Matakuliah: **Teknik Otomasi**

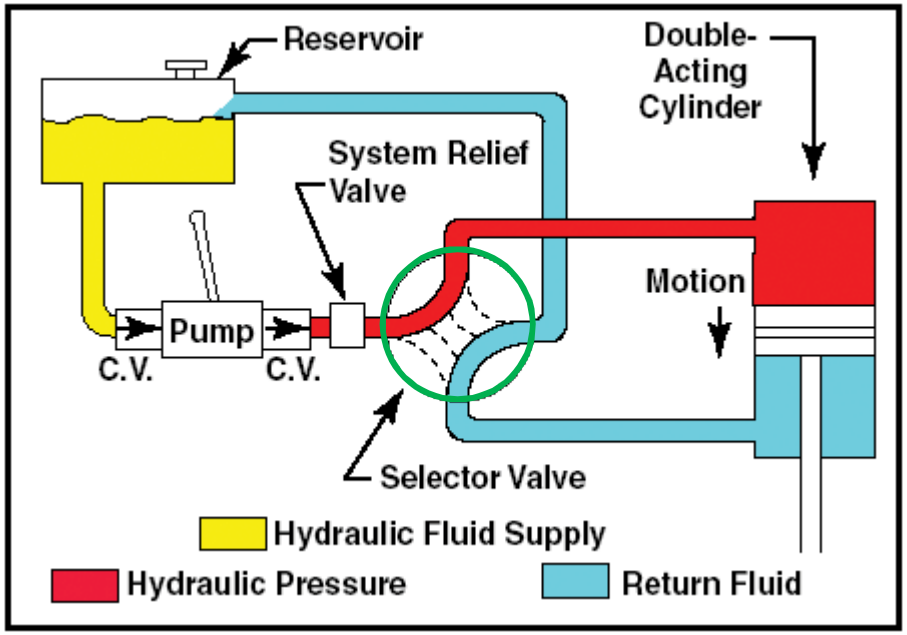
Pneumatic Control System

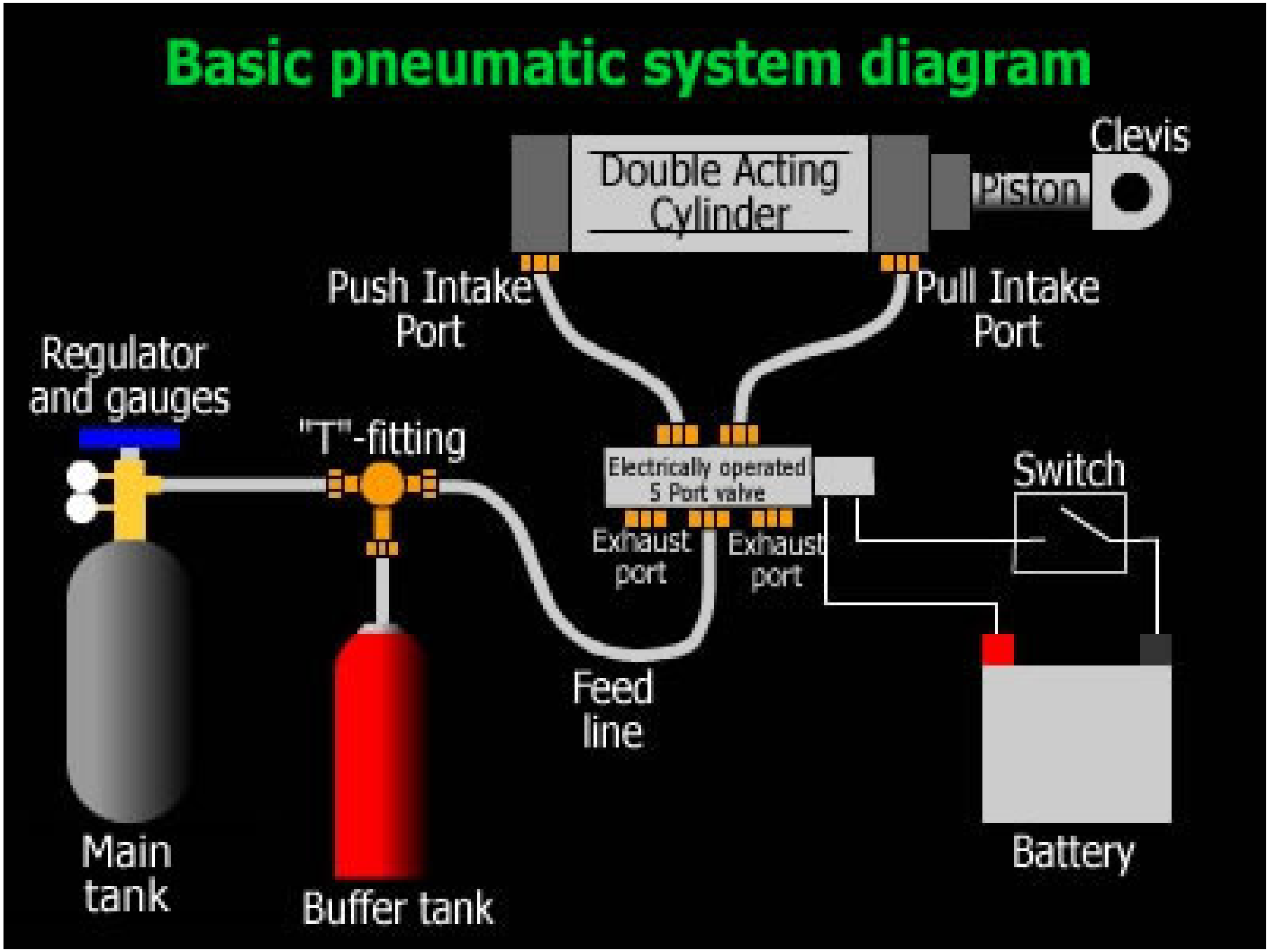
Eka Maulana, ST, MT, MEng.

What is Pneumatic?

- **Pneumatics** is a type of power transmission that uses a gas (in our case, air) and pressure differential to **create movement**.

Pneu*: *udara bertekanan

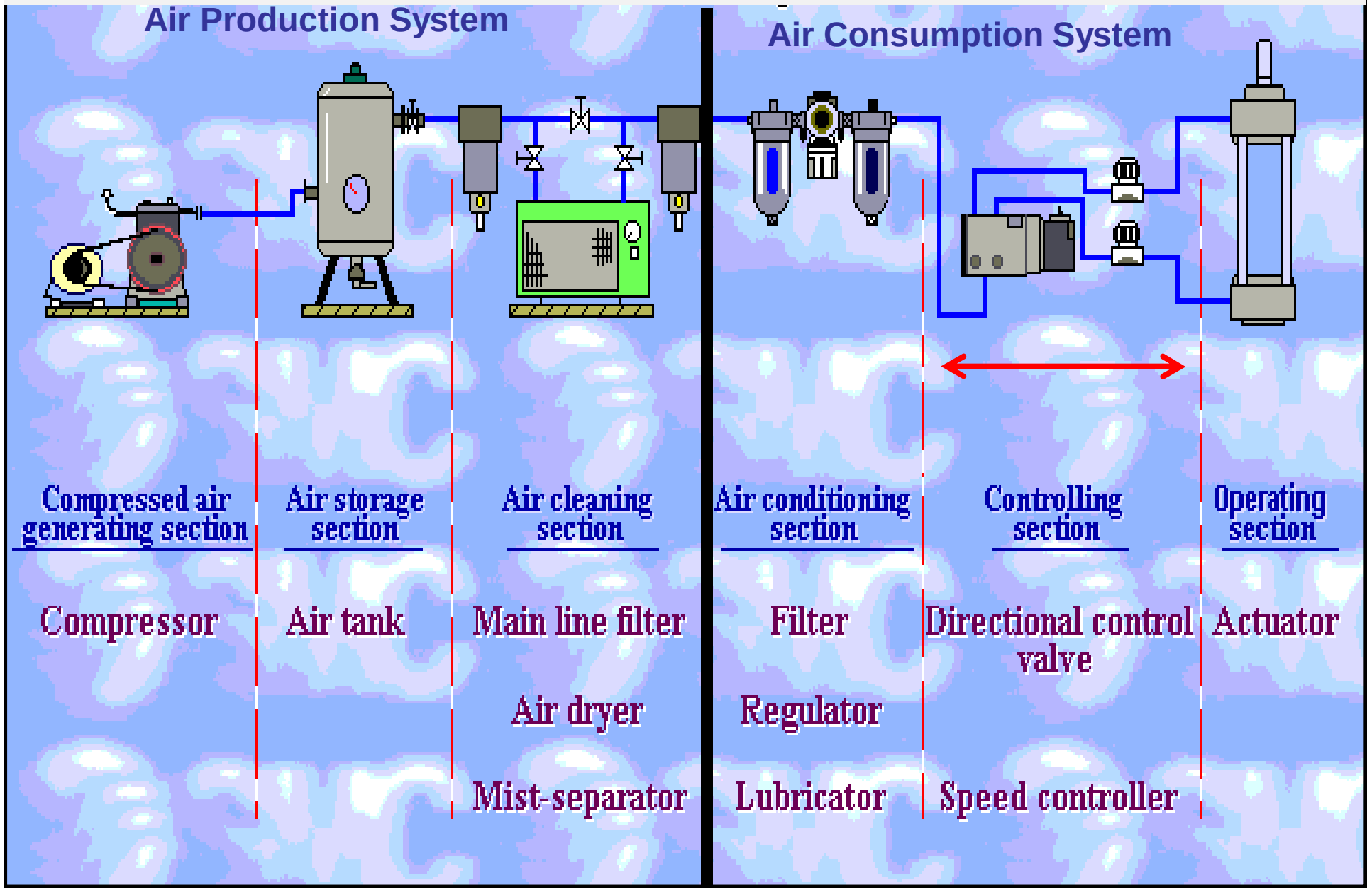



Basic pneumatic system diagram
Double Acting Cylinder
Clevis
Piston
Push Intake Port
Pull Intake Port
Regulator and gauges
"T"-fitting
Electrically operated 5 Port valve
Exhaust port
Exhaust port
Switch
Feed line
Main tank
Buffer tank
Battery

What can pneumatics do?

