

HYDRAULICS AND ELECTRICAL CONTROL OF HYDRAULIC SYSTEMS



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Licensing

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CHAPTER OVERVIEW

1: Introduction

[1.1: Introduction to Fluid Power Systems](#)

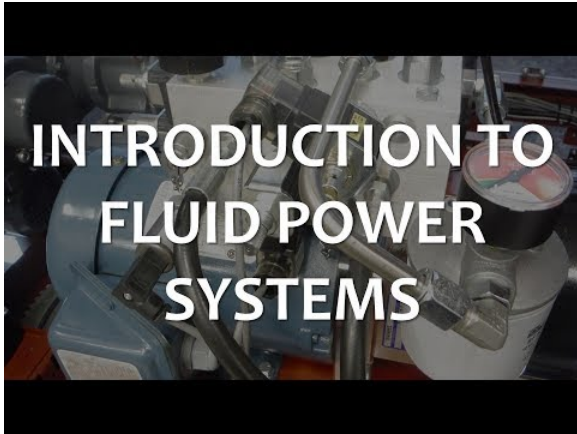
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1.1: Introduction to Fluid Power Systems



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Describe the purpose of a fluid power system

Differentiate between fluid power systems and mechanical or electrical systems

Differentiate between hydraulic and pneumatic systems with respect to the fluid medium employed, characteristics, capacity, performance, and cleanliness

Describe a basic fluid power system in terms of power conversion.

Describe the role of a prime mover like a motor or internal combustion engine in a fluid power system.

Draw the schematic symbol for a motor and internal combustion engine.

Describe the role of a pump in a fluid power system. Draw the schematic symbol for a pump and reservoir.

Describe what properties pressure, flow rate, and valve position influence in a fluid power system.

Describe Pascal's Law and the formula used to relate force, pressure, and area.

Describe the role of an actuator in a fluid power system. Draw the schematic symbol for a cylinder and hydraulic motor.

Comment on the drawbacks of systems composed of numerous stages

Comment on the advantages and disadvantages of fluid power systems

Identify safety concerns associated with fluid power systems.

Comment on sources of inefficiency within a fluid power system

Identify five different types of pressure control valves

Draw the schematic symbol for a pressure gauge, pressure switch, and pressure transducer

List the devices that control flow rate

Draw the schematic symbol for a flow control valve and comment on how they are employed in fluid power systems.

Draw the schematic symbol for flow meters and comment on how they are employed in fluid power systems.

Draw the schematic symbol for a check valve. Differentiate between free flow and blocked direction.

Describe the purpose of a directional control valve in a fluid power system.

Draw the schematic symbol for a 3 position, spring centered, manually actuated directional control valve with a closed center, a straight through position, and a cross connect position

Discuss how the above valve's position influences a double acting cylinder's actuation direction when the cap end port is hooked to actuator port A and rod end port is hooked to actuator port B.

Discuss how the above valve's position influences a double acting cylinder's actuation direction when the actuator ports are swapped (rod end port is hooked to actuator port A and cap end port is hooked to actuator port B).

Discuss how a double acting cylinder's actuation direction is influenced when one port is blocked.

Describe the purpose of mechanical limit switches, magnetic proximity switches, and position transducers in a fluid power system.

Differentiate between energy and power and give examples of common energy and power units.

Determine the energy requirement in ft*lb to move a 500lb object 12ft.

Determine the power requirement in ft*lb/s, hp, and W to move a 500lb object 12ft in 2.3s.

Given a 72% efficient system determine the input power in W necessary to produce 5.6hp output

Given a 79% efficient system determine the output power in hp if 3.2kW was input

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1.3: Hydraulic Cylinders



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Define the term actuator and give examples of a rotational electrical actuator and a linear hydraulic actuator.

Draw a pictorial diagram of a double acting hydraulic cylinder. Identify the barrel, piston, rod, cap end plate, rod end plate, rod wiper, cap end port, and rod end port. NOTE: the rod end is often called the “head” end and the cap end is often called the “blind” end.

Draw the schematic symbol for a double acting hydraulic cylinder.

Differentiate between the cap end and rod end. Which has more functional area?

Describe the act of extending and retracting a double acting cylinder in terms of which volumes are filled and which volumes are emptied. Comment on observed differences between extension and retraction speeds given constant flow rate.

Comment on how blocked ports affect extension and retraction of double acting hydraulic cylinders.

Differentiate between static and dynamic seals. Point out static and dynamic seals in a double acting hydraulic cylinder.

Comment on how a gasket is used to form a static seal. Comment on gasket composition and fluid compatibility.

Comment on how O-rings, piston rings and oil form a dynamic seal.

Comment on why oil is used in hydraulic systems.

Describe the cross sections of other dynamic seals.

Comment on the purpose of the rod wiper. Comment on storage of hydraulic equipment and the role of fabric bellows.

Comment on the purpose of a stop tube.

Describe a double rod cylinder and draw its schematic symbol.

Describe a tandem cylinder. Describe a duplex cylinder. Draw the schematic symbols.

Describe how a cushion works. Draw the schematic symbol for a cushion on extension. Draw the schematic symbol for a cushion on retraction. Draw the symbol for a variable cushion.

Draw lug, flange, flush, and tie rod mounted cylinders. Describe the purpose of fixed mounting methods.

Draw trunnion and clevis mounted cylinders. Describe the purpose of pivoting mounts. NOTE: Pivoting mounts are often specified by the location of the pivot point (example: head trunnion vs. center mounted barrel trunnion)

Describe and draw the schematic symbol for a single acting cylinder. Describe the means a single acting cylinder uses to retract.

Describe a ram. Describe how the descent of a lifted object can be controlled.

Describe a telescoping cylinder.

Describe how a spring can be used to apply or remove a brake in the event of pressure loss. Comment on how a spring is a source of hazardous energy.

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1.4: General Industrial Safety



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Comment on elements essential to emergency preparedness.

Enroll in a First Aid/CPR/AED class if you are not already certified

Define the purpose of a lock out and tag out program.

Describe lock out devices used for plugs, switches, and valve handles.

Describe how a hasp is utilized with a group of workers and their individual lock and tag.

Define lock out, define tag out, and differentiate between the two terms.

Describe the general procedure to conduct service on a system.

Comment on the purpose of inspecting Personal Protective Equipment (PPE) prior to use.

