

# Pneumatic & Electro-pneumatic Control Systems

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*Pneumatic and Hydraulic System  
(Operation and Trouble Shooting)*



## Overview

- 1 Basic Pneumatic System
- 2 Pneumatic System Components
- 3 Pneumatic Direction Control Valves (DCV) and Circuits
- 4 Electro-pneumatic Systems



# Introduction

- **Pneumatics** is the utilization of compressed air to perform mechanical work and control.
- Compressed air can be used in fire- and explosion-hazardous environment.
- Distribution of compressed air can be easily handled with pipes and hoses.
- The usage of pneumatic components is easy as well as their maintenance. Their functionality is generally very reliable.
- Both its pressure level and volume can be regulated quite easily.
- Compressed air – depending on its application – needs some preparation, especially filtration and drying.



# Pneumatic vs. Hydraulic Systems

Hydraulics	Pneumatics
Uses relatively incompressible liquid	Uses a compressible gas (nearly always air)
Slow, smooth motion	Quick, jumpy motion
Very precise	Not as precise as hydraulics
Self-lubricating	Lubricants must be added
Some leakages usually exists	Generally clean
Pressures of 30 to 300 bar	Pressures are around 7 bar

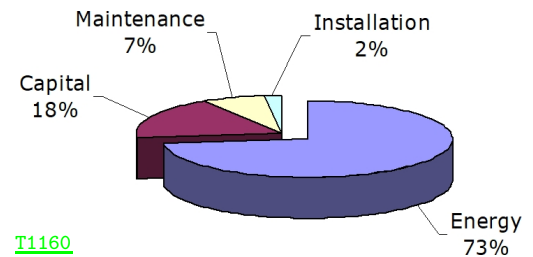
## Pneumatic systems:

- Ubiquitous in industry (75% of industry uses CA)
- Unique applications
- Misconceptions about cost:
  - ▶ Air is free
  - ▶ 10 x more expensive than electricity for work done



# Compressed-Air Systems: Inefficiencies

- Leakage
- High pressure drops
- Unsuitable applications
- Poor pressure control
- Compressors not matched to demand
- Frequent start-ups and unloaded running
- Heat recovery opportunities ignored
- Unsuitable air treatment



# Compressed Air - survey results

- 600 compressors in 8 countries
- Average size 300 kW (10 - 5500 kW)
- Leaks were 20% ave
- Savings potential was 30% ave
- 90% - pressure too high
- 80% - over capacity
- 70% - air treatment problems
- 20% - undersized pipes



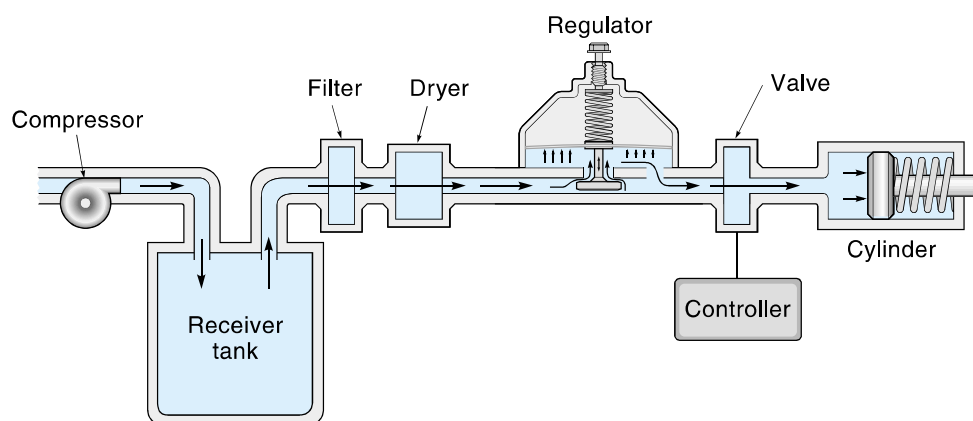
# Air Leakage

- Leak reduction is very low-cost opportunity
- 20% savings of total running cost is often achievable
- Air Leakage - typical culprits
  - ▶ Leaking hoses, couplings
  - ▶ Condensate drains, valves
  - ▶ Pipes, joints and flanges
  - ▶ Pressure regulators
  - ▶ Lack of interlocked isolation valves on machines
  - ▶ Air tools left connected when not in use
- Leakage tests:
  - ▶ Listen on a quiet day
  - ▶ Apply leak detection spray, soapy water and brush
  - ▶ Ultrasonic leak detectors
  - ▶ Measure pressure decay

