



## Fluid Power 1

### Actuators

Describe the operation of a double-acting pneumatic cylinder and give its schematic symbol  
Describe the function of a single-acting pneumatic cylinder and give an application  
Describe how cylinder sizes are specified, Size a pneumatic cylinder given a load, and Describe how to size a pneumatic cylinder  
Describe five common tie rod cylinder mounting styles and give an application of each  
Select a cylinder mounting style for a given application"  
Describe the operation of a quick exhaust valve and give its schematic symbol  
Describe 6 symptoms of pneumatic cylinder failure  
Describe the function of a rotary actuator and give an application  
Describe the function of a shock absorber  
Describe how to troubleshoot slow actuator speed  
Calculate the extension force of a cylinder given its size and pressure

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### Best Practices

Describe the importance of eliminating air leaks  
Describe four common pneumatic component failures and their probable causes  
Give five guidelines used in the construction of pneumatic circuits

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### Circuits and Logic

Describe the function of a pneumatic schematic  
Describe the line symbols used with fluid power circuits  
Design speed control circuits  
Design a pneumatic circuit that uses an externally air-piloted DCV  
Define air logic and give four applications  
Describe the function of a shuttle valve and give an application  
Connect and operate an air logic circuit to control a reciprocating cylinder  
Connect a hydraulic circuit given a schematic

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### Compressor and Conditioners

Explain how air pressure is created in a pneumatic system  
Describe the function of a dryer and give an application  
Describe the operation of a refrigeration type air dryer  
Describe the principle of operation of three types of dryers and give an application of each  
Describe the function of pneumatic system trap  
Describe the operation of two types of pneumatic traps and give the schematic symbol of each

## Connectors

Describe the function of a pneumatic quick connect fitting and give its schematic symbol

Describe the function of a tee and give its schematic symbol

Describe the function of a hydraulic quick disconnect fitting and give its schematic symbol

Describe the function of a hydraulic quick disconnect fitting and give its schematic symbol

## Direction Control Valves

Describe the function of a 5-way, 3-position pneumatic DCV and give an application

Describe the operation of a 5-way, 3-position pneumatic DCV and give its schematic symbol

Describe the function of a 3/2 pneumatic DCV and give an application

Connect and operate a pneumatic cam-operated 3/2 DCV

Describe the operation of a 3/2 pneumatic DCV and give its schematic symbol

Describe the function of a pneumatic cam-operated valve and give an application

Describe the operation of a pneumatic cam-operated DCV and give its schematic symbol

Describe the function of an externally air-piloted DCV and give an application

Describe the operation of an externally air-piloted DCV and give its schematic symbol

Describe the function of a pilot-operated DCV and give an application

Describe the operation of internal and external DCV pilots of a pilot-operated DCV

Describe the function of internal and external DCV pilots

Describe the symptoms of pilot-operated DCV failure and their causes

Describe how to inspect and troubleshoot a pilot-operated DCV

Describe the operation of a 3-position, 4-way DCV and give an application

Describe the operation of a 3-position, 4-way DCV and give its schematic symbol

Connect and operate a double-acting cylinder using a 4/3 solenoid-operated hydraulic DCV

Connect and operate a double-acting cylinder using a 4/2 solenoid-operated DCV

Connect and operate a single-acting cylinder using a 5/2 solenoid-operated pneumatic DCV

## Electro-Fluid Power

Describe the operation of two types of hydraulic solenoids and explain the application of each

Describe the operation of two types of solenoid-operated pneumatic DCVs

Describe the operation of a solenoid-operated hydraulic DCV and give its schematic symbol

