced.

Alternator Rotor

The rotor is a basic component of an alternator. It turns on a shaft, supported by bearings. The rotor assembly consists of two iron pole pieces with interlacing fingers, mounted over many turns of wire, wound over the rotor core. The rotor coil is connected by slip rings to the battery, and when energized, the rotor coil is an electro-magnet which produces alternating north and south poles. The rotor has a total of 14 poles.

Alternator Stator

The stator is a basic component of the alternator. It's the stationary part around which, or in which, the rotor rotates. The stator assembly consists of three separate windings, each having seven coils consisting of many turns of wire. There is one coil for each set of rotor poles. A complete cycle of AC voltage will be produced as a north and south pole pass by a coil.

Parts of an Alternator

A rectifier bridge, a regulator and a diode trio are basic components of the alternator. The rectifier bridge contains six diodes which are connected to two heat sinks. It converts the alternating current produced by the rotor and stator into direct current by only allowing the positively biased power to pass. The regulator, contained within the alternator in most modern alternators, controls voltage by managing the field current and electronically switching the voltage on and off across the field windings between ten and seven-thousand times per second. The alternator also contains a diode trio which rectifies the voltage going to the regulator.

Troubleshooting Charging Circuits

We discussed previously that properly conducted troubleshooting includes methodical, logical, thoughtful steps, seeking simple and sensible solutions first, with no assumptions along the way.

You should troubleshoot charging systems in the same manner. First, assure that any undercharged condition has not been caused by accessories which may have been left on for extended periods. Check drive belts for proper tension and, if a battery is suspected, perform previously outlined battery checks. Check the wiring and all end connections, including battery cables for tightness and cleanliness. If these checks do not identify the problem, further troubleshooting will be necessary.

Performing Voltage Checks

A quick and easy test of the charging system can be performed by checking system voltage with a multimeter before disconnecting any components. With the engine stopped, read and record the battery voltage. Check the voltage again with the engine running. The voltage should be greater with the engine running but not higher than 15 volts for a 12 volt system or 31 volts for a 24 volt system.

Perform a Charging System Load Test

If the previous tests prove satisfactory, but there still seems to be problems with the system, it will be necessary to perform a load test on the system.

This is done by connecting a carbon pile to the battery and setting the load so that the rated output of the alternator/generator is achieved. If the ampere output is within 15 amperes of the rated output stamped on the alternator/generator, the unit is not defective.

Review and Summary

During this module you learned how to identify the components and troubleshooting techniques for electrical components and systems including lead-acid batteries, starting systems, and charging systems. You also learned that the basic steps of troubleshooting are to proceed in logical steps, to never assume that a component is either good or bad and to not overlook the obvious.

LOW VOLTAGE ELECTRICAL BATTERIES, STARTING AND CHARGING SYSTEM OVERVIEW QUIZ AND SUMMARY

Knowledge Check

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

Note

KNOWLEDGE CHECK

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: Identify the main function or functions of a mobile crane engine battery.

- ◯ Supply power to electrical systems
- ◯ Compensates for charging shortages
- ◯ Absorb voltage surges
- ◯ All answers listed are correct

Check

Tries Remaining: 3

Select the best answer.

Q: Select the item from the list that would be an inappropriate or incorrect step in the troubleshooting process for a possible battery or starting problem.

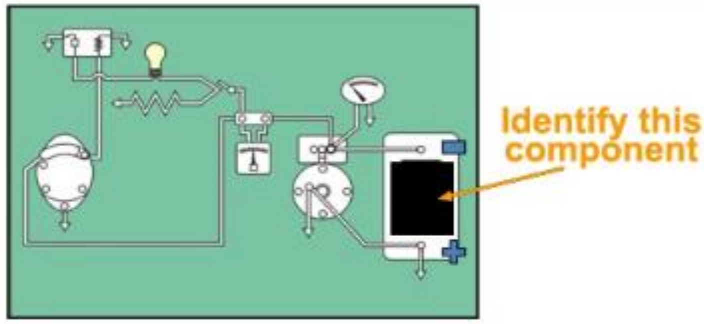
- ◯ Check battery cables for good connections and condition
- ◯ Put the battery under a load with a carbon pile.
- ◯ Check the resistance between the negative and positive terminals
- ◯ Test the electrolyte with a hydrometer

Check

Tries Remaining: 3

Select the best answer.

In the following illustration of a charging system, identify the indicated component.