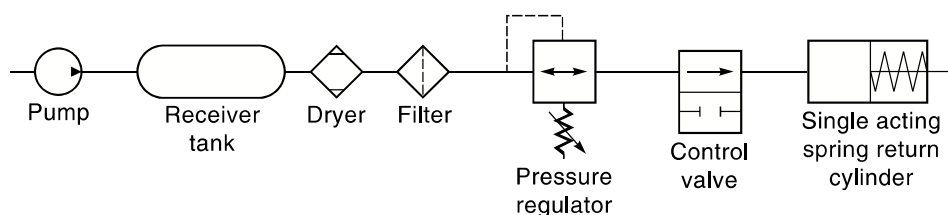


## Pneumatic System Components

# A Basic Pneumatic System



(a) Diagram

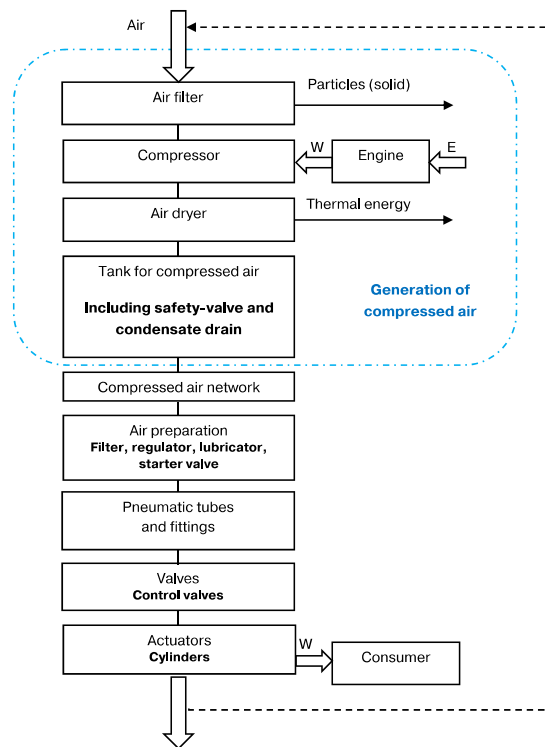


(b) Symbolic diagram





# Compressed air from its generation to the consumer



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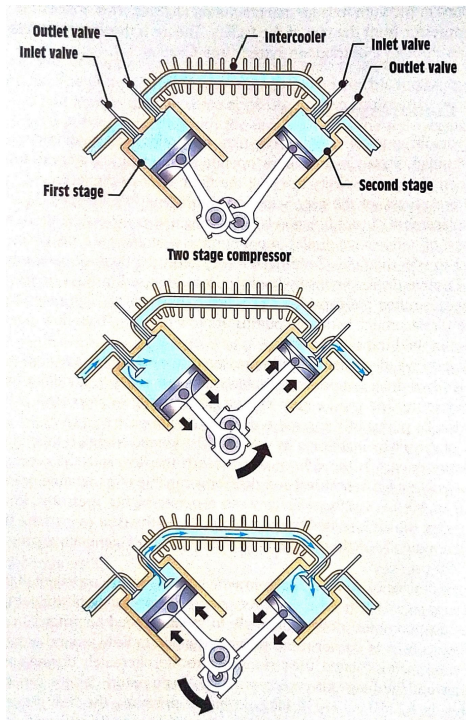


## Key Components of a Pneumatic system

- Air **compressor** pumps air from the atmosphere into a tank. There are a number of types of compressors, but one of the most common is the reciprocating piston compressor.
- Moisture from compressed air must be removed, or it will cause damage the pneumatic components. Removing is done by the **dryer**, of which there are two major types: after-cooler and desiccant dryer.
- **Receiver tank** receives air from the compressor and becomes the high-pressure air reservoir for the system.
- **Pressure regulator** can supply air at a constant pressure regardless of the source pressure as long as the source pressure stays above the desired regulated pressure.
- **Pneumatic control valves** regulate the air flow, commonly ON or OFF.
- **Pneumatic actuators** convert air pressure into mechanical motion. There are two basic types: (a) linear actuators (cylinder/piston or diaphragm types) and (b) rotary actuators.



# Reciprocating Compressors

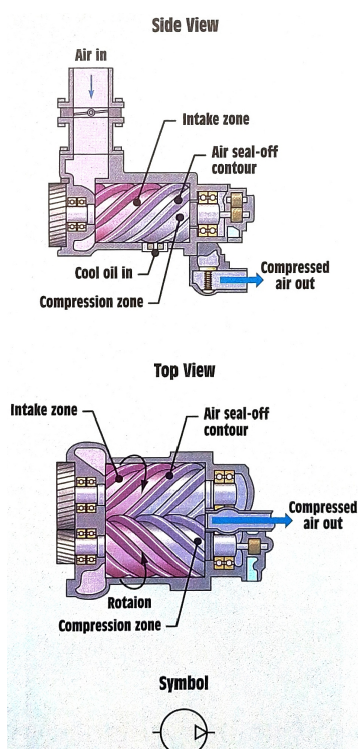


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# Rotary Screw Compressors



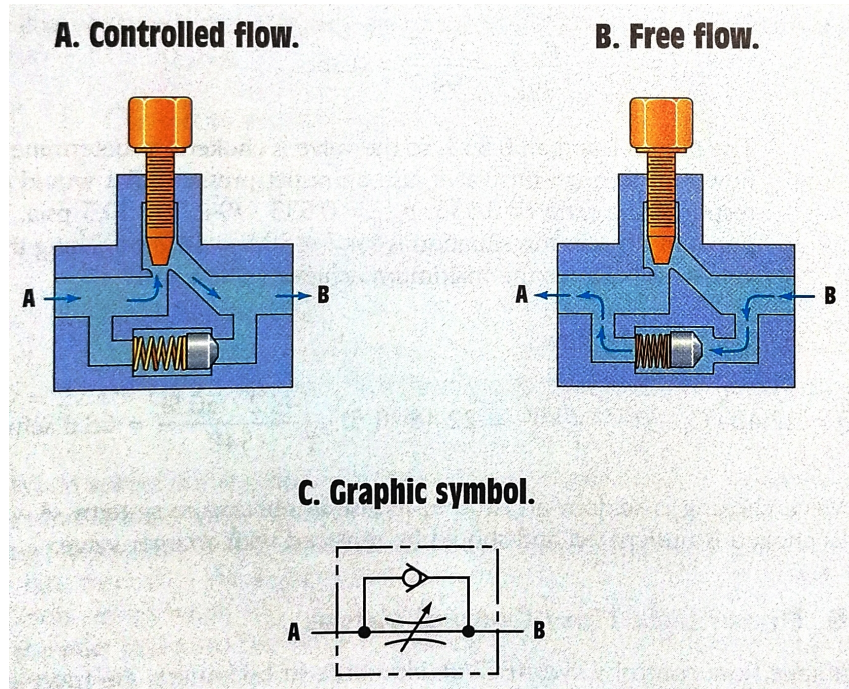
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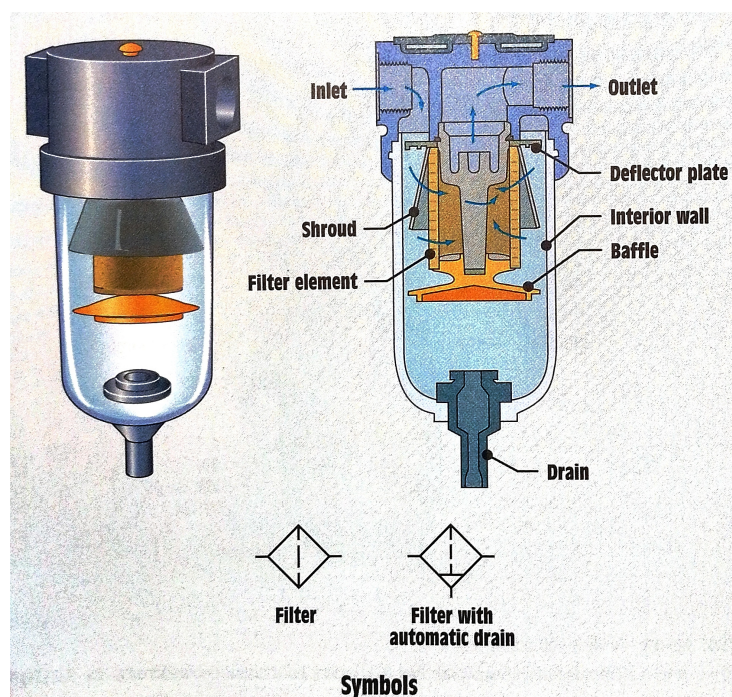
# Flow control valve