- Operation of system valves for air, water or chemicals
- Unloading of hoppers in building, steel making, mining & chemical industries
- Lifting and moving in slab molding machines
- Crop spraying and operation of other tractor equipment
- Spray painting
- Holding and moving in wood working and furniture making
- Holding in jigs and fixtures in assembly machinery and machine tools
- Holding for gluing, heat sealing or welding plastics
- Holding for brazing or welding
- Forming operations of bending, drawing and flattening
- Spot welding machines
- Bottling and filling machines
- Wood working machinery drives and feeds
- Component and material conveyor transfer
- Pneumatic robots

Pneumatic System



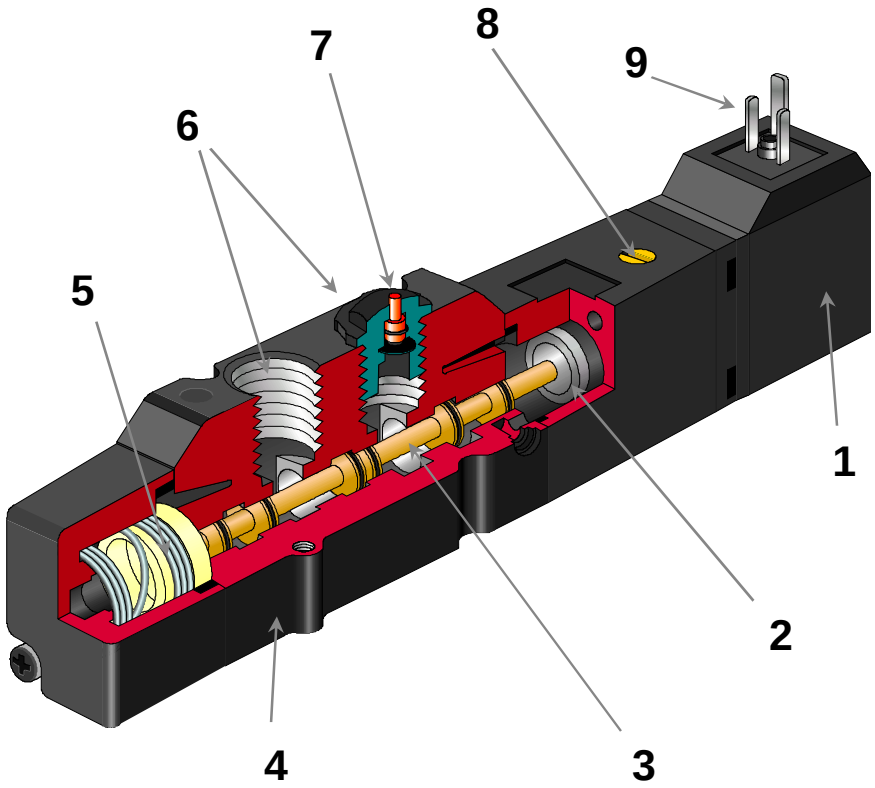
Advantages of Pneumatics

- **Complete kit**
- **Weight**
  equal or lighter than comparable alternatives
- **Simple**

  Review the manual that comes with the pneumatic kit and you're ready to go
- **Strong**
  Force from 9 lbs to 180 lbs – easily adjustable
- **Adjustable Force**
  - Different bore cylinders change the available force
  - By adjusting the applied pressure you can instantly adjust the force
- **Durable**
  No burned up motors – stall with no damage
- **Easy to expand once installed**

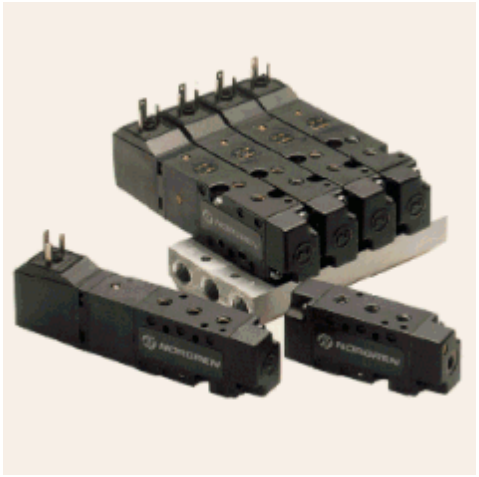
Typical Valve

- **Identification of the component parts of a typical 5/2 solenoid valve with spring return (Sub-base not shown)**
  - **(1) Solenoid (15mm)**
  - **(2) Piston**
  - **(3) Spool with disc seals**
  - **(4) Valve body**
  - **(5) Return spring**
  - **(6) Alternative ports 2, 4**
  - **(7) Pressure indicator**
  - **(8) Manual override**
  - **(9) Electric connectors**



Style

- **Style reflects the look of a valve range as well as the underlying design principle. Examples are Nugget, ISO Star and Super X**



Type

- **Type refers to the valves installation arrangement for example sub-base, manifold, in line, and valve island**

Design

- **Design refers to the principle of operation around which the valve has been designed, for example, spool valve, poppet valve and plate valve**

Operators

- An operator is the mechanism that causes a valve to change state
- They are classified as manual, mechanical and electrical

Push Button

Shrouded Button

Mushroom Button

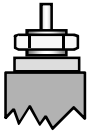
Twist

Switch

Emergency Stop

Key Released

Key Operated

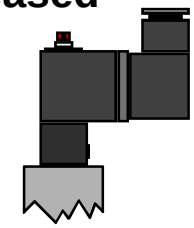


Plunger

Roller

One Way Tip

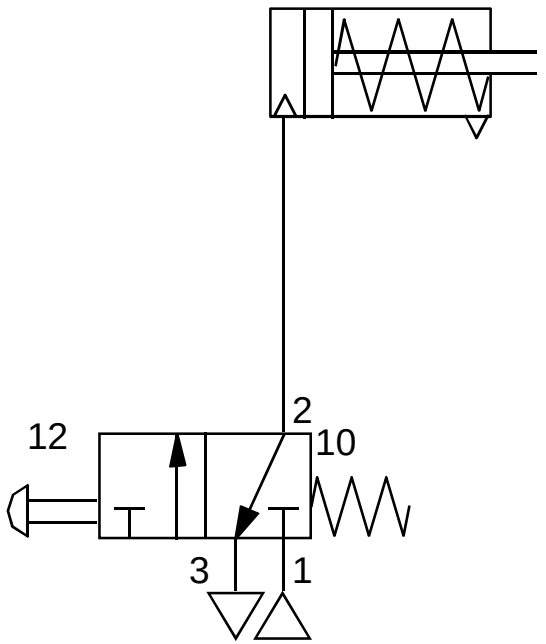
Air Pilot



Solenoid Pilot

Actuator Control (3/2 valve)

- A 3 port valve provides the inlet, outlet and exhaust path and is the normal choice for control of a single acting cylinder
- In the normal position produced by the spring, the valve is closed
- In the operated position produced by the push button the valve is open
- The push button must be held down for as long as the cylinder is outstroked



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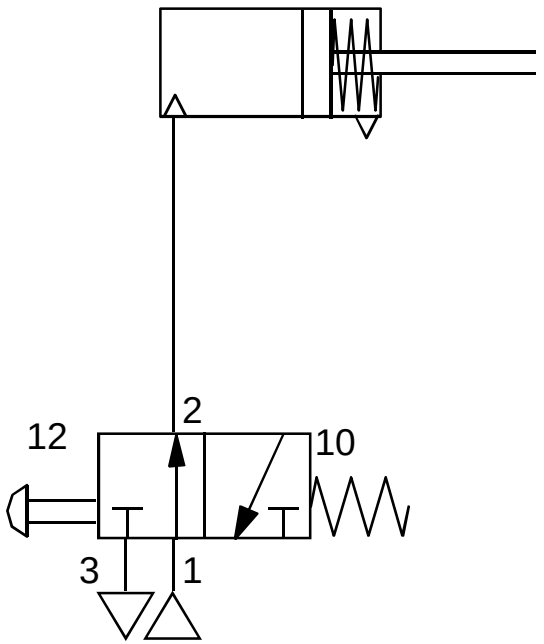
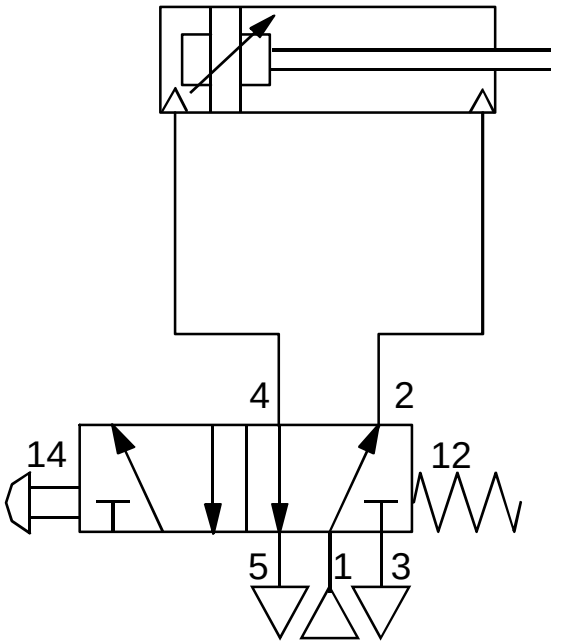