Differentiate between types and classes of hard hats.

Describe the features and types of eye protection and prescription eyewear.

Describe the purpose of eye wash stations and emergency showers.

Differentiate between ear plugs and ear muffs.

Describe how the NRR of a hearing protection device affects environmental noise.

Describe the time weighted average requirement

Comment on protective clothing and hand protection utilized for specialized industrial tasks (ie: electrical, abrasion resistance, chemicals, etc.).

Comment on machine guards.

Comment on the purpose of protective toes and oil resistant soles.

Comment on when fall arrest systems must be utilized.

Comment on the purpose of a harness and shock absorbing lanyard.

Describe the purpose and function of a ladder climber.

Describe the purpose of suspension trauma mitigation straps.

Describe the purpose of a work positioning lanyard. Describe other uses of a work positioning lanyard.

Describe the purpose of a rescue, retrieval and evacuation device.

Describe how a pre-roped pulley assembly, additional pulleys, slings, and carabiners complement a rescue kit.

Describe the purpose of an exclusion zone and tethering.

Describe the 3 features of a confined space and how environmental testing, attendants, communication, and rescue equipment mitigate the problems associated with confined spaces.

Describe some of the unique safety concerns associated with fluid power systems and best practices to mitigate these hazards.

Describe the purpose of OSHA.

Describe the purpose of ANSI.

Describe the purpose of the NEC.

Describe the purpose of NRTLs and give examples.

Describe the purpose of the NEMA and the IEC and differentiate between them.

Show up to your assigned lab period wearing long pants and closed toed shoes.

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CHAPTER OVERVIEW

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2.1: Pascal's Law



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Describe Pascal's Law and the formula used to relate force, pressure, and area. Solve for F in terms of p and A . Solve for p in terms of F and A . Solve for A in terms of F and p .

List common units of force, pressure, and area.

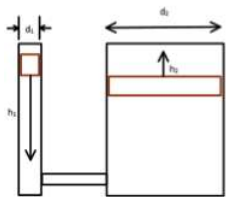
Determine equivalency for psi, Pa, and bar.

If area is kept constant determine how changes in pressure affect force.

If pressure is kept constant determine how changes in area affect force.

If area is kept constant determine how changes in force affect pressure.

If force is kept constant determine how changes in area affect pressure.



Given a force multiplication system with the following dimensions:

$$d_1 = 3/4 \text{ in}$$

$$F_1 = 120 \text{ lbf}$$

$$h_1 = 4 \text{ in}$$

$$d_2 = 1 \frac{1}{4} \text{ in}$$

Calculate A_1 , p , V_1 , A_2 , F_2 , h_2 , $\text{energy}_{\text{in}}$, $\text{energy}_{\text{out}}$

Comment on the differences between the cap end and rod end of a double acting cylinder with respect to functional area.

Explain why the pressure necessary to retract is greater than the pressure necessary to extend with the same force for a double acting cylinder.

Explain why the force of extension is greater than the force of retraction given the same pressure limit for a double acting cylinder.

Given cylinder X with the following dimensions:

$$d_{\text{cap}} = 2 \frac{7}{8} \text{ in}$$

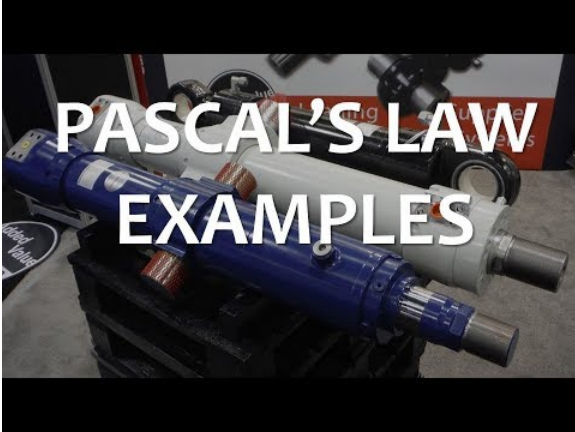
$$d_{\text{rod}} = \frac{7}{8} \text{ in}$$

Calculate p_{ext} and p_{ret} for cylinder X given the system is tasked with moving a 1350lbf object.

Calculate F_{extMAX} and F_{retMAX} for cylinder X given the system is limited to 640psi.

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2.2: Pascal's Law Examples



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2.3: Pressure and Pressure Measurement



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List common units of pressure. Equate psi, bar, and Pa.

Convert 230psi to bar and kPa.

Convert 7.3 bar to psi and kPa.

Convert 440kPa to bar and psi.

Determine the minimum of height of a water tower necessary to ensure at least 30 psi

Describe atmospheric pressure and the sources of variance.

Convert 550psi to psia

Convert 900psia to psig

Define a vacuum

Describe the function of a pressure gauge and draw its schematic symbol.

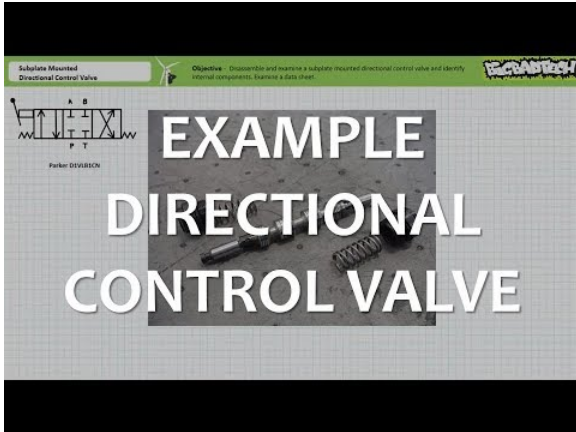
Differentiate between analog (needle) and digital pressure gauges.

Differentiate between bourdon tube and spring loaded piston (Schrader) gauges and describe the basic operation and constituent parts of both.

Differentiate between pressure switches and pressure sensors (transducers).
Describe set, reset, and span (hysteresis) for a pressure switch.

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2.8: Example Directional Control Valve



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3.2: Accumulators



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List common functions of accumulators in a hydraulic system

List the two general classes of accumulators.

List the two types of mechanical accumulators. Describe each one. Draw the schematic symbol.

