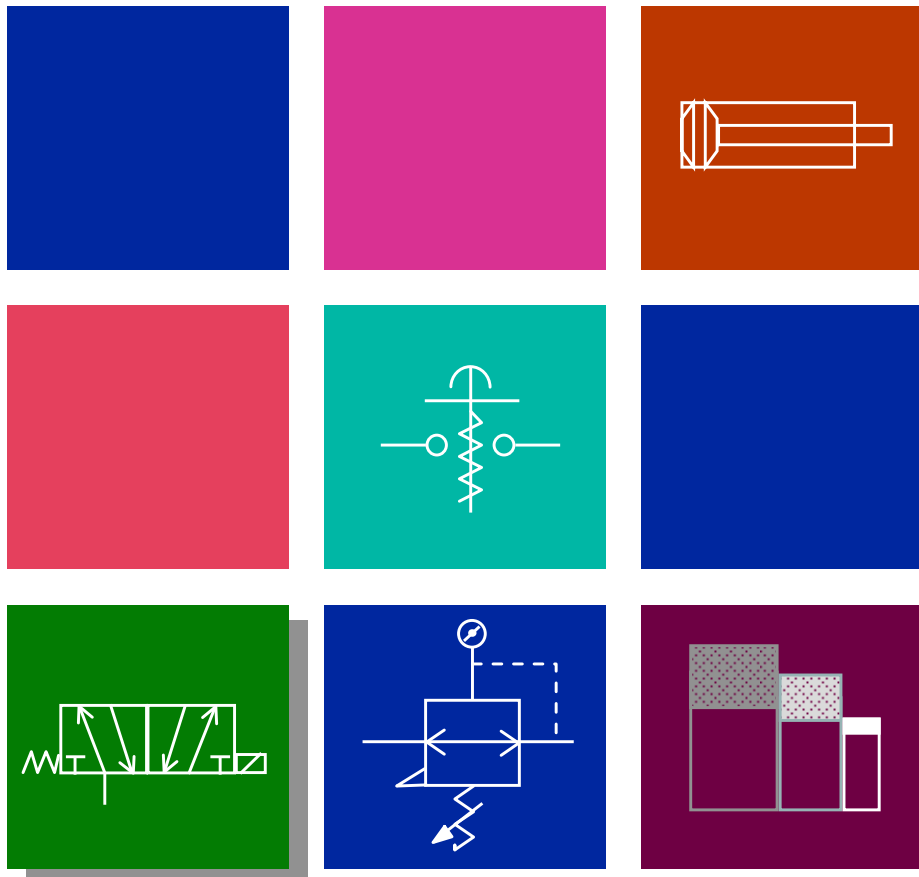




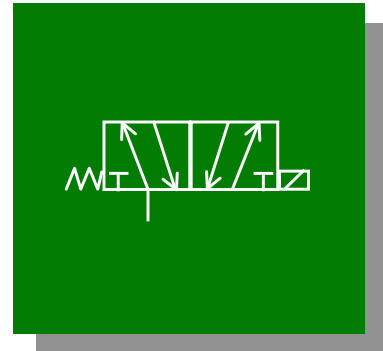
TRAINING GROUP

Instruction & Guidance for the Pneumatics Industry

Valves Training Manual



Valves Training Manual



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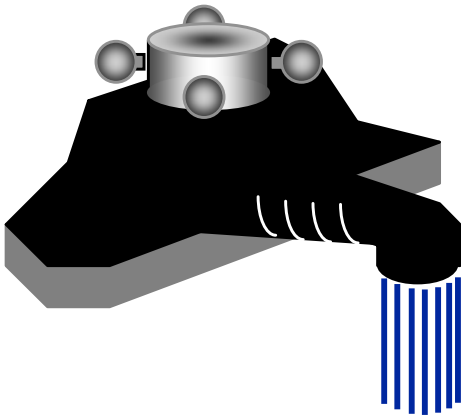
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What is a Valve?

A mechanical device used to direct the flow of a fluid -- pneumatic directional control valves are used to direct air flow.



Valves are described by:

- Flow directions
- Normal or start condition
- Number of ports
- Operator type
- Number of positions