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# Air-line Filter

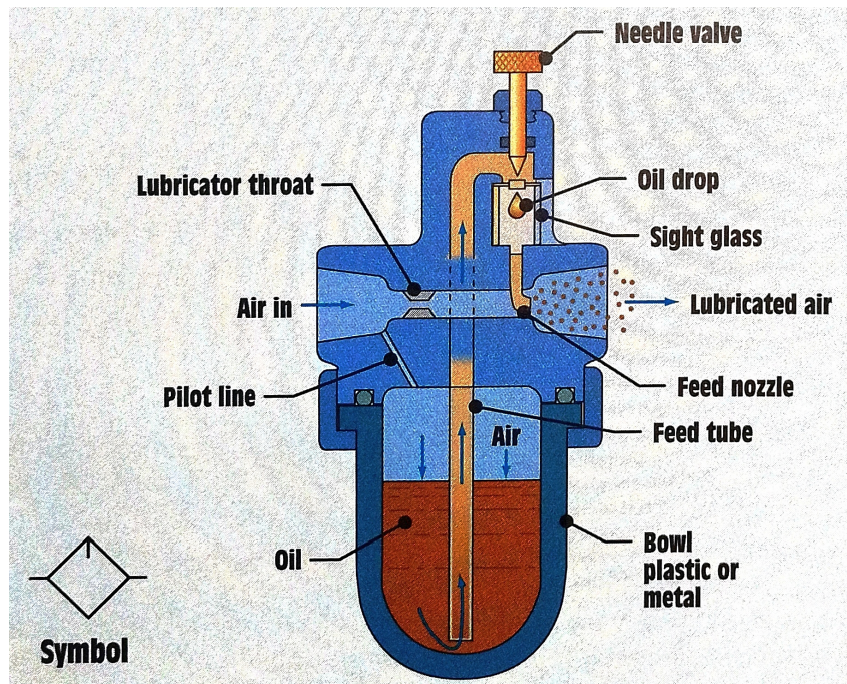


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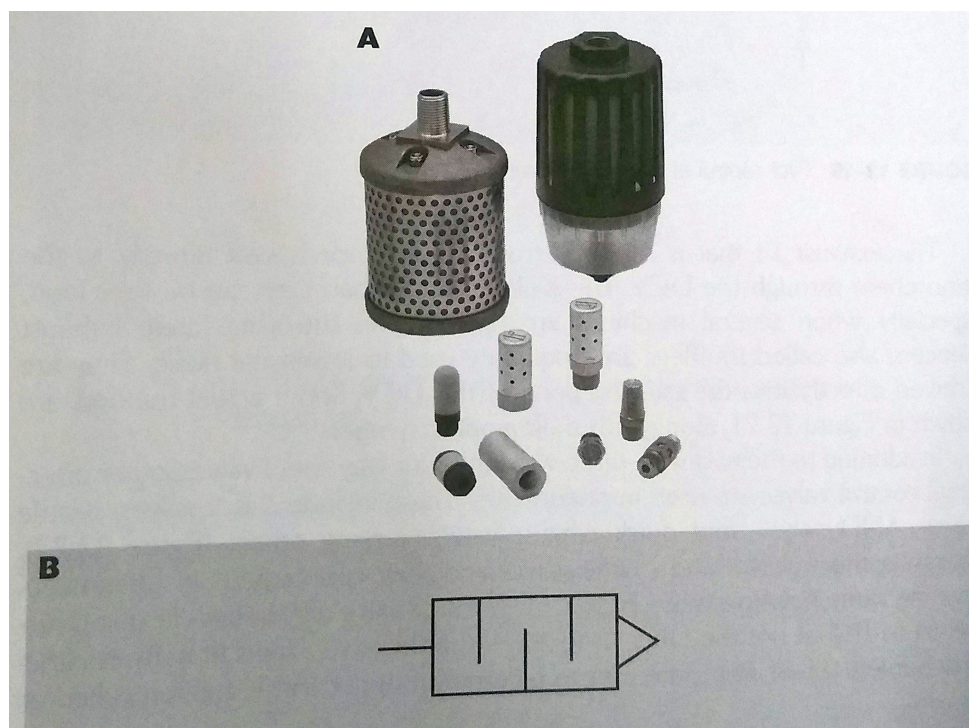
# Air-line Lubricator