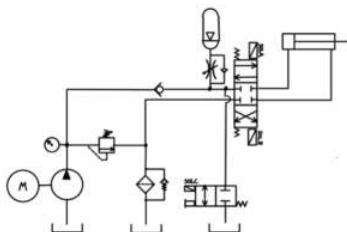
List the three types of hydro-pneumatic accumulators. Draw the schematic symbol. Describe each one. Draw the cutaway view of each type.

Draw the cutaway view of a bladder type hydro-pneumatic accumulator in various states of charge. Identify various components and their function.

Define precharge.

Describe why dry nitrogen or another inert gas is used to precharge accumulators.

Use this schematic to describe how an accumulator influences a hydraulic circuit. Describe the purpose of the flow control valve with check valve bypass on the accumulator. Describe how a technician would release the stored energy in the accumulator.



Differentiate between the terms adiabatic and isothermal with respect to charging and discharging an accumulator

List which data is required to properly size a Parker A series piston accumulator. Given an application with a minimum pressure of 500psi determine the recommended precharge for a Parker A series piston accumulator. ([Parker A Series Piston Accumulator datasheet](#))

Draw a cutaway view of a piston style hydro-pneumatic accumulator. Identify the internal components.

Differentiate between failure modes and loss of precharge for piston, diaphragm, and piston style hydro-pneumatic accumulators

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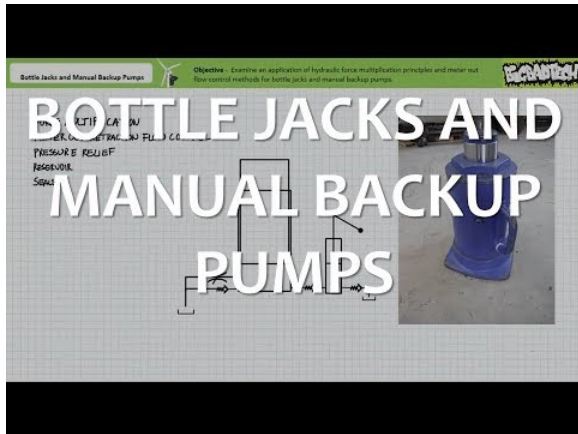
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5.2: Sequence Valves



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NOTE: first 13 entries are REVIEW of pressure control valve family

List the 5 main types of pressure control valves. Draw their associated schematic symbols.

Identify the 5 main characteristics used to classify pressure control valves.

Describe the purpose of a pilot line. Describe the schematic symbol.

Identify pressure control valves that make use of internal pilot lines on their primary, or input, port.

Identify pressure control valves that make use of internal pilot lines on their secondary, or output, port.

Identify pressure control valves that make use of external pilot lines.

Identify pressure control valves that have a NC deactivated state.

Identify pressure control valves that have a NO deactivated state.

Identify pressure control valves that have a check valve bypass. Identify why a check valve bypass is necessary.

Identify pressure control valves that do not have a check valve bypass. Identify why a check valve bypass is not necessary.

Identify pressure control valves that have an internal drain. Identify why an external drain is not necessary.

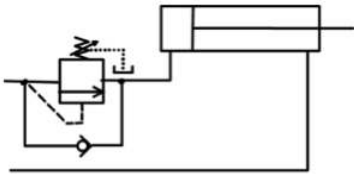
Identify pressure control valves that have an external drain. Identify why an external drain is necessary. Describe the schematic symbol for an external drain.

Identify customary locations for the 5 main pressure control valves.

Describe a sequence valve using the 5 main characteristics used to classify pressure control valves.

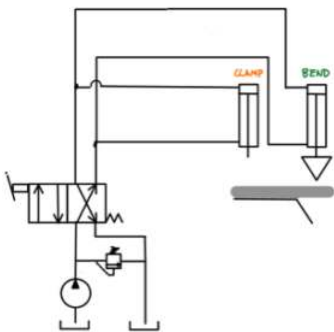
Identify functions of the P, S, D, and X ports for a sequence valve

Describe how the orientation of the check valve bypass influences this actuator's action.

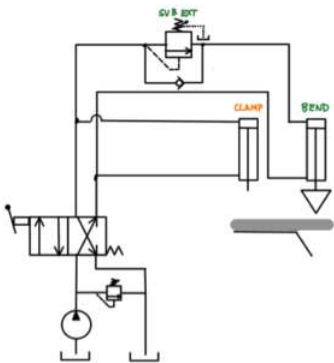


Describe the basic operation of a sequence valve.

Describe operation of this multi actuator clamp and bend hydraulic circuit.

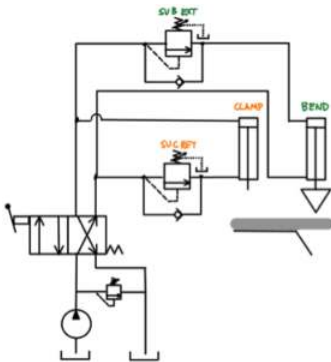


Describe the operation of this multi actuator hydraulic circuit making use of a sequence valve on the cap end of the bend cylinder. Assume the set value of the sequence valve is 400psi and the main pressure relief valve is set to 800psi.

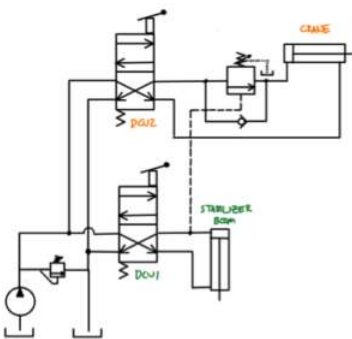


Identify potential disadvantages of coordinating actuation sequence using solely pressure input.

Describe the operation of this multi actuator hydraulic circuit making use of a sequence valve on the cap end of the bend cylinder and another sequence valve on the rod end of clamp cylinder.

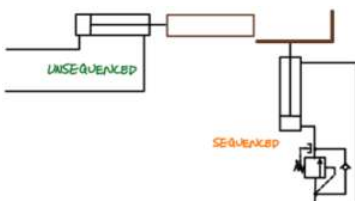


Describe the operation of this hydraulic circuit making use of a sequence valve with an external remote pilot used to coordinate two separate actuators (stabilizer boom and crane) using two independent directional control valves.

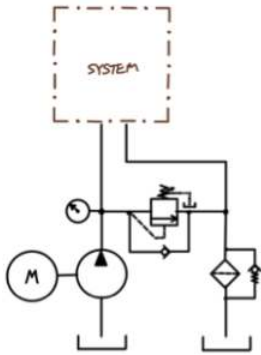


Differentiate between the operation of a normal versus a kick down style sequence valve.