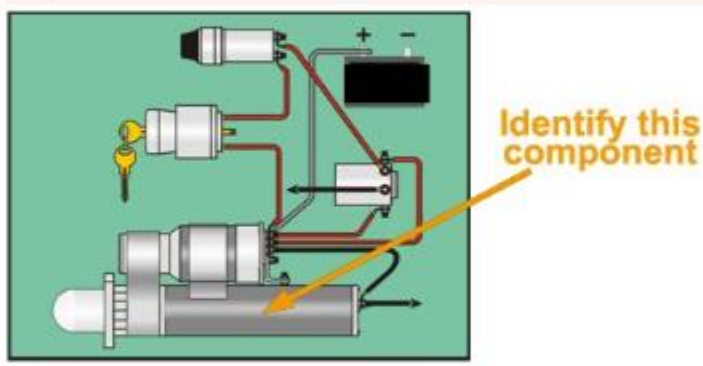
- ◯ Ammeter
- ◯ Battery
- ◯ Alternator
- ◯ Light bulb

Check

Tries Remaining: 3

Select the best answer.

In the following illustration of a starting system, identify the indicated component.



- ◯ Key Switch
- ◯ Start Relay
- ◯ Push Button Switch
- ◯ Starter

Check

Tries Remaining: 3

True or False

Q: The charge of a battery increases as the ambient temperature in a working environment decreases.

- ◯ True
- ◯ False

Check

Tries Remaining: 2

Select the best answer.

Q: The basic steps of troubleshooting are to:

- ◯ proceed in logical steps.
- ◯ never assume that a component is either good or bad.
- ◯ not overlook the obvious.
- ◯ all answers are correct.

Check

Tries Remaining: 3

True or False

Q: The stator is a stationary part of a motor or generator, around which or in which a rotor rotates.

- ◯ True
- ◯ False

Check

Tries Remaining: 2

NOTES:

Mobile Crane Brakes

Welcome

Welcome to Mobile Crane Brake

Instructional Objectives:

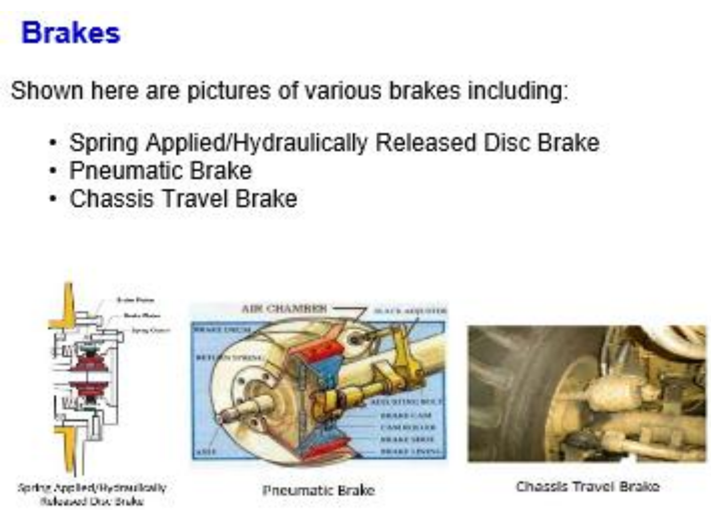
Upon the successful completion of this module you will be able to:

Understand the operation of mobile crane brake systems.

Brakes

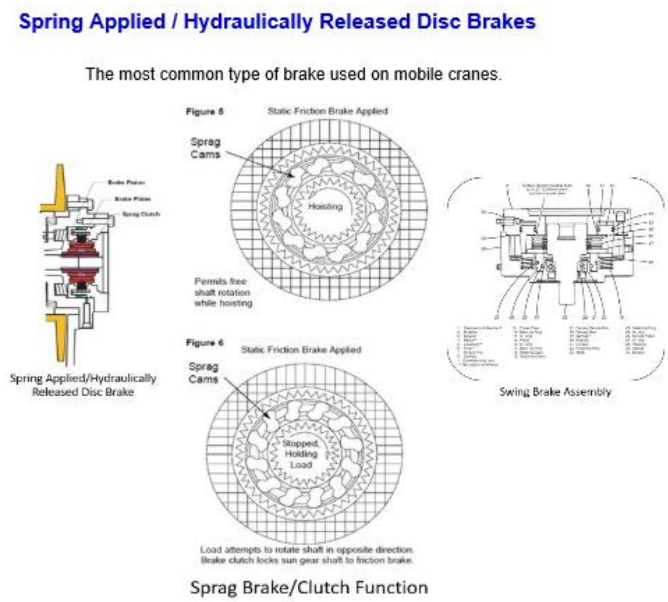
Shown here are the pictures of various brakes including:

- Spring Applied/Hydraulically Released Disc Brake
- Pneumatic Brake
- Chassis Travel Brake