Describe the function and operation of a hydraulic DCV manual override

Use the manual override of a solenoid-operated pneumatic DCV to jog a cylinder

Use the manual override of a solenoid-operated hydraulic DCV to jog a cylinder

Describe the function of electro-pneumatic controls and give an application

Describe the function and operation of a pneumatic DCV manual override

Describe the function of a limit switch and give an application

Describe how to interpret limit switch symbols

Describe the operation of a limit switch and give its schematic symbol

Describe the operation of limit switch in an event sequencing circuit

Describe the operation of a single-cycle cylinder reciprocation circuit

## Filters

Describe the function of an air filter  
Describe the operation of an air filter and give its schematic symbol  
Drain a pneumatic filter  
Describe two methods of removing water vapor from a pneumatic system  
Describe four symptoms of filter failure and their causes  
Describe how to inspect and troubleshoot a filter

## Fittings

Describe the construction and give an application of three types of pneumatic fitting threads  
Install and seal a straight thread fitting  
Describe the function of an adapter and give an application  
Describe the UNF thread size used for pneumatic fittings  
Describe the operation of straight threaded fittings  
Describe how to identify and specify pipe size  
Identify the nominal pipe size of a fitting given an example  
Describe the function of a reducing bushing and give an application  
Install a reducing bushing to connect an oversized port  
Describe how to specify the size of a reducing bushing  
Identify the shape, type and size of tubing connectors

## Flow Control & Relief Valves

Describe the function of a muffler and give its schematic symbol  
Describe the function of a pneumatic check valve and give an application  
Describe the operation of three types of check valves and give their schematic symbol  
Describe the function of a check valve and give an application  
Connect and operate a check valve  
Describe the operation of two types of pneumatic check valves and give their schematic symbols  
Describe the operation of a flow control valve and give its schematic symbol  
Connect and adjust a flow control valve to control speed of an actuator  
Describe what determines the speed of a pneumatic actuator  
Describe the effect of actuator load changes on flow control valve operation  
Describe the operation of a flow control valve and give its schematic symbol  
Describe the function of the flow control valve and give an application  
Troubleshoot a flow control valve using an in-circuit test  
Describe how to inspect and troubleshoot a flow control valve  
Describe the symptoms of flow control valve failure and their causes  
Connect and adjust a flow control valve to control speed of an actuator  
Describe the operation of a meter-in flow control circuit and give an application  
Connect and operate a meter-in flow control circuit  
Describe the operation of a meter-out flow control circuit and give an application  
Connect and operate an exhaust port speed control circuit  
Connect and operate a meter-out flow control circuit  
Describe the operation of an exhaust port speed control and give an application  
Connect and operate a needle valve to control actuator speed  
Connect and operate a needle valve to control the speed of an actuator  
Describe the operation of a needle valve and give its schematic symbol

Describe the main function of a pneumatic needle valve and give an application  
Describe the main function of a needle valve  
Describe the symptoms of quick exhaust valve failure and their causes  
Describe how to inspect and troubleshoot a quick exhaust valve  
Describe the function of an exhaust restrictor and give an application  
Describe the symptoms of exhaust restrictor failure  
Describe the operation and construction of a exhaust restrictor  
Describe the function of a relief valve and give an application  
Connect and adjust the pressure setting of a PRV  
Describe the operation of an integral check valve and give its schematic symbol  
Connect a relief valve in a circuit to limit pressure in the system  
Describe the operation of a direct-acting relief valve and give its schematic symbol

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## Gages and Instruments

Read a pneumatic pressure gage  
Read a hydraulic pressure gage  
Describe how pressure gages are calibrated  
Measure Delta P across pneumatic components  
Connect and read a manometer  
Describe the operation of two types of manometers  
Describe the function of a flowmeter and give an application  
Connect and read a flow meter  
Describe the operation of two types of flowmeters and give their schematic symbol  
Connect and read a flowmeter  
List and give an advantage of each of three devices used to measure vacuum levels  
Connect and read a vacuum gage  
Convert between units of mercury and units of air pressure  
Convert between units of water column and units of mater pressure