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# Exhaust port Silencers

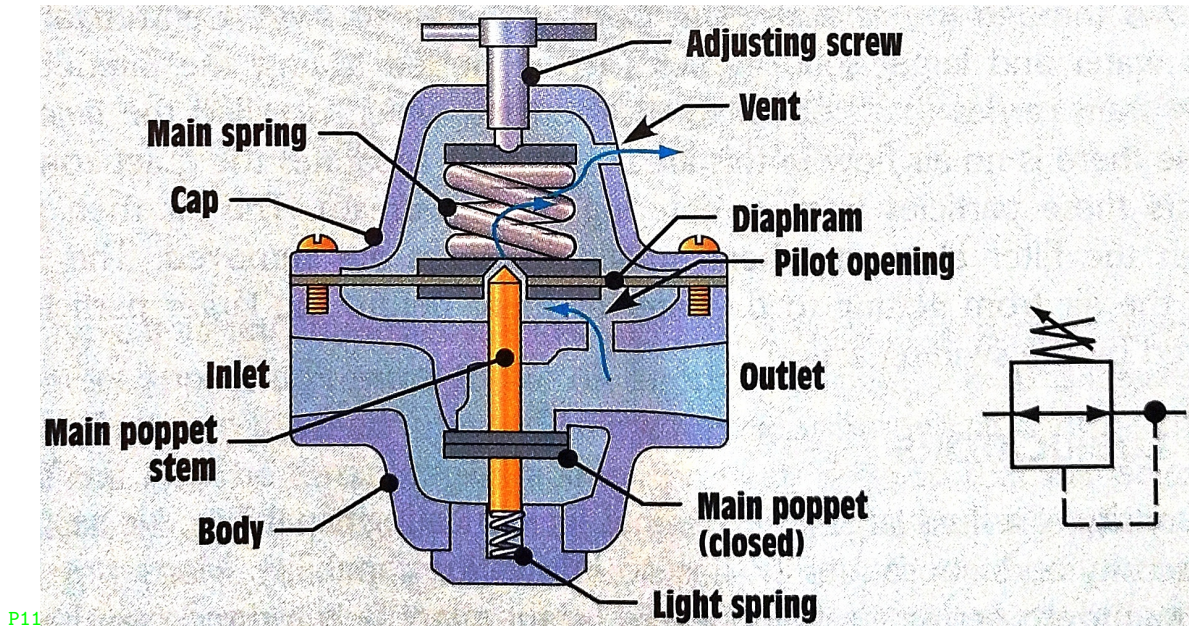


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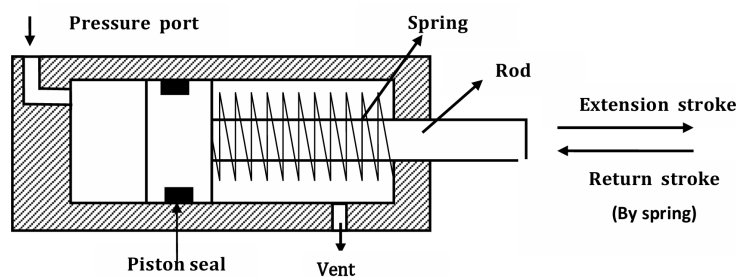
# A Pneumatic Pressure Regulator



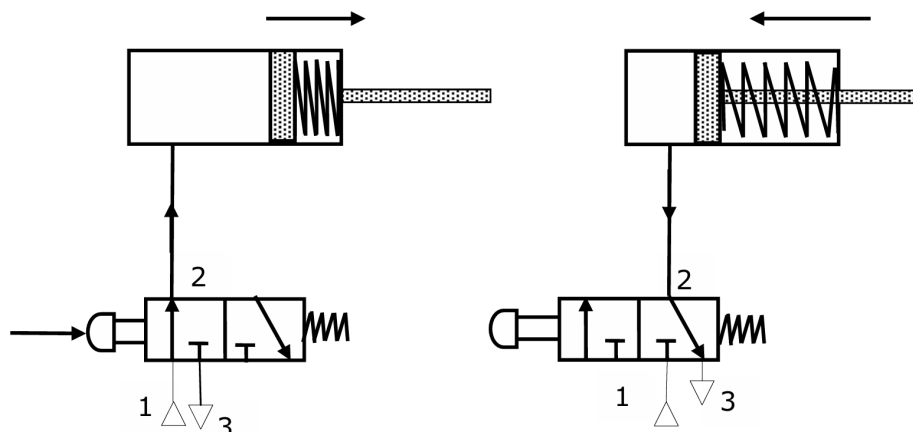
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# Single Acting Cylinder



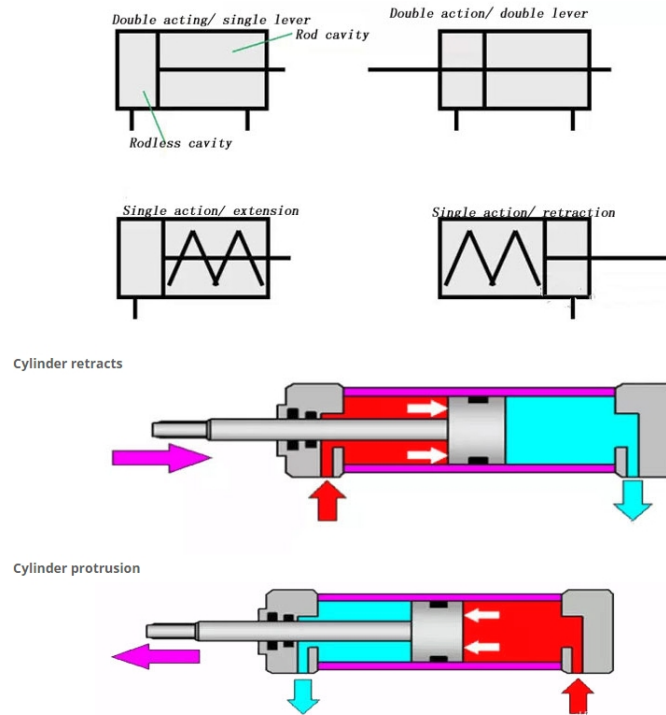
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# Double Acting Cylinder