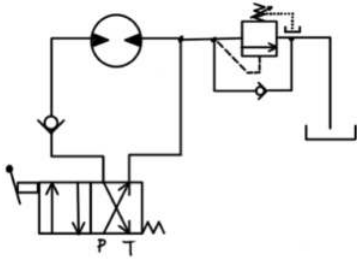
Describe the operation and advantages of this multi actuator hydraulic circuit making use of a kick down style sequence valve.



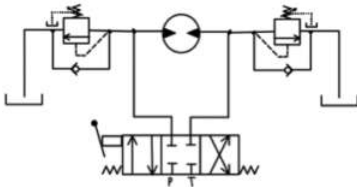
Describe how a sequence valve can present an advantage when used as a pressure relief valve in this hydraulic circuit.



Describe how this sequence valve and check valve can be used to brake a unidirectional hydraulic motor.



Describe how these two sequence valves can be used to brake a bidirectional hydraulic motor.

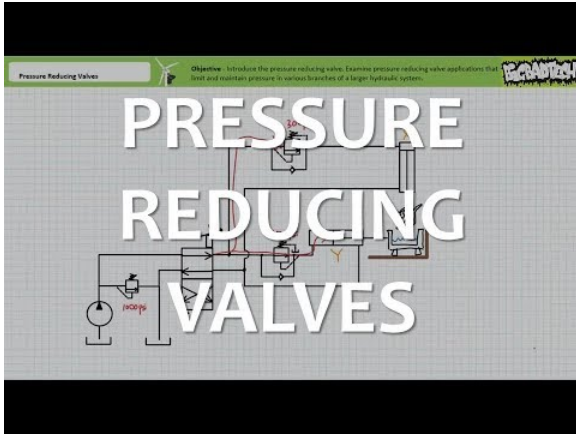


Describe how the set value of the above sequence valves influences the deceleration rate of the hydraulic motor.

Identify the purpose of a makeup check valve.

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5.3: Pressure Reducing Valves



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NOTE: first 13 entries are REVIEW of pressure control valve family

List the 5 main types of pressure control valves. Draw their associated schematic symbols.

Identify the 5 main characteristics used to classify pressure control valves.

Describe the purpose of a pilot line. Describe the schematic symbol.

Identify pressure control valves that make use of internal pilot lines on their primary, or input, port.

Identify pressure control valves that make use of internal pilot lines on their secondary, or output, port.

Identify pressure control valves that make use of external pilot lines.

Identify pressure control valves that have a NC deactivated state.

Identify pressure control valves that have a NO deactivated state.

Identify pressure control valves that have a check valve bypass. Identify why a check valve bypass is necessary.

Identify pressure control valves that do not have a check valve bypass. Identify why a check valve bypass is not necessary.

Identify pressure control valves that have an internal drain. Identify why an external drain is not necessary.

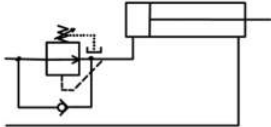
Identify pressure control valves that have an external drain. Identify why an external drain is necessary. Describe the schematic symbol for an external drain.

Identify customary locations for the 5 main pressure control valves.

Describe a pressure reducing valve using the 5 main characteristics used to classify pressure control valves.

Describe the basic operation of a pressure reducing valve.

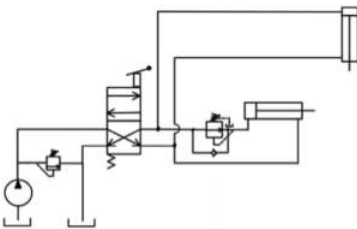
Describe how the orientation of the check valve bypass influences this actuator's action.



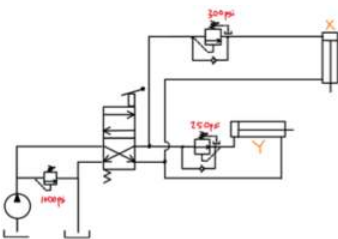
Identify functions of the P, R, and D ports for a pressure reducing valve

Differentiate between constant pressure type pressure reducing valves and constant reduction type pressure reducing valves.

Describe operation of this multi actuator hydraulic circuit making use of a pressure reducing valve.



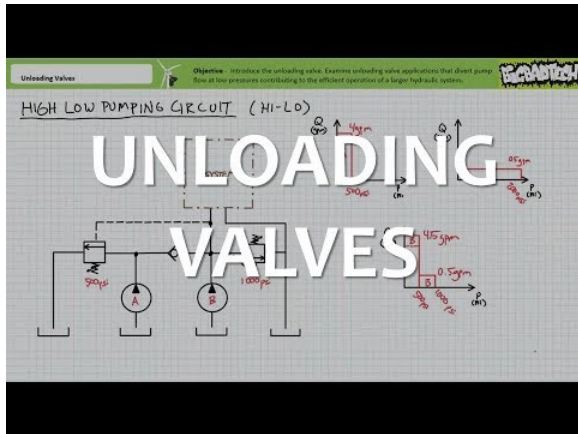
Describe operation of this multi actuator hydraulic circuit making use of both a pressure reducing valve and a sequence valve.



Discuss how set values of the pressure reducing valve, sequence valve, and main pressure relief valve influence the proper functionality of the above system.

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5.4: Unloading Valves



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NOTE: first 13 entries are REVIEW of pressure control valve family

List the 5 main types of pressure control valves. Draw their associated schematic symbols.

Identify the 5 main characteristics used to classify pressure control valves.

Describe the purpose of a pilot line. Describe the schematic symbol.

Identify pressure control valves that make use of internal pilot lines on their primary, or input, port.

Identify pressure control valves that make use of internal pilot lines on their secondary, or output, port.

Identify pressure control valves that make use of external pilot lines.

Identify pressure control valves that have a NC deactivated state.

Identify pressure control valves that have a NO deactivated state.

Identify pressure control valves that have a check valve bypass. Identify why a check valve bypass is necessary.

Identify pressure control valves that do not have a check valve bypass. Identify why a check valve bypass is not necessary.

Identify pressure control valves that have an internal drain. Identify why an external drain is not necessary.

Identify pressure control valves that have an external drain. Identify why an external drain is necessary. Describe the schematic symbol for an external drain.