Actuator Control (5/2 valve)

- A five port valve provides an inlet port 1 that is switched between two outlet ports 2 and 4 each with an exhaust port 3 & 5
- In the normal position produced by the spring 1 is connected to 2 with 4 to exhaust 5
- In the operated position produced by pushing the button port 1 is connected to 4 with 2 to exhaust 3



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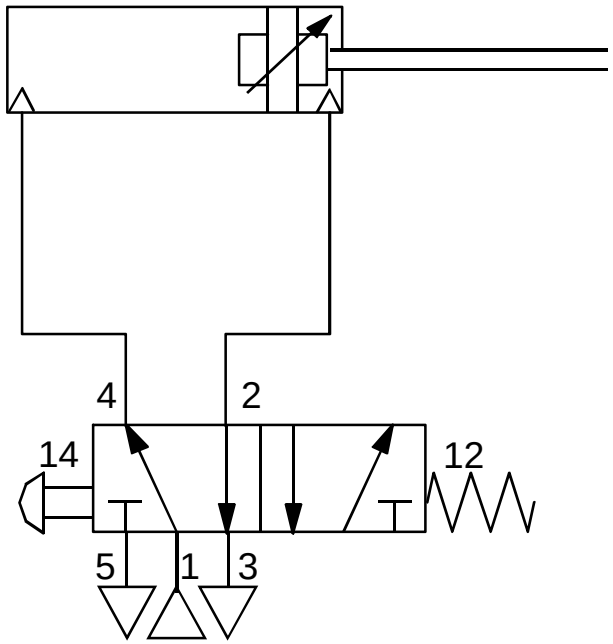
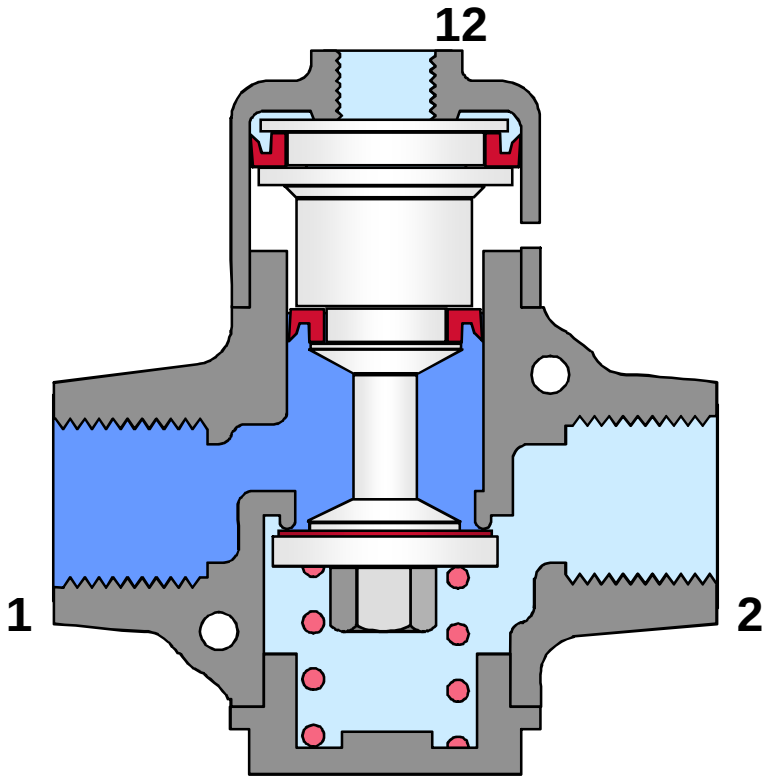


Poppet Valves

Poppet Valve 2/2

- The Poppet valve is a simple and effective design used mainly in 2/2 and 3/2 functions
- It has good sealing characteristics and can often be the choice for a supply shut off valve
- A poppet seal has a butt action against a raised edged aperture
- Illustrated is a 2/2 air operated poppet valve



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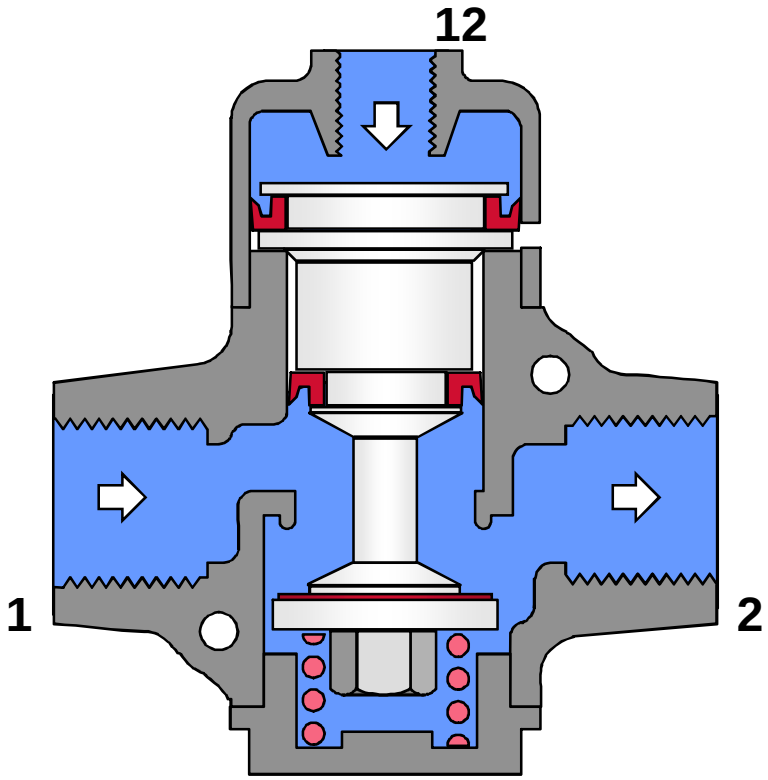
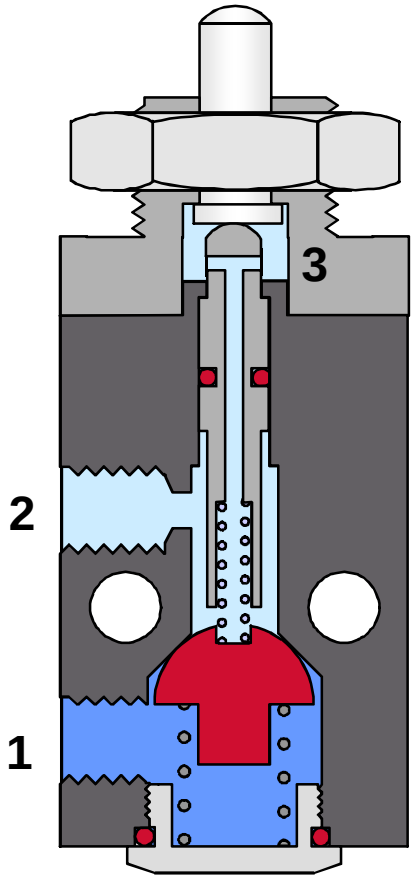


Poppet Valve 3/2

- Miniature 3/2 valve used for generating signals
- The poppet seal will give long life (not subjected to sliding friction)
- Supply to port 1 assists the spring to hold the poppet shut
- Outlet port 2 is connected through the plunger to a plain exhaust port
- When operated exhaust path sealed and poppet opened (flow 1 to 2)



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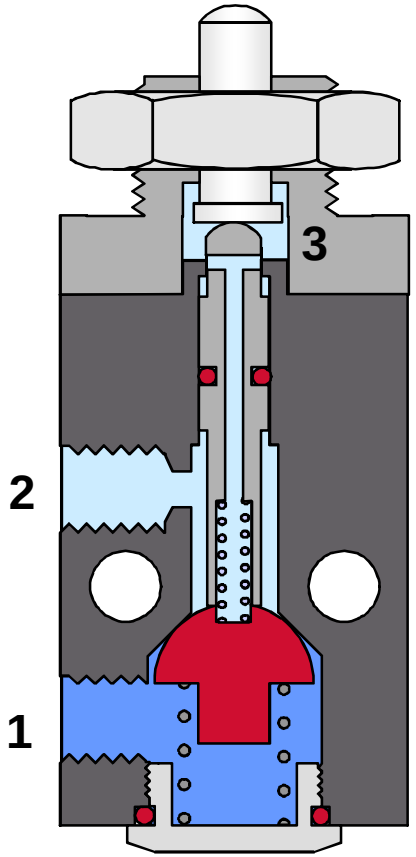