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## Pneumatic Direction Control Valves (DCV) and Circuits

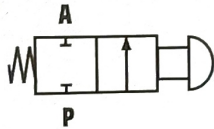
# Direction Control Valves (DCV)

- Directional control valves ensure the flow of air between air ports by opening, closing and switching their internal connections.
- Classification is determined by the number of ports, the number of switching positions, the normal position of the valve and its method of operation. Common types of directional control valves include 2/2, 3/2, 5/2, etc. The first number represents the number of ports; the second number represents the number of positions.
- Pneumatic DCVs are divided into 3 categories: two-way, three-way and four-way valves. The number of 'ways' is the number of ports.

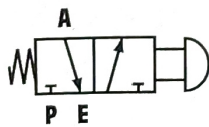


## 2/2 and 3/2 DCV

### A. Two-way, two-position.



### B. Three-way, two-position.



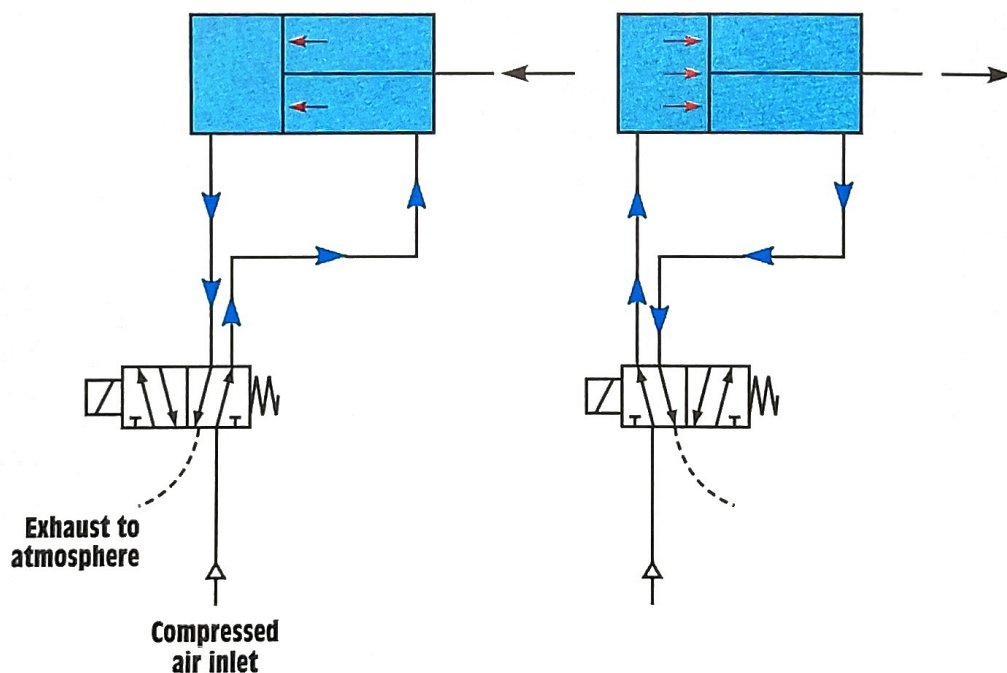
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- A 2-port valve has a pressure port (P) and an outlet port (A). Pressure port is connected to the compressed air source and outlet port is connected to the actuator or other air-operated devices.
- 2-p system can be used just to start or stop flow in a particular line.
- A 3-port valve has a pressure(P) port, an outlet (A) and an exhaust port (E). The outlet port is connected directly to the atmosphere.
- Most common application of 3/2 valve is to control a single-acting cylinder. Simple circuit can be used to clamp, press or for numerous other applications. It can be used to shut-off or vent a branch of pneumatic system.



### A. Retract cylinder.

### B. Extend cylinder.



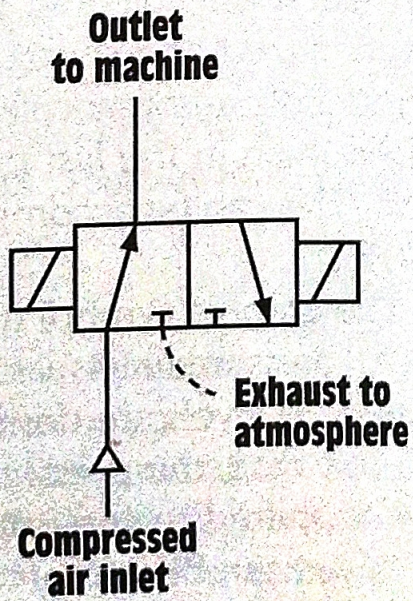
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*3/2 DCV controlling a single-acting cylinder.*