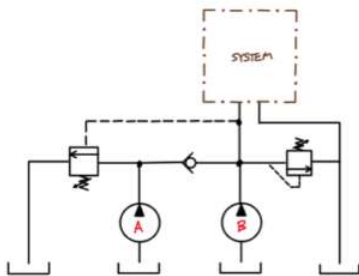
Identify customary locations for the 5 main pressure control valves.

Describe an unloading valve using the 5 main characteristics used to classify pressure control valves.

Describe the basic operation of an unloading valve.

Identify functions of the P, T, and X ports for an unloading valve

Describe operation of this high-low pumping circuit making use of an unloading valve. Assume pump A is high flow/low pressure and pump B is low flow/high pressure. Assume set value of unloading valve is half that of the main pressure relief valve. Identify the purpose of the check valve between pump A and B.

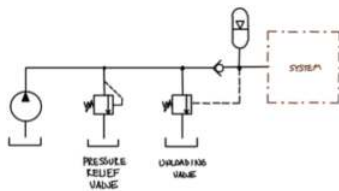


When pressure in the external pilot line reaches the set value of the unloading valve identify the magnitude of the pressure differential across the unloading valve when it opens.

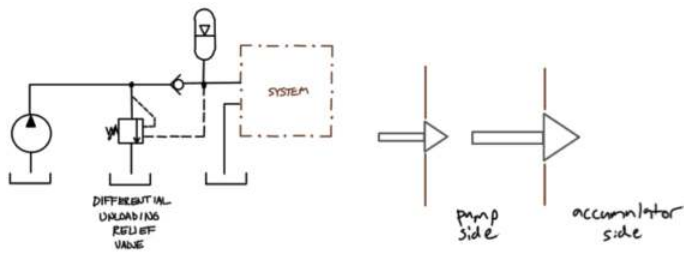
Identify 2 general applications of a high-low pumping circuit.

Compare and contrast regenerative extension with high-low pumping circuits making use of an unloading valve.

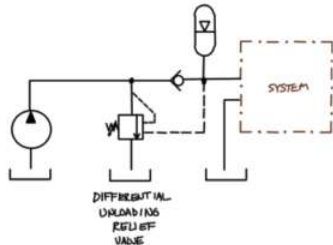
Describe operation of this hydraulic circuit making use of an unloading valve and an accumulator. Identify problems with this circuit when the unloading valve is pilot operated.



Use this hydraulic circuit and diagram of two pilot darts to describe the general operation of a differential unloading relief valve.

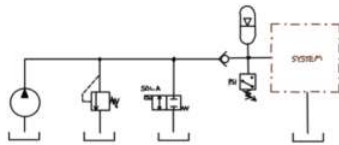


Describe the operation of this hydraulic circuit making use of a differential unloading relief valve and an accumulator.

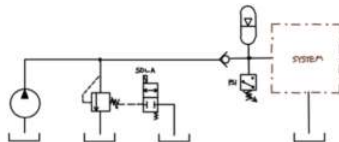


Identify the source of the differential range experienced during the operation of differential unloading relief valve

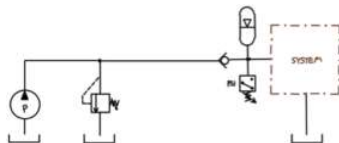
Describe how this hydraulic circuit making use of a pressure switch replicates the function of an unloading valve.



Describe how this hydraulic circuit making use of a pressure switch replicates the function of an unloading valve.

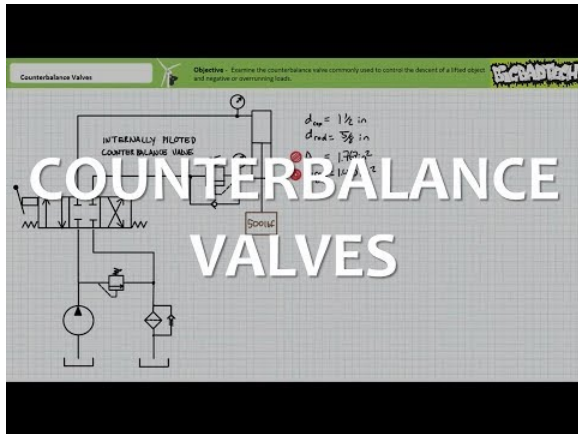


Describe how this hydraulic circuit making use of a pressure switch that turns off the prime mover when pressure is in excess of the set value contributes towards efficient operation.



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5.5: Counter Balance Valves



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NOTE: first 13 entries are REVIEW of pressure control valve family

List the 5 main types of pressure control valves. Draw their associated schematic symbols.

Identify the 5 main characteristics used to classify pressure control valves.

Describe the purpose of a pilot line. Describe the schematic symbol.

Identify pressure control valves that make use of internal pilot lines on their primary, or input, port.

Identify pressure control valves that make use of internal pilot lines on their secondary, or output, port.

Identify pressure control valves that make use of external pilot lines.

Identify pressure control valves that have a NC deactivated state.

Identify pressure control valves that have a NO deactivated state.

Identify pressure control valves that have a check valve bypass. Identify why a check valve bypass is necessary.

Identify pressure control valves that do not have a check valve bypass. Identify why a check valve bypass is not necessary.

Identify pressure control valves that have an internal drain. Identify why an external drain is not necessary.

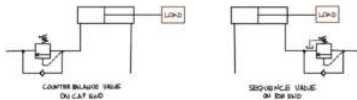
Identify pressure control valves that have an external drain. Identify why an external drain is necessary. Describe the schematic symbol for an external drain.

Identify customary locations for the 5 main pressure control valves.

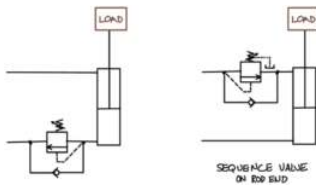
Describe a counterbalance valve using the 5 main characteristics used to classify pressure control valves.

Describe the basic operation of a counterbalance valve.

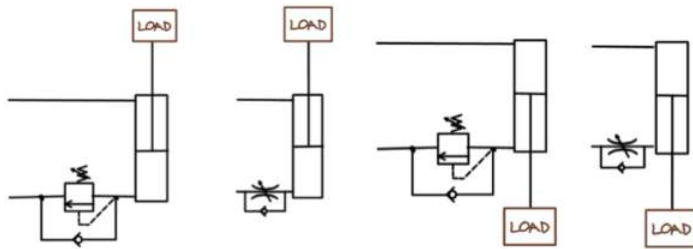
Compare the operation of these two hydraulic circuits when the laterally manipulated load is fully supported by some outside force.