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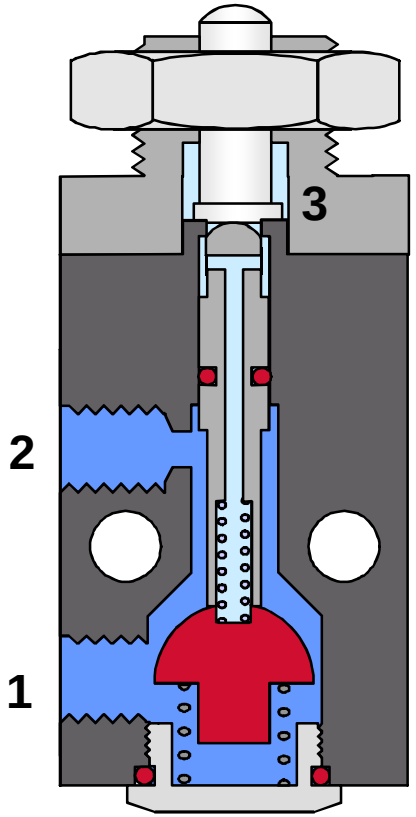
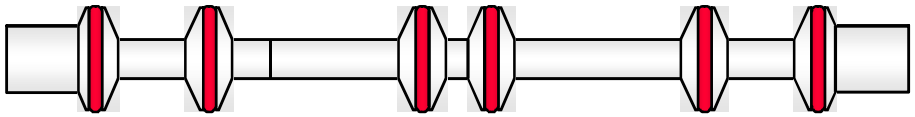


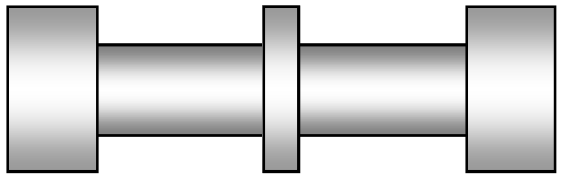
Spool Valves

- A long standing popular versatile design
- Available in most functions 3/2, 3/3, 5/2, 5/3, etc.
- Fully force balanced
- Wide range of styles, sizes, operators and mounting arrangements
- Suit a multiple range of applications

Spool Types

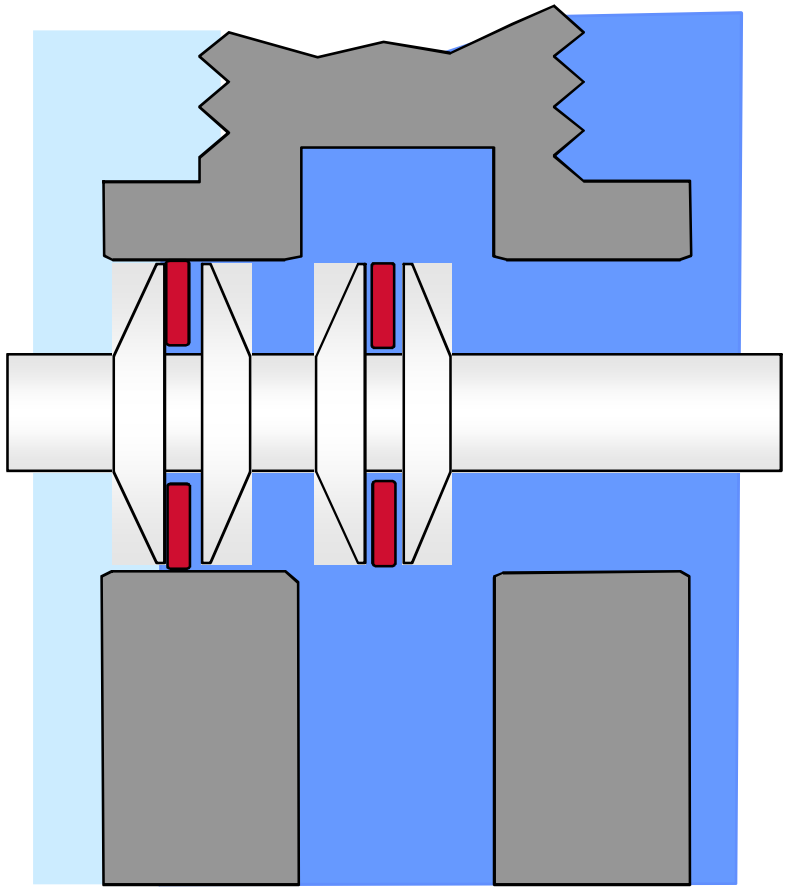
- A spool has a number of major and minor diameters called lands and valleys
- The lands seal with the valve bore and the valleys connect valve ports to control flow direction
- Dynamic seal type has the seals on the spool
- Glandless type have no sliding seals
- Static seal type has the seals fixed in the valve bore





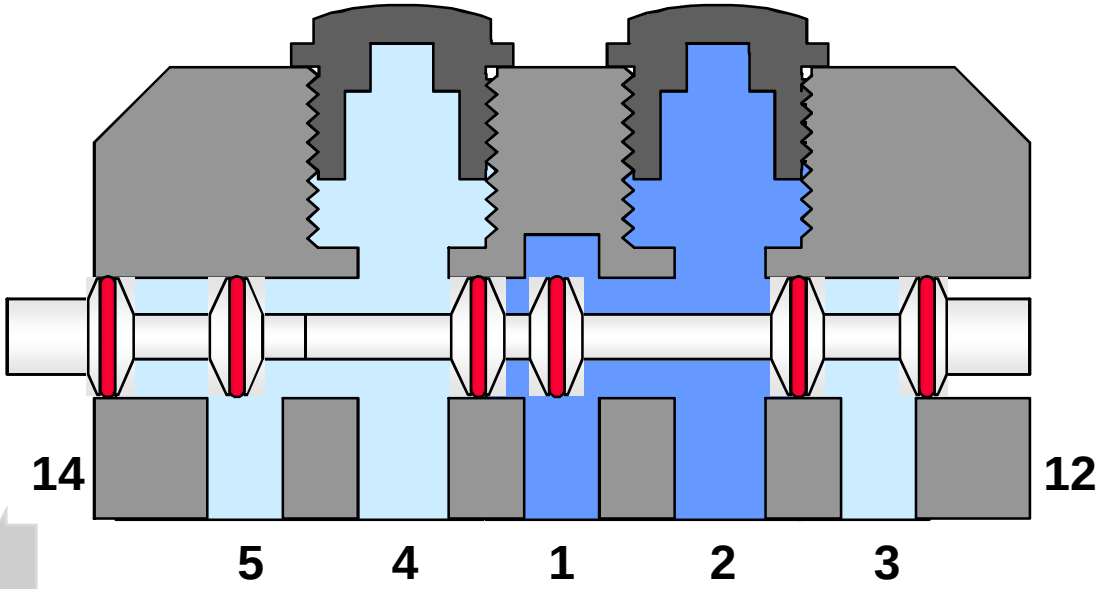
Disc Seals

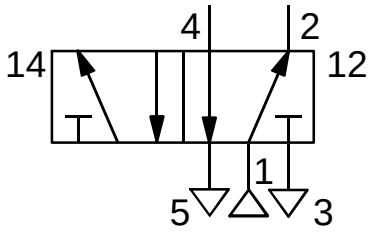
- A disc seal is a loose fit in the groove, with the outer diameter just in contact with the valve bore.
- Under differential pressure the disc seal is pushed sideways and outwards to seal the clearance between the outer diameter of the piston and the valve bore
- The slim profile gives low radial force therefore reducing friction



Spool Valve (dynamic seals)

- This 5/2 valve has a spool fitted with disc seals
- The seals move with the spool therefore they are called dynamic
- Normal position: port 1 is joined to 4 and 2 is joined to 3
- Operated position: port 1 is joined to 2 and 4 is joined to 5