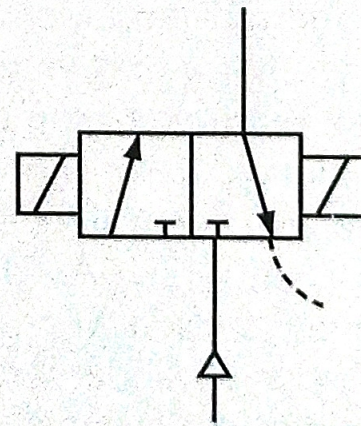




### A. Machine pressurized.



### B. Machine vented.



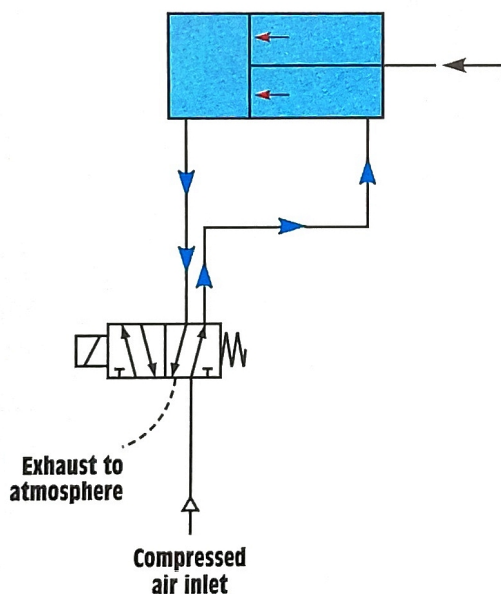
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*3/2 DCV used to shut-off or vent application.*

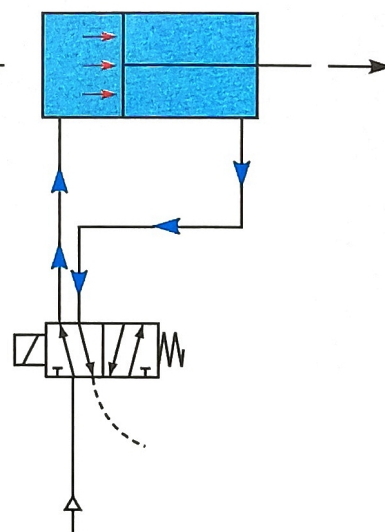


## 4-way DCV

### A. Retract cylinder.



### B. Extend cylinder.



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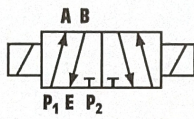
*4-way DCVs are most commonly used to control double-acting cylinders.*



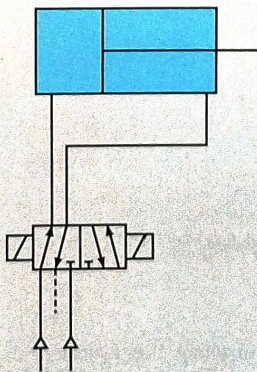


## 5-way DCV

A. Graphic symbol.



B. Controlling a double-acting cylinder.



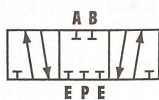
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- 5-way DCVs have two pressure inlets and only one exhaust port. It is used when two different pressure levels are desired to operate the double-acting cylinders.
- High pressure may be required to extend to clamp the work-piece, while only low pressure is required to return the cylinder to the retracted position under no-load.

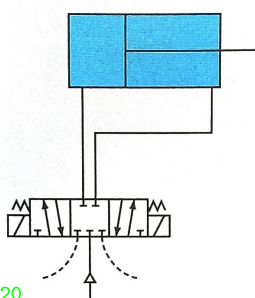


## 4-way 3-position DCV

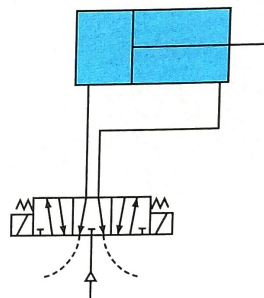
A. Closed center.



B. Float center.



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- DCVs can have third position (neutral) to allow the actuator to be held fixed in position (closed center) or allowed to float when not in use (float center).
- The closed-center valve will cause the cylinder to hold position when in neutral as air is trapped between the DCV and the cylinder.
- The float-center valve will allow the cylinder to float as both ports are connected to the exhaust ports.



## Pneumatic DCV actuation types



**A. Manual lever**



**B. Pushbutton**



**C. Foot pedal**



**D. Mechanical (cam)**



**E. Pilot-operated**



**F. Solenoid**



**G. Pilot-operated solenoid**



## Pneumatic DCV positioning



**A. Two-position, spring return.**



**B. Three-position, spring centered.**

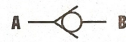


**C. Two-position, maintains last position.**

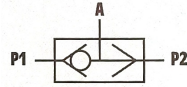
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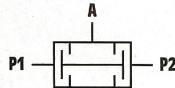
## Other Pneumatic Direction Control Valves



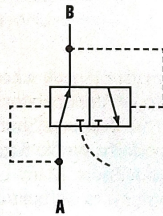
A. Check valve.