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## Hoses

Describe the three functions of an air line  
Describe how hose is specified  
Describe how to determine the length of a hose for an application  
Identify hose size given a specification  
Identify hose size by measurement  
Describe how to cut hose  
Cut off hose using a cut-off saw  
Describe how to calculate the pressure drop given hose size and flow rate  
Calculate the pressure drop given hose size and flow rate  
Describe how to maintain a hose system

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## Lubricators

Describe the function of air lubrication and list three lubrication methods  
Describe the operation of three types of pneumatic lubricators and give an application of each  
Describe the function of a lubricator and give its schematic symbol  
Describe four symptoms of lubricator failure and their causes  
Describe how to inspect and troubleshoot a lubricator

## Metal Tubing

Describe how metal tubing is specified  
Select and size metal tubing for an application  
Select and size metal tubing for an application  
Describe how to select and size metal tubing for a given application  
Calculate the head loss given metal tubing size and flow rate  
Describe how to calculate the head loss given metal tubing size and flow rate  
Write a tubing specification given its dimensions  
Identify metal tubing given a specification  
Identify metal tubing specification by measurement  
Describe four types of metal tubing and give an application of each  
Describe the operation of a tube bender  
Use a tube bender to bend tubing to a certain angle  
Determine bend locations and angles given a tubing layout drawing  
Describe how to determine bend locations and angles  
Describe how to use a tube cutter to cut metal tubing  
Describe three methods of assembling metal tubing  
Describe how to solder metal tubing  
Cut, bend and assemble steel tubing using flared and flareless fittings  
Assemble copper tubing using flared and flareless fittings  
Describe how to assemble tubing using flared and flareless fittings

## Motors

Describe the function of a pneumatic motor and give an application  
Describe how to size a pneumatic motor  
List three types of hydraulic motors and give an application of each  
Describe the operation of a hydraulic motor and give its schematic symbol  
Describe the function of a hydraulic motor and give an application  
Calculate the air flow needed for a pneumatic motor  
Select a pneumatic motor  
List three common pneumatic motor designs and explain where they are used  
Describe the operation of a pneumatic motor and give its schematic symbol  
Define pneumatic motor torque and give its units of measurement  
Describe how to use a torque-speed curve to determine pneumatic motor speed  
Define three types of torque and give its units of measurement  
Describe four symptoms of pneumatic motor failure  
Troubleshoot a motor using an in-circuit test  
Describe how to inspect and troubleshoot a pneumatic motor

## Pressure Sequence Valves

Describe the function of a pressure sequence valve and give an application  
Design a two-sequence valve control circuit  
Design a pressure sequence circuit  
Connect and operate a pressure sequence circuit  
Connect and adjust the pressure setting of a sequence valve  
Explain why a sequence valve is externally drained  
Describe the function of a two-sequence valve control circuit

Describe the function of a by-pass check valve in a sequence valve circuit  
Describe the operation of a direct-acting sequence valve and give its schematic symbol

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## Pump and Reservoir

Describe the operation of a hydraulic power unit  
Describe the operation of a fixed-displacement pump and give its schematic symbol  
Describe the operation of three types of fixed displacement pumps and give an application of each  
describe maintenance of a hydraulic power unit

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## Regulators

Describe the operation of a pressure regulator and give its schematic symbol  
Describe the operation of a pressure regulator under flow conditions  
Describe the function of a pressure regulator valve and give an application  
Describe four symptoms of regulator failure and their causes  
Describe how to inspect and troubleshoot a regulator  
Describe the operation of a direct-acting PRV and give its schematic symbol

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## Safety

Explain six pneumatic safety rules  
Describe eight pneumatic troubleshooting safety rules  
Piping safety test  
Describe the function of a lockout/tagout system  
Describe the operation of an electrical lockout/tagout system  
Describe the operation of a pneumatic lockout/tagout system  
Perform a lockout/tagout on a pneumatic system  
Describe seven rules of safe dress for working with piping