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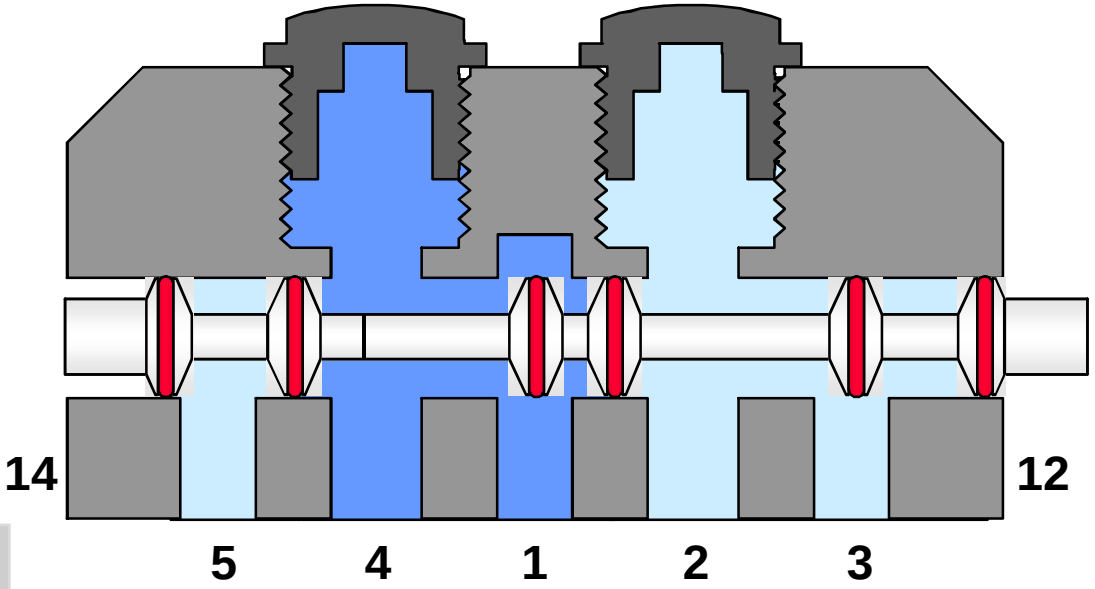
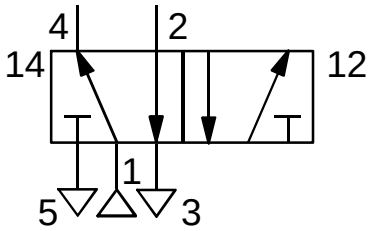
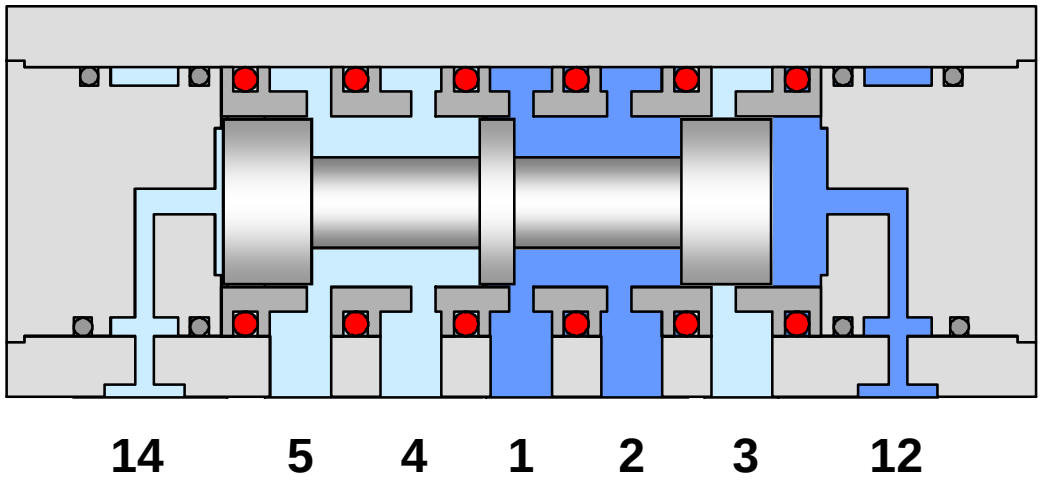
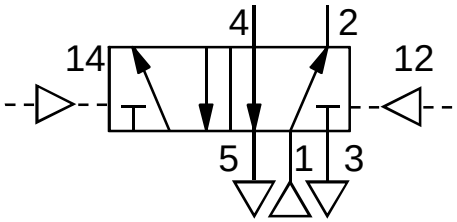




Spool Valve (glandless)

- This 5/2 valve has a matched spool and sleeve. The fit is so precise that seals between them are unnecessary
- The tiny amount of air crossing the spool lands provides an air bearing
- The result is low friction and long life





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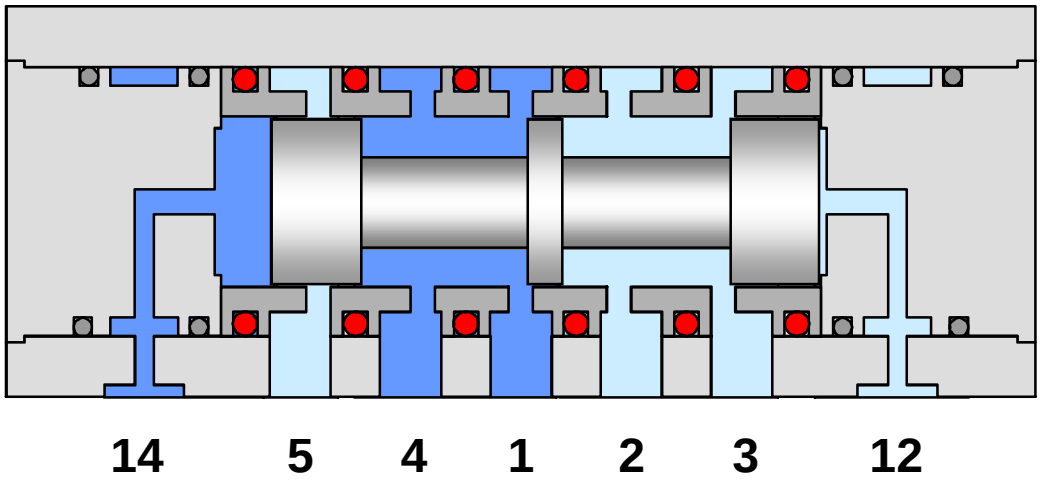
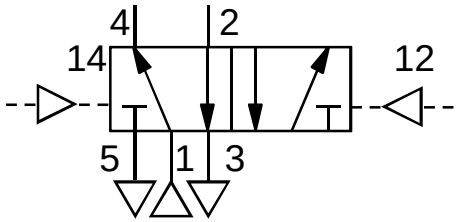
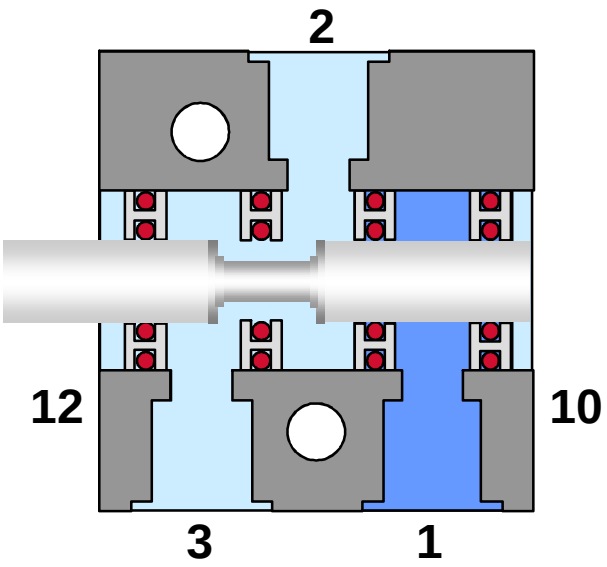
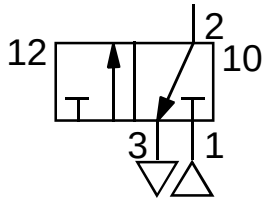




Spool Valve (static seals)

- This 3/2 valve has a plain spool sliding within static seals
- The O Ring seals are held in carriers fixed in the valve bore and positioned by spacers (not shown)
- The larger O Rings seal the valve bore with the carriers
- The smaller O Rings seal the carriers with the spool





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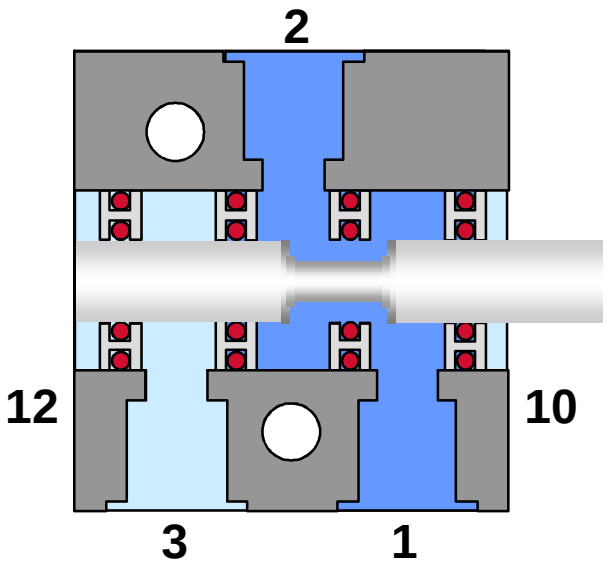
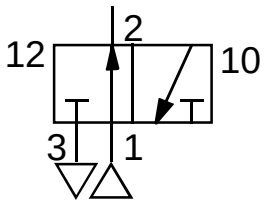
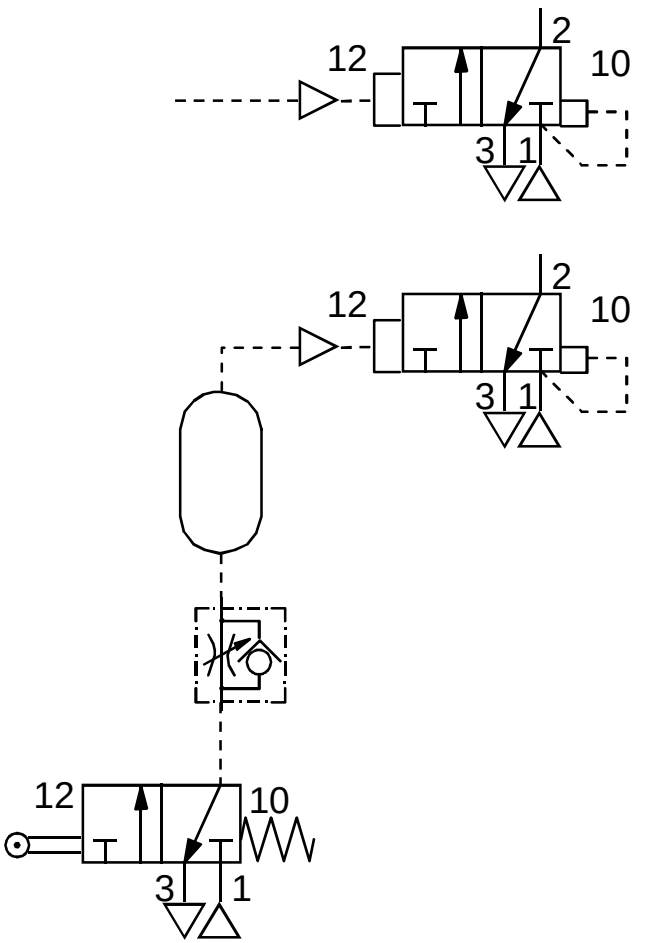