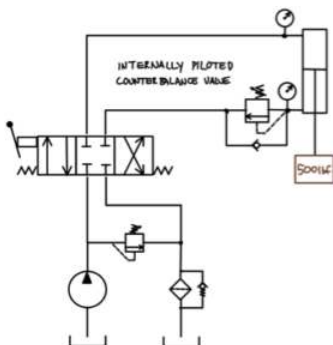
Compare the operation of these two hydraulic circuits when the vertically manipulated load is influenced by some outside force like gravity.



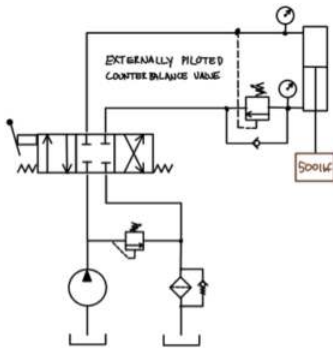
Compare and contrast these circuits making use of counterbalance valves and meter out flow control circuits.



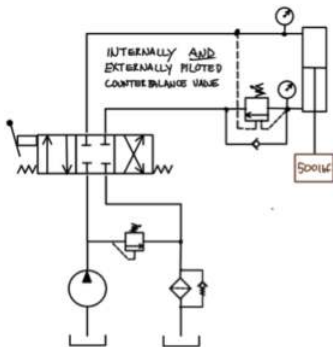
Describe the operation of this circuit making use of an internally piloted counterbalance valve. Comment on the maximum downwards force exerted by this system.



Describe the operation of this circuit making use of an externally piloted counterbalance valve used to lower a heaving mold, forming piece or platen. Comment on the behavior of this system during lowering and the maximum downwards force it is capable of generating.



Describe the operation of this circuit making use of an internally and externally piloted counterbalance valve used to lower a heaving mold, forming piece or platen. Comment on the behavior of this system during lowering and the maximum downwards force it is capable of generating.

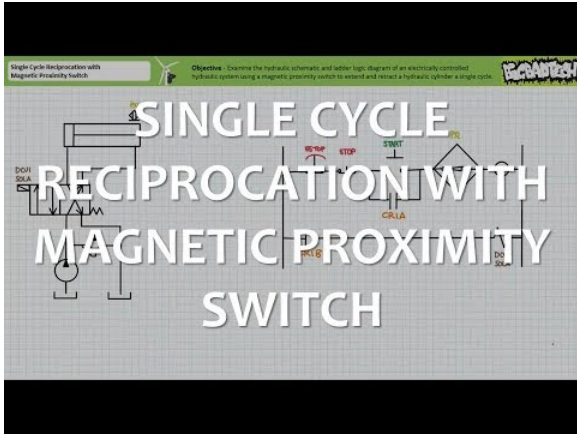


Comment on observed behavior of hydraulic systems for different counterbalance valve set values and loads.

Compare and contrast the general behavior of internal, external, and internal and externally piloted counterbalance valves.

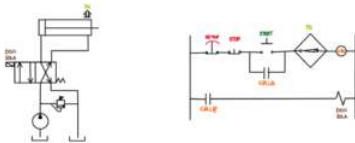
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6.1:0 Single Cycle Reciprocation with Magnetic Proximity Switch



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Describe the behavior of this electrically controlled hydraulic circuit.

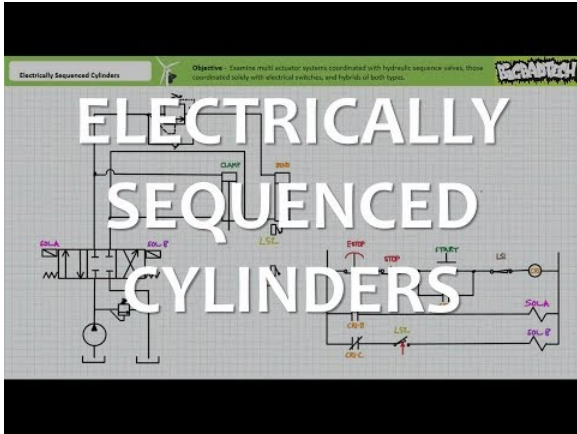


Discuss the influences of loss of power to magnetic proximity switch.

Discuss the influences of an errant metal object near the magnetic proximity switch.

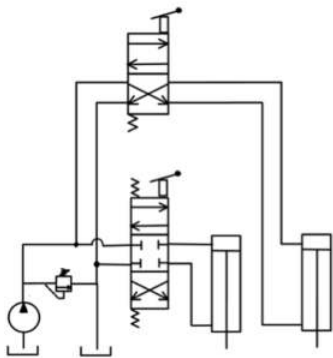
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6.1:1 Electrically Sequenced Hydraulic Cylinders

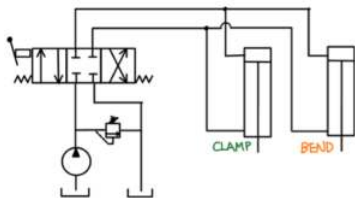


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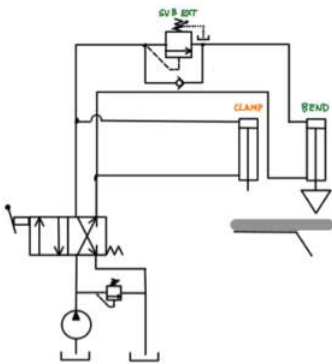
Describe the operation of this manually sequenced clamp and bend hydraulic circuit. Discuss any disadvantages of this system.



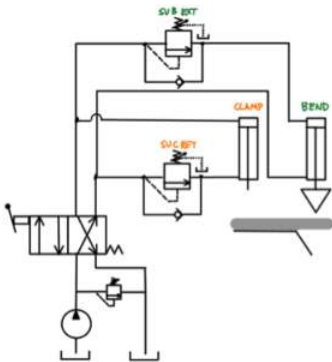
Describe the operation of this clamp and bend hydraulic circuit making use of a single directional control valve. Discuss any disadvantages of this system.



Describe the operation of this multi actuator hydraulic circuit making use of a sequence valve on the cap end of the bend cylinder. Assume the set value of the sequence valve is 400psi and the main pressure relief valve is set to 800psi.