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## Theory

Define pneumatic pressure and give its units of measurement  
Convert between absolute pressure and gage hydraulic pressure  
Define hydraulic pressure and give its units of measurement  
Convert between gage and absolute pressures  
Describe two methods of representing pressure  
Describe how to calculate the force output of an extending cylinder  
Describe how to calculate the force output of a hydraulic cylinder in retraction (pull)  
Describe how to calculate the actual force output of an extending cylinder  
Calculate the retraction force of a cylinder given its size and pressure  
Calculate the extension force of a cylinder given its size and pressure  
Describe how to calculate the force output of a cylinder in retraction (pull)  
State Pascal's Law and explain its significance in pneumatics  
State Pascal's Law and explain its significance in hydraulics  
Explain how force is multiplied using Pascal's Law  
Explain how force is multiplied using Pascal's Law  
State Boyle's Law and explain its significance

Use Boyle's Law to calculate changes in pressure and volume  
Explain how a pneumatic system creates air flow  
Measure Delta P across a hydraulic component  
Explain how Delta P describes hydraulic resistance  
Explain how Delta P describes pneumatic resistance and explain its importance  
Define air flow rate and give its units of measurement  
Define flow rate and explain how it can be measured  
Define dew point and relative humidity and explain their importance  
Explain how water condenses in a pneumatic systems and its effect  
Define hydraulics and give an application  
Describe the function of a hydraulic schematic  
Describe the functions of five basic components of a hydraulic system  
Define pneumatics and give an application  
Explain how pressure is distributed in a hydraulic system  
Describe how to calculate the extend speed of a hydraulic cylinder  
Calculate the cylinder stroke time given its size and a flow rate  
Calculate the retract speed of a cylinder given its size and a flow rate  
Calculate the extend speed of a hydraulic cylinder given its size and a flow rate  
Describe how to calculate the stroke time of a cylinder  
Describe how to calculate the retract speed of a cylinder

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## Threaded Pipe

Identify pipe size and type by measurement  
Write a pipe specification given its dimensions  
Identify pipe size given a specification  
Describe the function of a piping schematic drawing  
Read and interpret a piping schematic drawing  
Identify the pipe fitting schematic symbols  
Describe the function of an expansion joint and give an application  
Install an expansion joint  
Describe the operation of an expansion joint

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## Troubleshooting & Testing

Describe two levels of pneumatic troubleshooting and give an application of each  
Define pneumatic troubleshooting and explain its importance  
Describe two methods of testing a pneumatic component and give an application of each  
Describe four types of in-circuit component tests and give an application of each  
Describe three pneumatic troubleshooting measurements and give an application of each  
Use a pressure test point to check system pressure  
Describe the construction of a pressure test point and give an application  
Describe how to interpret a pneumatic troubleshooting chart  
Describe how to use a flowchart to aid in troubleshooting  
Describe the construction of a troubleshooting flowchart  
Describe the function of a troubleshooting flowchart  
Describe the four methods of system level troubleshooting  
Describe how to use PLC I/O indicators to troubleshoot a pneumatic system process  
Troubleshoot a pneumatic system using PLC indicator lights  
Describe how to troubleshoot zero system pressure  
Troubleshoot high system pressure  
Troubleshoot low system pressure

Describe how to troubleshoot high system pressure  
Describe how to troubleshoot low system pressure

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## **Vacuum**

List two methods used to produce vacuums and give an advantage of each  
Define a vacuum and give three industrial applications  
Describe three symptoms of vacuum generator failure and their causes  
Describe how to inspect and troubleshoot a vacuum generator  
Describe two symptoms of vacuum cup failure and their causes  
Describe how to inspect and troubleshoot a vacuum cup  
Describe the function of a vacuum switch and give an application  
Describe how to inspect and troubleshoot a vacuum switch  
Describe a symptom of vacuum switch failure  
Describe the operation of a vacuum switch  
Describe the function of a vacuum pump and give an application  
Describe the operation of a reciprocating vacuum pump  
Describe how to inspect and troubleshoot a vacuum pump