Other Valve Designs

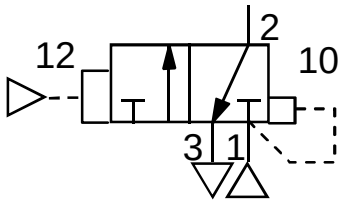
Pressure Switch (pneumatic)

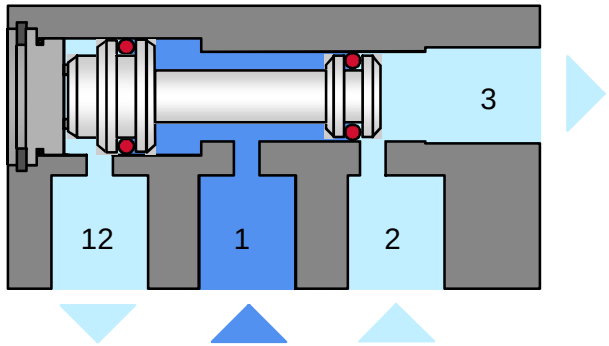
- Relay to boost weak signals
- Relay for a pneumatic time delay
- When the signal at port 12 reaches about 50% of the supply pressure at port 1, the pressure switch operates to give a strong output signal at 2
- For time delays at any pressure only the linear part of the curve will be used giving smooth adjustment



Pressure Switches

- Pressure applied at port 1 acting on the differential annular areas holds the spool to the left
- The weak or slowly rising pressure of a signal applied to port 12 needs only to reach about 50% of he pressure at port 1 to operate the valve
- Port 1 is then connected to port 2
- Removing the signal allows the differential force to reset the valve





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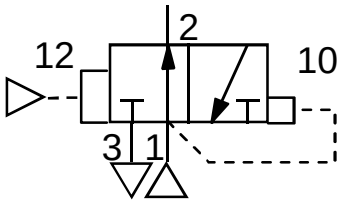
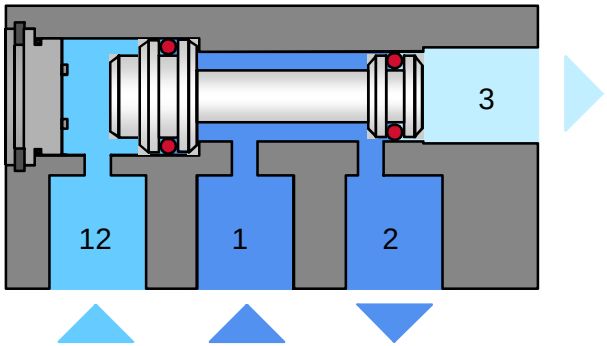
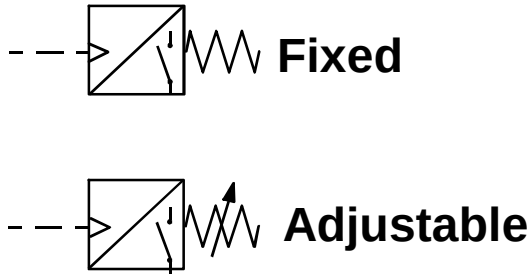
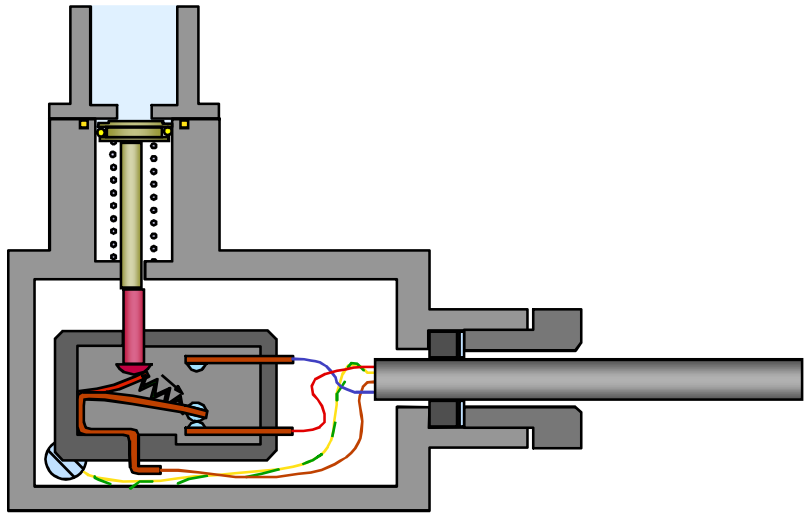




Pressure Switches (electrical)

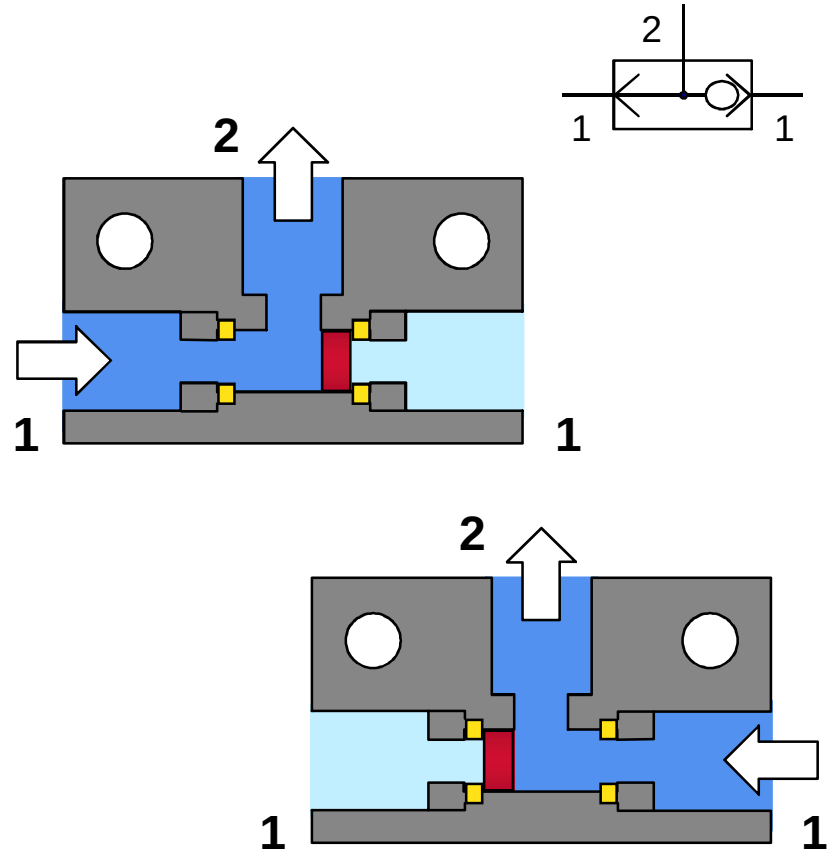
- This fixed value example uses a built in single acting cylinder to operate a standard changeover microswitch
- The operating pressure is about 3 bar this needs to overcome the combined force of the cylinder and microswitch springs
- Adjustable pressure switches are also available





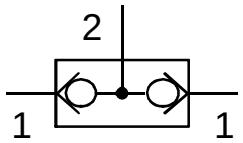
Logic “OR” Shuttle Valve

- An air signal given to either the left hand port 1 or the right hand port 1 will result in an output at port 2
- The sealing disc moves across to seal the exhaust signal line to prevent loss of signal pressure