B. Shuttle (OR) valve.

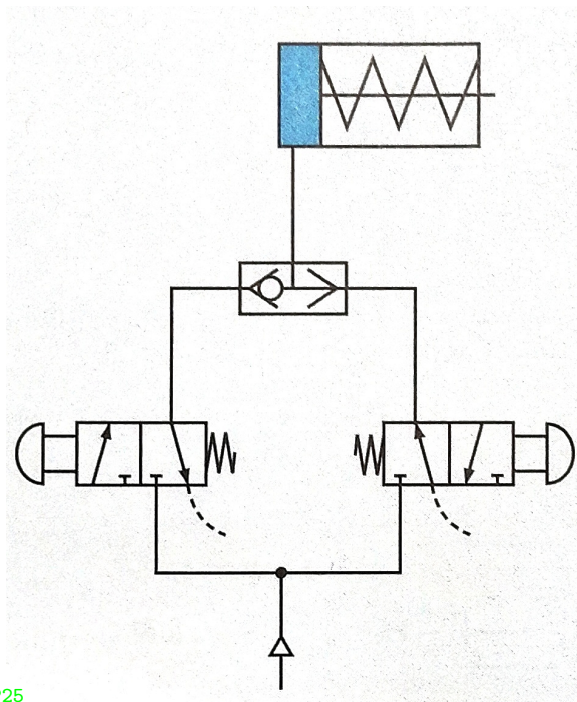


C. AND valve.



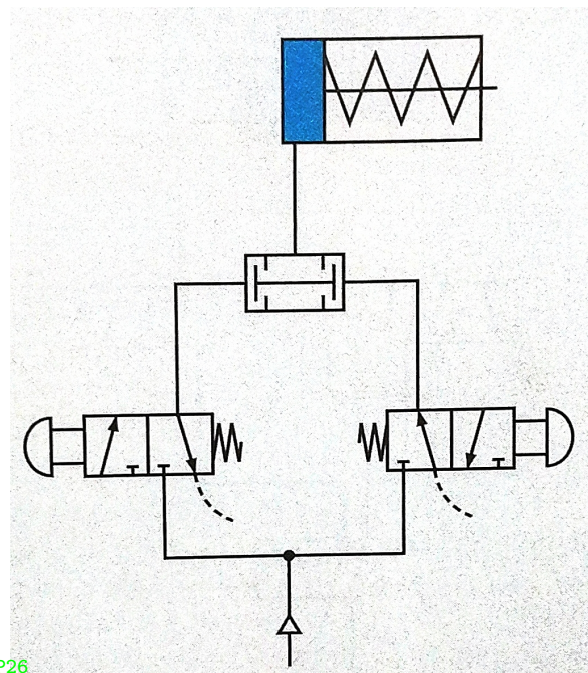
D. Quick exhaust valve.

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*Shuttle valve application.*



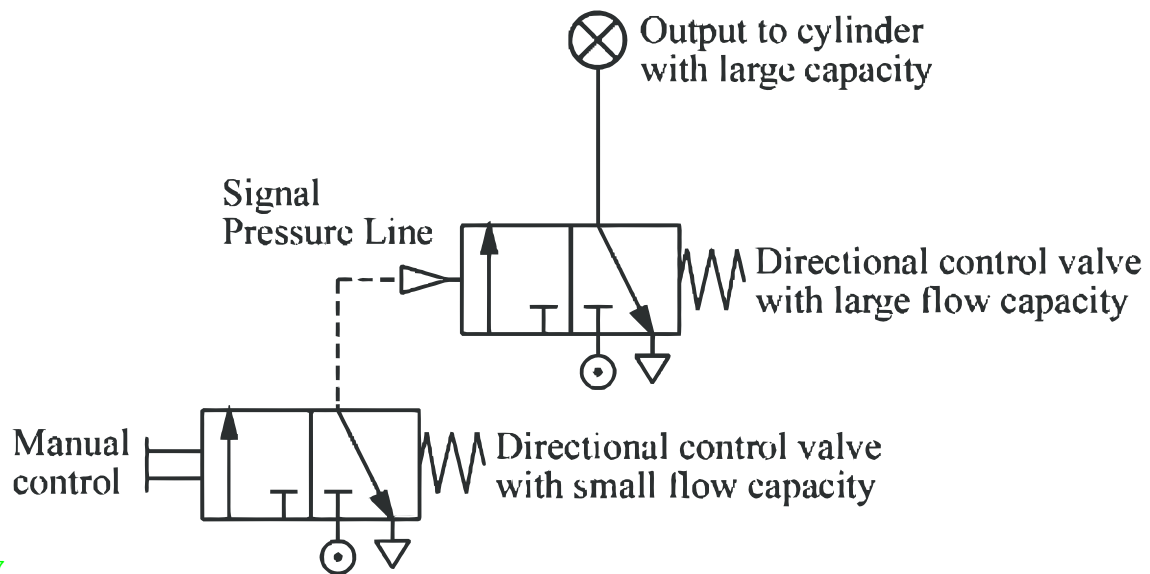
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*AND valve application.*