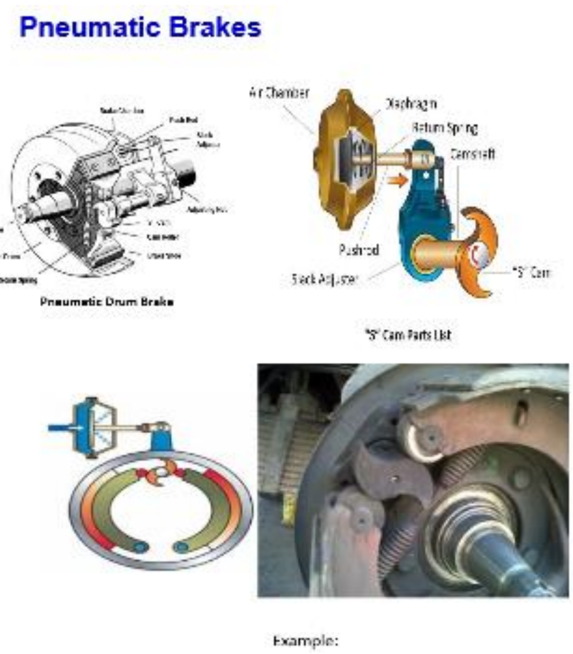
Spring Applied/Hydraulically Released Disc Brakes

The most common type of brake used on mobile cranes in the hoist and rotate systems is a spring applied, hydraulically released multiple disc brake. In hoist applications, they typically are used in conjunction with a one-way sprag clutch, between the input shaft and the static disc brake. The clutch allows the input shaft to turn freely in the direction required to lift the load. When the hoist is stopped, the sprag clutch locks the hoist gear train to the mechanical brake holding the load in place. The hoist will not lower until sufficient pilot pressure is available to open the brake valve hydraulically releasing the static brake.



Pneumatic Brakes

Pneumatic brakes, commonly used in mobile type application for travel brakes, are drum type brakes which are engaged with either the S-cam or wedge type system. The S-cam type is demonstrated in the picture. These brakes can be used for stopping or parking. If used as a parking brake they incorporate a spring which applies the brake and is released pneumatically. Adjustment to air brake system on travel brake systems normally consists of adjusting the slack adjuster. This simply reduces the clearance between the shoe lining and drum (i.e. shoe clearance).



Example:

Chassis Travel Brakes

Chassis Travel Brakes on mobile cranes may need to be disassembled for inspection of linings and components.

The slack adjuster travel is an important measurement to make when doing this inspection. OEM manuals should be consulted for the proper specifications.

There are usually inspection covers which can be removed to inspect the brake lining thickness.

Inspection Attributes

When inspecting, adjusting or simply looking over the equipment, remember to check brakes for the following conditions: damage; wear; proper lubrication; disk condition; proper release; proper engagement; stopping action; evidence of overheating; leaks; chattering; vibration; abnormal noise; binding; loose or worn components; proper shoe alignment; proper fluid level; lines for damage, leakage, loose connections; proper stopping in both directions; air valves and lines for proper operation and leaks.

Mobile crane OEM's typically require winch disassembly at varying intervals for inspection of gearing and brake components. Closely follow OEM guidance for disassembly, inspection, and reassembly.

Cracked and Damaged Hoses

On hydraulic brakes and pneumatic brakes, always check the condition of hoses and lines. If the hose has a spring around it, move the spring so that the actual condition of the hose may be observed. Over time the rubber will deteriorate and crack, or the outer casing may separate from the reinforcing mesh underneath. The lines may crack if unsupported, so check for properly spaced hangers. Fittings may leak if loose, and if the flare is work-hardened, tightening it may not cure the leak.

What should I do if I find a problem?

The pitch is the distance between the threads. The point is the chamfer on the threaded end of the bolt which permits easier starting of the thread.

Review and Summary

In this module you learned about basic types of brakes, their adjustments, and basic repair/inspection considerations.

MOBILE CRANE BRAKES OVERVIEW QUIZ AND SUMMARY

Knowledge Check

The next several screens contain questions relating to the covered material. Check your comprehension of the course content by answering these questions.

KNOWLEDGE CHECK

Note

The next several screens contain questions relating to the material covered in this module. Check your comprehension of the covered material by answering the following questions.

Select the best answer.

Q: Which type of brake is not a common mobile crane brake.

- ◯ Pneumatic Brake
- ◯ Mechanical Band Brake
- ◯ Spring applied/hydraulically released brake
- ◯ Chassis Travel Brake

Check

Tries Remaining: 3

Select the best answer.

Q: Brake components should be checked for all of the following except:

- ◯ Lubrication
- ◯ Wear
- ◯ Loose or missing fasteners
- ◯ Manufacturer

Check

Tries Remaining: 3

Select True or False

Q: Common pneumatic brakes use a wedge type or a S-Cam to engage the brake.

- ◯ True
- ◯ False

Check

Tries Remaining: 2

Select the best answer.

Q: What should you do if you find a problem?

- ◯ Move on to the next step in the procedure.
- ◯ Find someone that knows how it works.
- ◯ Notify your supervisor.
- ◯ Ignore the problem and proceed.

Check

Tries Remaining: 3

True or False

Q: A sprag clutch is used to lower the hoist or load.

- ◯ True
- ◯ False

Check

Tries Remaining: 2