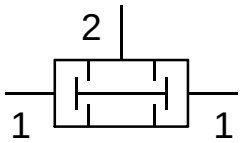


Logic “AND” Shuttle Valve

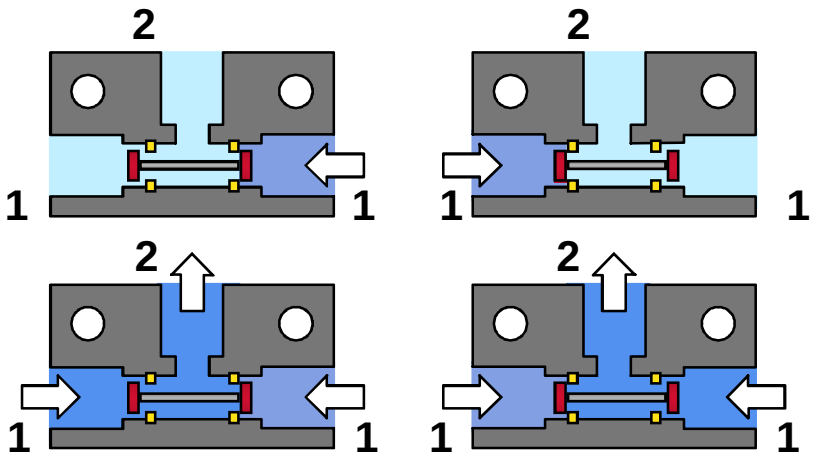
- A single air signal at either of the ports 1 will cause the shuttle to move and block the signal
- If a signals are applied at both the left hand AND right hand ports 1 only one of them will be blocked the other will be given as an output at port 2
- If the pressures are not equal the one with the lowest pressure is switched



ISO 1219-1 symbol

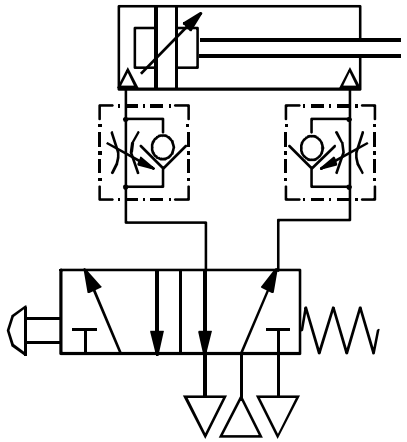


Popular old symbol



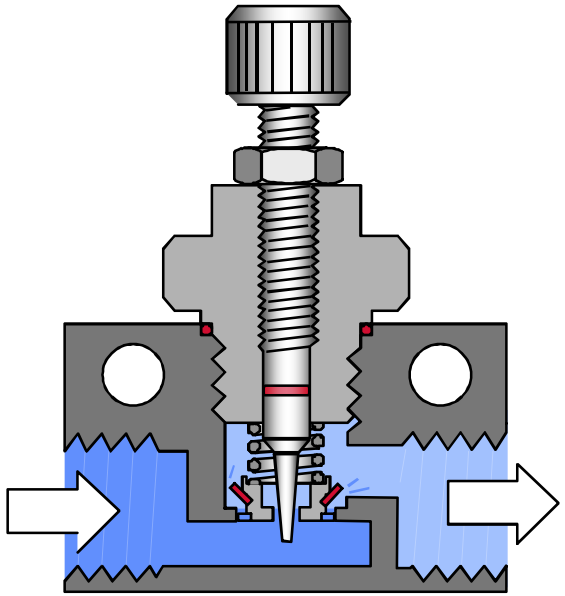
Flow Regulation

- By the use of flow regulators the outstroke speed and instroke speed of a piston rod can be independently adjusted
- Speed is regulated by controlling the flow of air to exhaust
- The front port regulator controls the outstroke speed and the rear port regulator controls the instroke speed



Flow Regulator

- **Uni-directional, line mounted adjustable flow regulator**
  - **Free flow in one direction**
  - **Adjustable restricted flow in the other direction**



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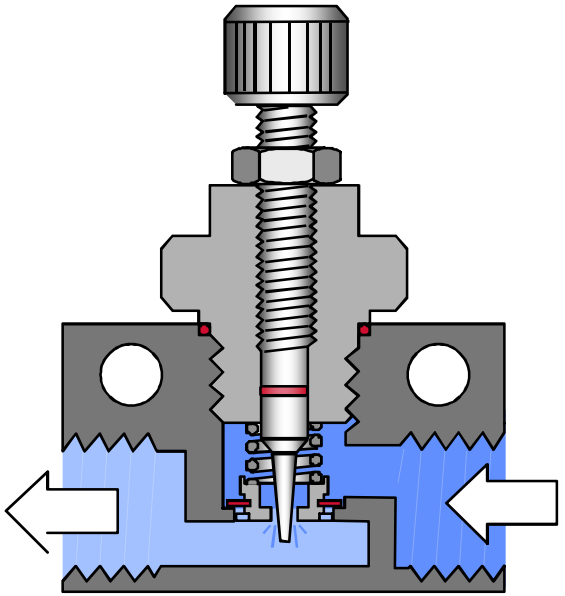
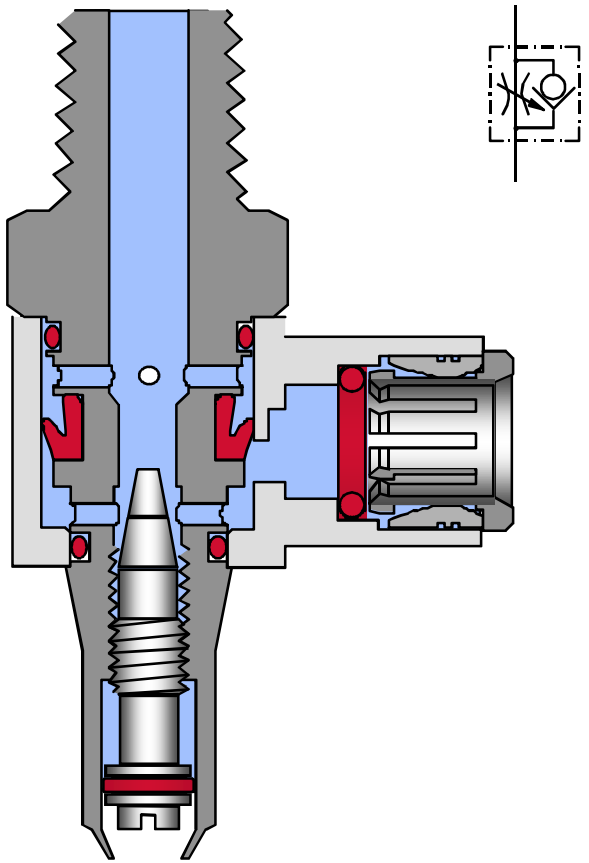


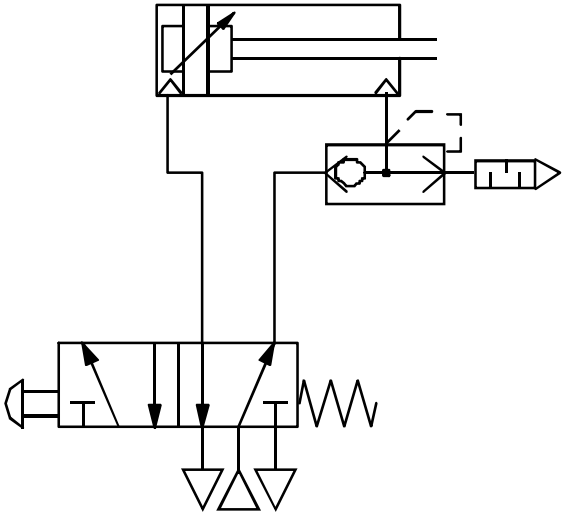
Banjo Flow Regulator

- Designed to fit directly in to cylinder ports, so placing adjustment at the appropriate cylinder end
- Two types:
  - One to give conventional flow restriction out of the cylinder and free flow in (as illustrated)
  - The other type to give restricted flow in to the cylinder and free flow out (not illustrated)



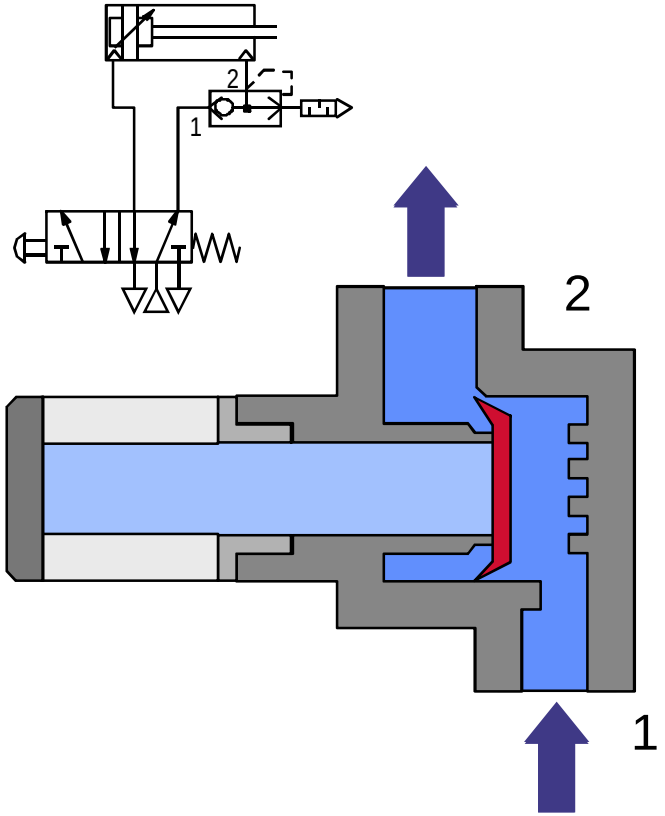
Quick Exhaust Valve

- In some applications cylinder speed can be increased by 50% when using a quick exhaust valve
- When operated, air from the front of the cylinder exhausts directly through the quick exhaust valve
- The faster exhaust gives a lower back pressure in the cylinder therefore a higher pressure differential to drive out the piston rod