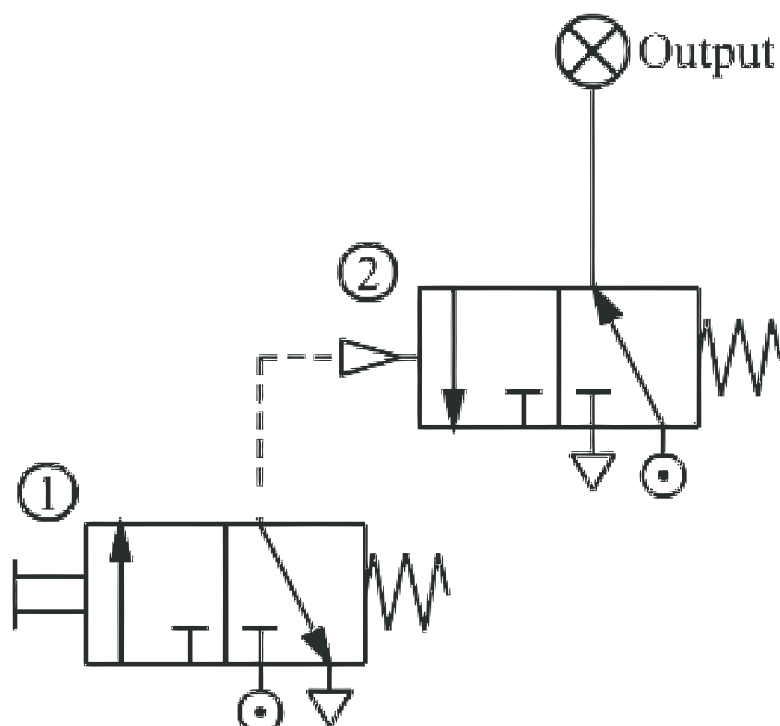
## Example: Flow Amplification



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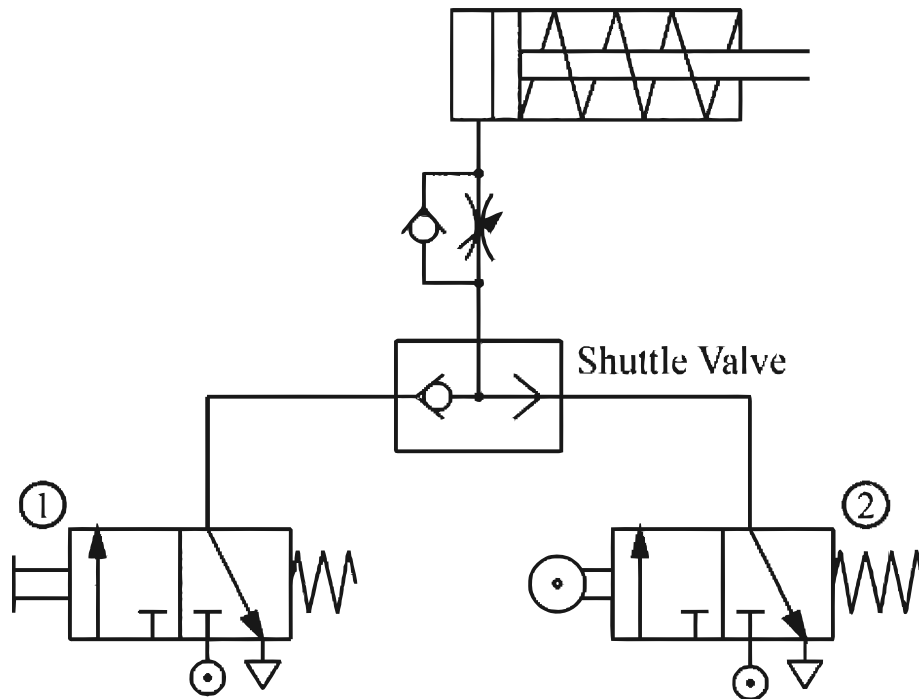
## Example: Signal Inversion



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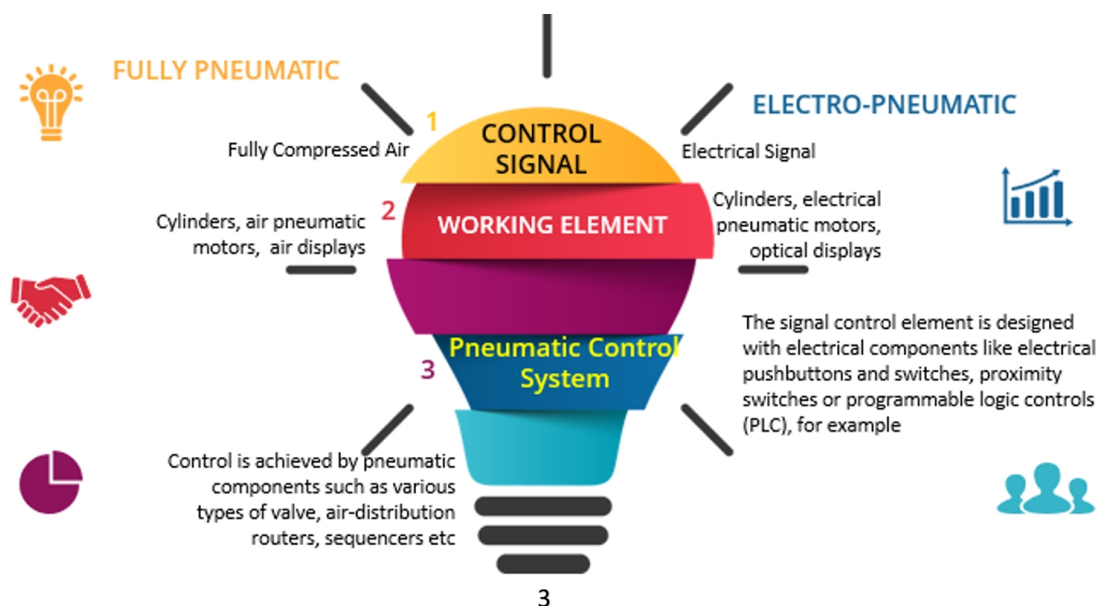
## Example: OR Function



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## Electro-pneumatic Systems

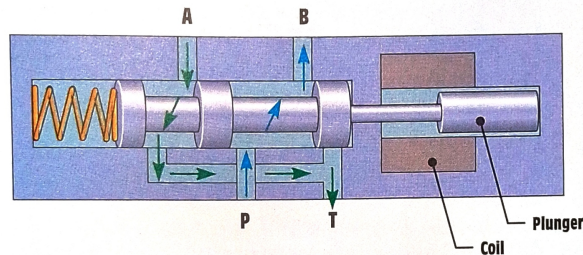


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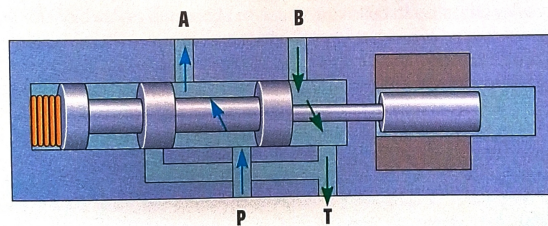


# Solenoid Valve in Electro-pneumatic Systems

**A. Valve in the normal position (solenoid de-energized).**



**B. Valve actuated (solenoid energized).**



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## Thanks a Lot!