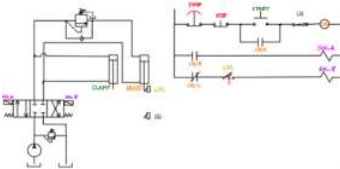


Describe the operation of this multi actuator hydraulic circuit making use of a sequence valve on the cap end of the bend cylinder and another sequence valve on the rod end of clamp cylinder.



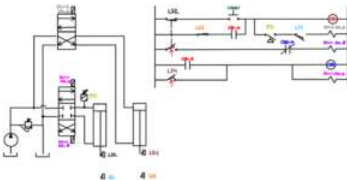
Identify potential disadvantages of coordinating actuation sequence using solely pressure input.

Describe the operation of this electrically controlled clamp and bend hydraulic system.



Describe what would occur if the clamp cylinder ever lagged significantly behind the bend cylinder during retraction.

Describe the operation of this electrically sequenced clamp and bend hydraulic system.



Discuss any advantages exhibited by the above purely electrically sequenced clamp and bend system compared to those making use of hydraulic sequence valves.

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6.3: Solenoid Operated Valves



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Describe a solenoid operated valve and identify its purpose in an electrically controlled system

Describe the similarities and differences between a solenoid operated valve and a contactor

Differentiate between the terms NO and NC as applied to electrical switches and valves

Draw the hydraulic schematic symbol for a spring offset, 2 position, four way, solenoid operated valve with a cross connect in the deactivated state and a straight through in the activated state

Draw the electrical schematic symbol for the coil of a solenoid operated valve

Describe a solenoid and discuss its function and purpose inside a solenoid operated valve

Describe the purpose of the drain port inside a solenoid operated hydraulic valve

Describe the purpose of a manual override for a solenoid operated valve and draw its schematic symbol

Differentiate between the applications of closed, tandem, float, and open center 3 position valves

Describe the problems associated with the simultaneous activation of both solenoids for a double solenoid valve and discuss the means of preventing this from occurring

Differentiate between electrically held and detented solenoid operated valves

Describe the components of a typical solenoid operated valve and identify their purpose

Define and differentiate between rated voltage, pickup voltage, hold in voltage, and dropout voltage

Describe why a 120V AC coil cannot be used with 24V DC

Differentiate between inrush and sealed in current

Describe why a means of voltage spike suppression must be used for certain coils

Discuss points of inspection and maintenance procedures for solenoid operated valves

Describe shift limit characteristics for solenoid operated valves

Define both “rated flow” and “maximum inlet pressure” for solenoid operated valves

Describe both the “pressure drop for different flow rates” and “operating limits” performance curve for solenoid operated valves

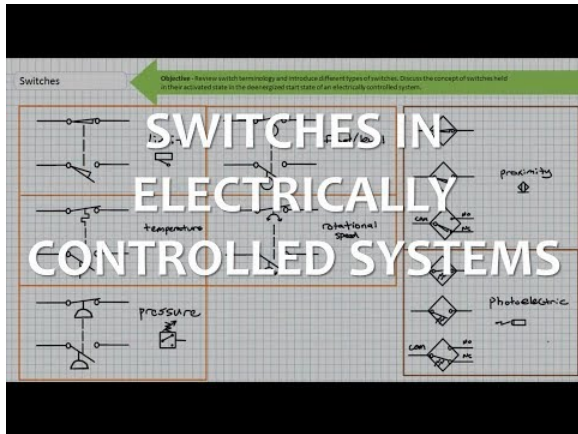
Describe leakage, fluid compatibility, and required filtration specifications for solenoid operated valves

Describe a variable solenoid operated valve and discuss its application for a hydraulic system

Describe a piggyback valve and discuss its application for a hydraulic system

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6.4: Switches in Electrically Controlled Systems



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Compare and contrast switches and sensors/transducers.

Discuss observed properties of closed and open switches with respect to resistance and current.

Define the terms pole and throw.

Draw the schematic symbol for the following switches: SPST, SPDT, SPTT-CO, DPST, DPDT, 3PST

Define the term electrical isolation.

Define the term actuation and differentiate between manually and mechanically/automatically actuated switches.

Define making and breaking.

Differentiate between the deactivated state and activated state of a switch.

Identify in which state switches are illustrated in schematics.

Differentiate between the deenergized state and energized state of a load.

Differentiate between NC and NO switches in their deactivated and activated states. Identify resistance and current carrying ability in both states.

Describe advantages of a double break switch over a single break switch.

Define a mechanical interlock.

Differentiate between momentary and maintained contact switches.

Draw the schematic symbol for a maintained contact ESTOP button.

Draw the schematic symbol for a momentary contact break-make pushbutton package consisting of a mechanically interlocked set of NC and NO contacts.

Identify the purpose of an auxiliary contact block.

Draw the schematic symbol for a maintained contact 3 position selector switch with two associated contacts A and B. Assume contact A is closed in position 1, both contacts are open in position 2, contact B is closed in position 3. Draw the target table/contact chart illustrating this functionality.

Draw the schematic symbol for a drum or cam switch used to reverse the rotational direction of an industrial 3 phase AC motor. Draw the target table/contact chart illustrating this functionality.

Draw the ladder logic representation of a limit switch consisting of a mechanically interlocked pair of NC and NO contacts. Draw the hydraulic schematic representation of a limit switch.

Describe the concept of switches being held in their activated state using both the gravity and arrow convention. Draw examples of each. Identify the preferred method.

Draw the schematic symbol for a temperature switch consisting of a mechanically interlocked pair of NC and NO contacts.

Draw the ladder logic representation of a pressure switch consisting of a mechanically interlocked pair of NC and NO contacts. Draw the hydraulic schematic representation of a pressure switch.

Differentiate between the set and reset value of a pressure switch. Identify why this is a desirable trait.

Draw the ladder logic representation of a float switch consisting of a mechanically interlocked pair of NC and NO contacts.

Draw the ladder logic representation of a rotational speed (plugging/anti-plugging) switch consisting of a mechanically interlocked pair of NC and NO contacts.

Differentiate between electromechanical and solid state switches, give examples of each.

Draw the ladder logic representation of a proximity switch consisting of a SPDT transfer contact. Draw the hydraulic schematic representation of a proximity switch.