Quick Exhaust Valve

- Port 2 is connected directly to the end cover of a cylinder
- Port 1 receives air from the control valve
- Air flows past the lips of the seal to drive the cylinder
- When the control valve is exhausted, the seal flips to the right opening the large direct flow path
- Air is exhausted very rapidly from the cylinder for increased speed



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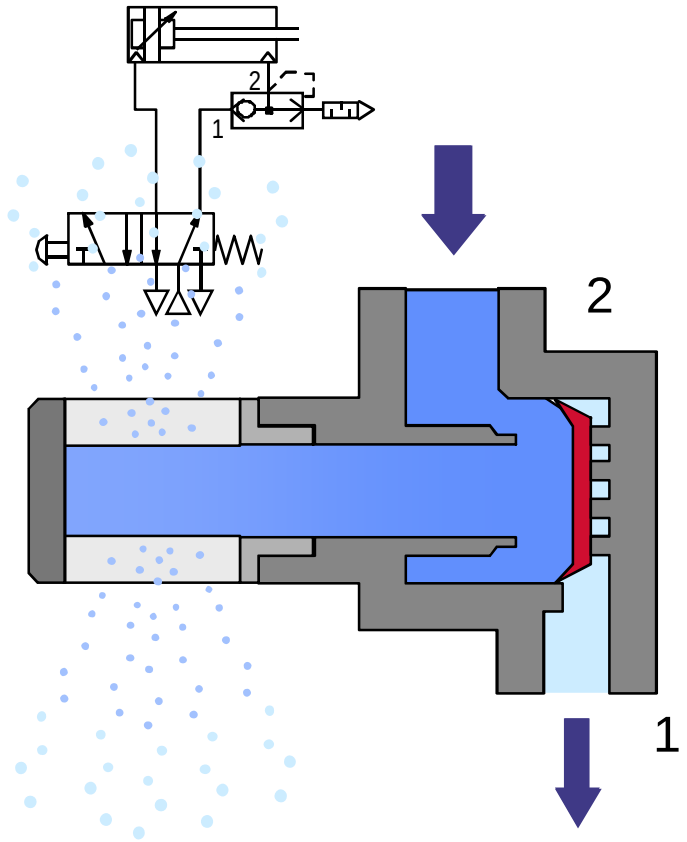
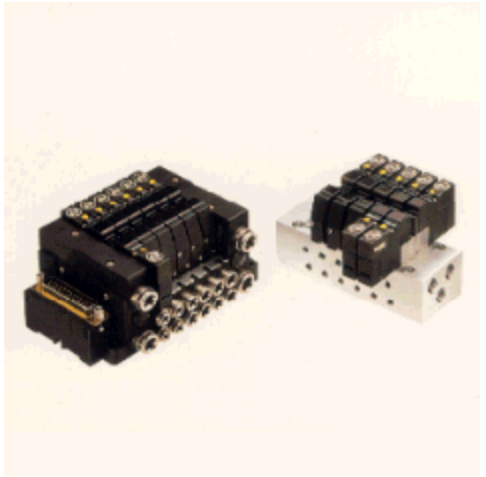


Solenoid Valves

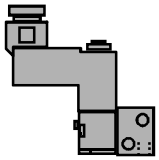
- Solenoid valves are electro-pneumatic relays
- The state of an electrical input controls the state of a pneumatic output
- Solenoid valves are the interface between electronic control systems and pneumatic power
- Types are:
  Direct acting
  Pilot operated
  Proportional



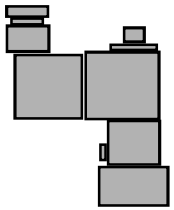
Direct Acting Solenoid Valves

- **Used for:**
  Signal generation and processing
  Control of small bore single acting cylinders
- **Single station sub-base mounted**
- **Multi-station sub-base mounted**
- **Integrated to larger valves to become solenoid pilot operated valves**
- **15, 22, 32 represent the mm width of the valve**

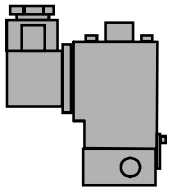
Nugget 30



Excel 15



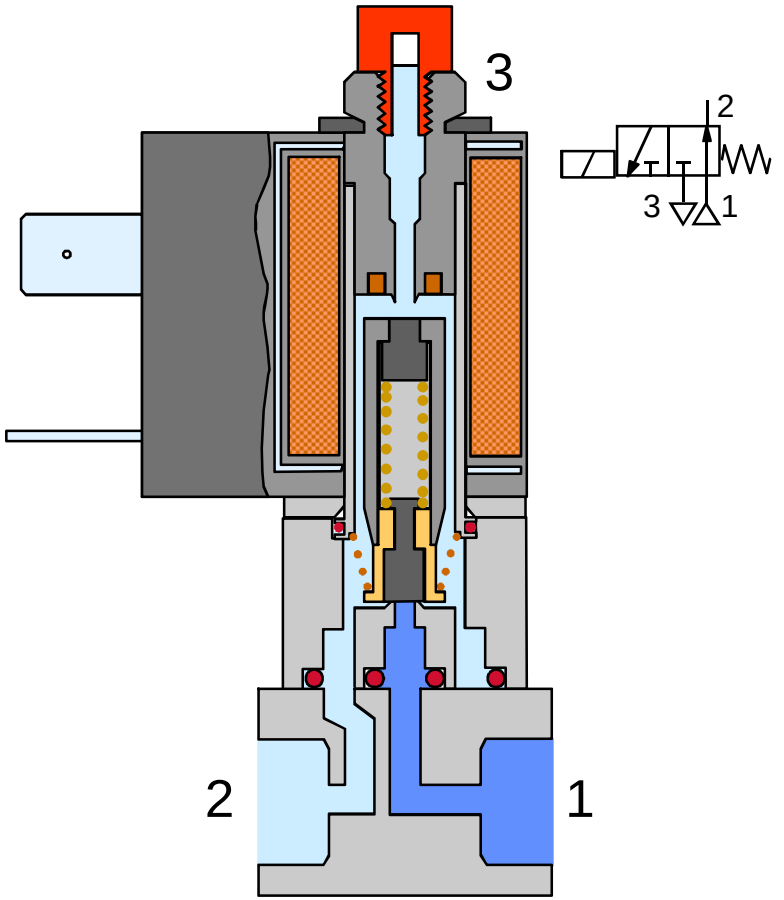
Excel 22



Excel 32

Principle of operation

- The double poppet armature is held by a spring against the inlet orifice sealing the supply at port 1
- Outlet port 2 is connected to exhaust port 3
- When the coil is energised the armature is pulled up closing the exhaust orifice and connecting the supply port 1 to the outlet port 2



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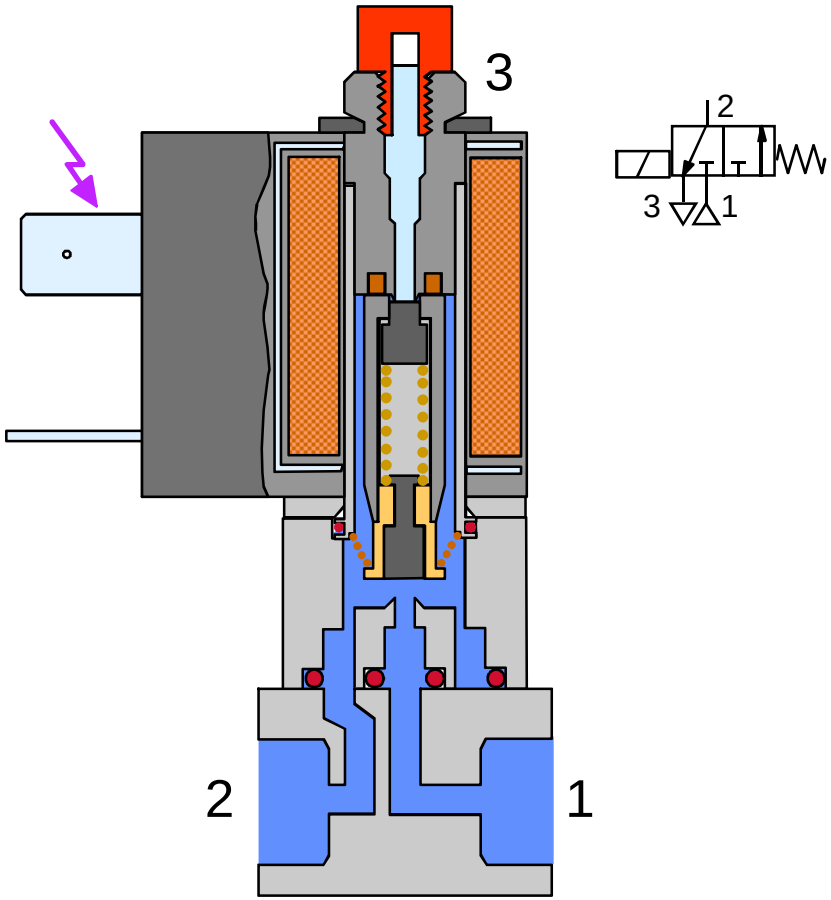

End