Identify the advantages and disadvantages of proximity switches compared to limit switches.

Differentiate between inductive and capacitive proximity switches.

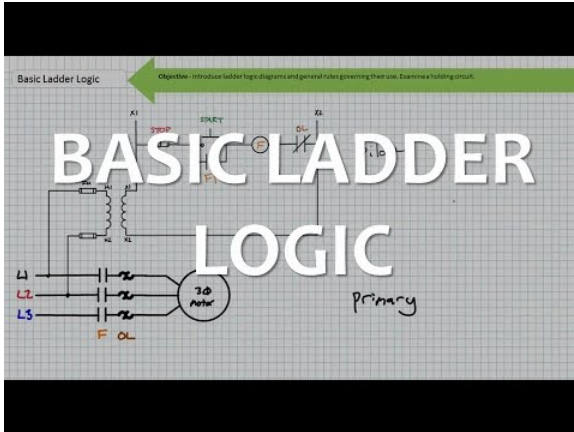
Define the terms operating point, release point, and hysteresis with respect to a proximity switch.

Draw the ladder logic representation of a photoelectric switch consisting of a SPDT transfer contact. Draw the hydraulic schematic representation of a photoelectric switch.

Differentiate between through beam scanners, retroreflective scanners, and diffuse scanners. Identify when a polarized retroreflective scanner would be used.

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6.5: Basic Ladder Logic



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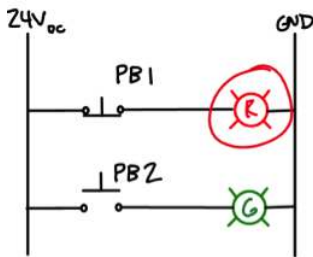
Describe ladder logic diagrams and indicate the advantages of ladder logic

Differentiate between control/pilot signal and power/primary signals

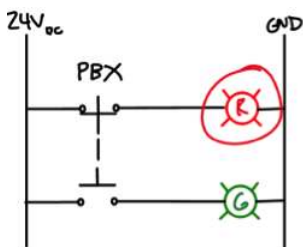
Describe the purpose of separating pilot and primary

List the 11 basic rules of ladder logic as discussed in this lecture

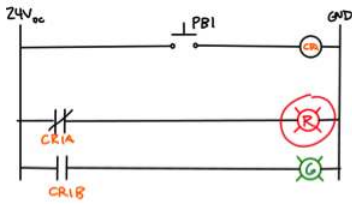
Describe the behavior of this system for all possible combinations of input conditions.



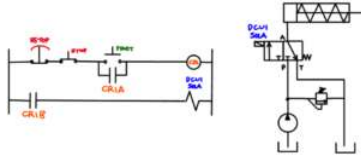
Describe the behavior of this system for all possible combinations of input conditions.



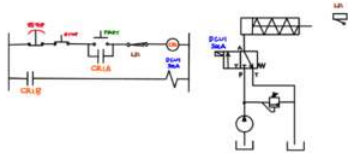
Describe the behavior of this system for all possible combinations of input conditions.



Describe the behavior of this electrically controlled hydraulic system. Define the purpose of the holding circuit.



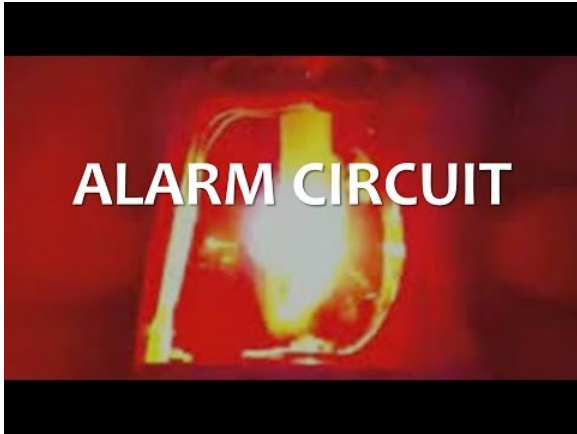
Describe the behavior of this electrically controlled hydraulic system incorporating a limit switch.



Compare and contrast hard wired relay based ladder logic with a programmable logic controller.

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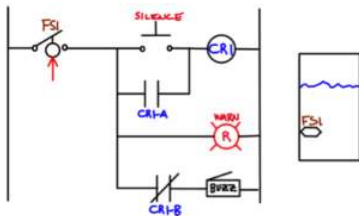
6.6: Alarm Circuit



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Discuss the significance of contacts being held in their activated state by a deenergized system.

Describe the behavior of this alarm system.

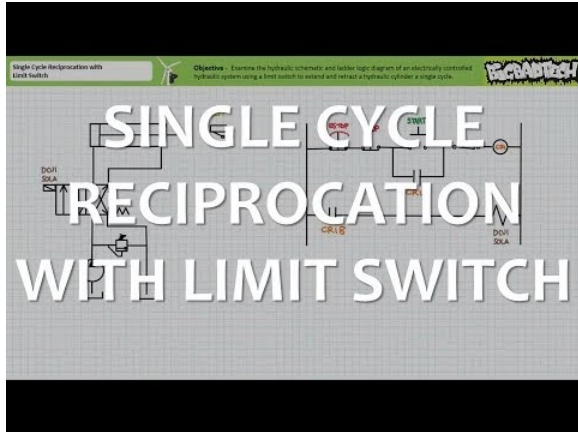


Describe the behavior of the above circuit if a NO pressure switch and a NO temperature switch are placed in parallel with the NC-HO FS1.

Describe the behavior of the above circuit if the NC-HO FS1 at the top of the tank is replaced with a NO FS1 at the bottom of a tank.

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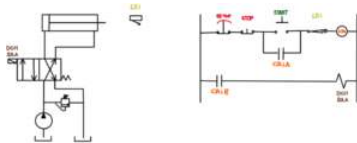
6.9: Single Cycle Reciprocation with Limit Switch



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Define a single cycle reciprocation action.

Describe the behavior of this electrically controlled hydraulic circuit.



Discuss the influences of inadvertent opens at various points in ladder logic diagram.

Discuss the influences of the loss of primary hydraulic power.

Comment on the influences of an improperly set pressure relief valve.

Discuss the influences of an activated ESTOP.

Discuss the influences of a limit switch inadvertently triggered by some errant object.

Discuss the influences of an improperly positioned limit switch that fails to activate.

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