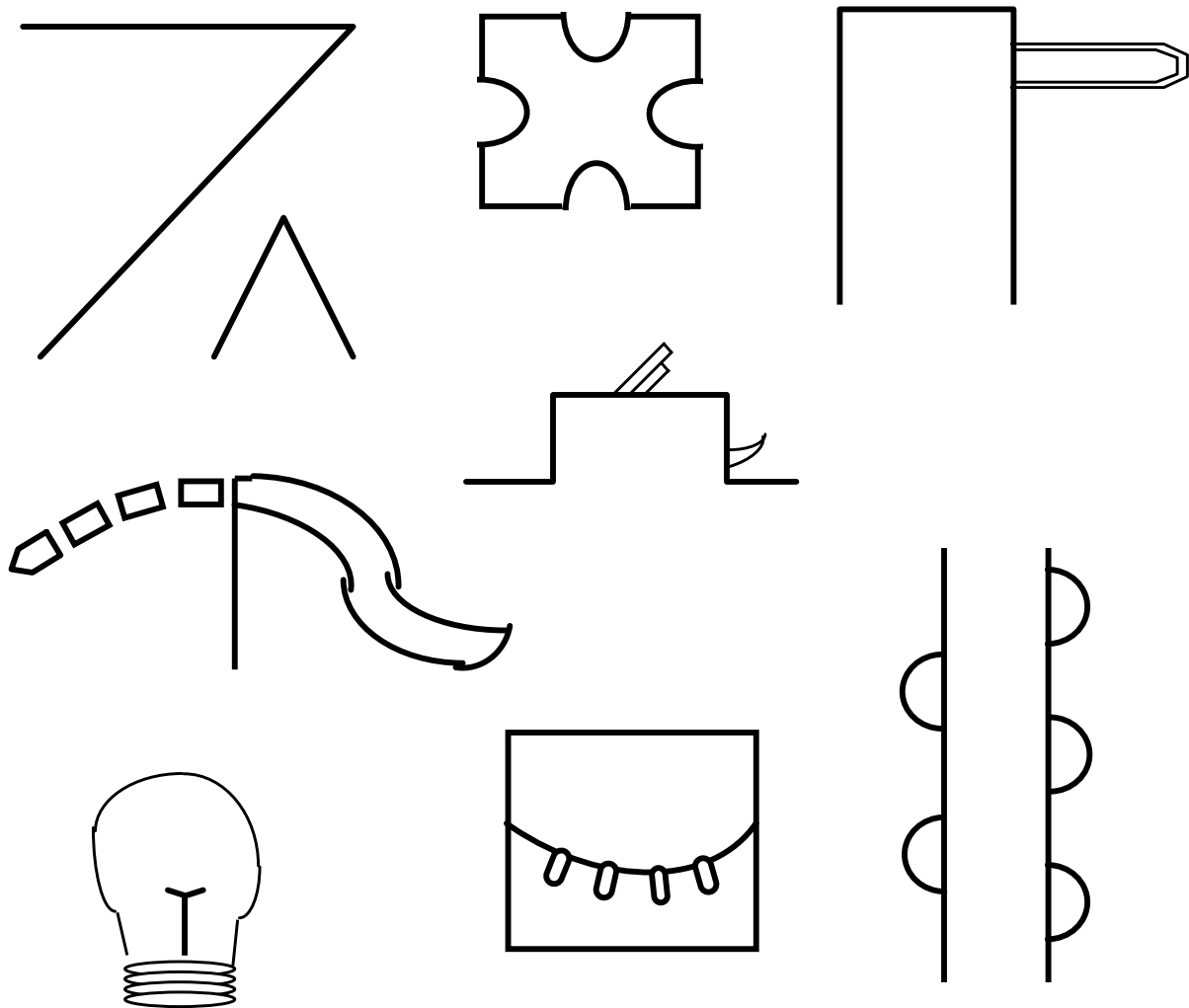
OR

Valves are defined by their respective symbol

CONCEPT

What is a Symbol?

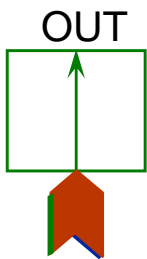
A graphic representation of an idea.



To understand the symbol, you have to possess some understanding of what the symbol is showing.

Flow Paths

With pneumatic symbols, our concern is flow

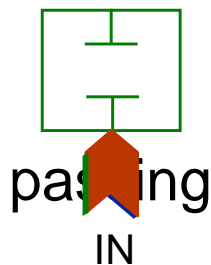


A flow path

May be called open or passing

Shows flow in the direction of the arrow

-- AND --



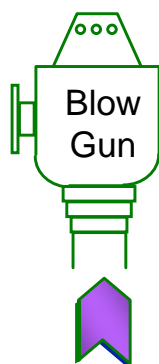
No flow path

May be called closed or non-

Shows a blocked flow path

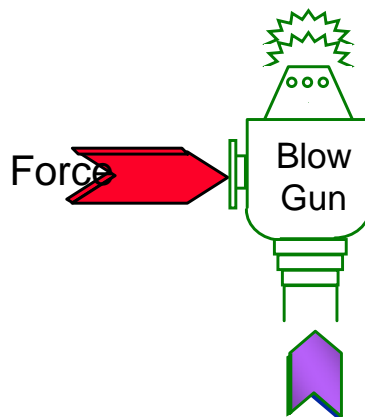
A valve has two states:

Actuated



80 PSIG

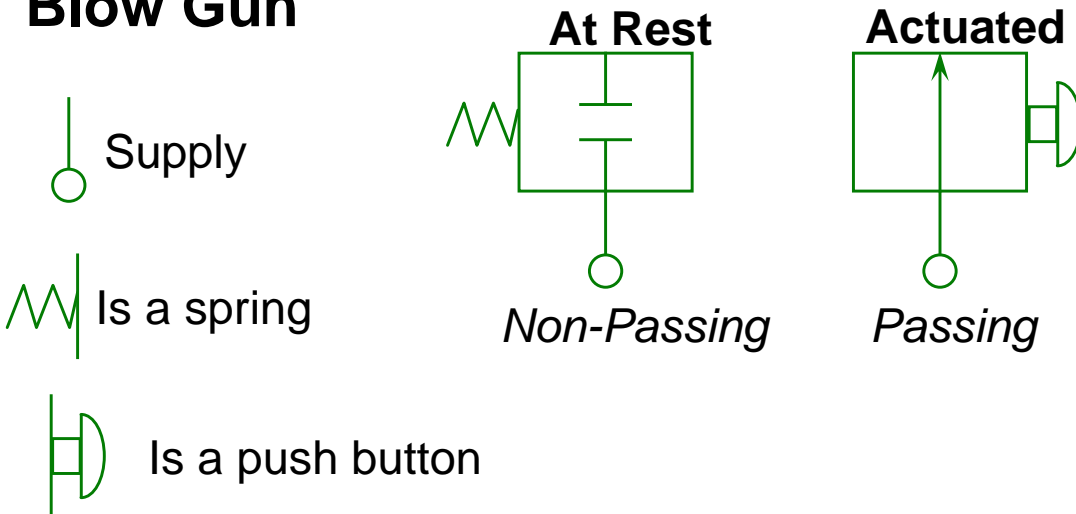
Force



80 PSIG

Basics

Blow Gun

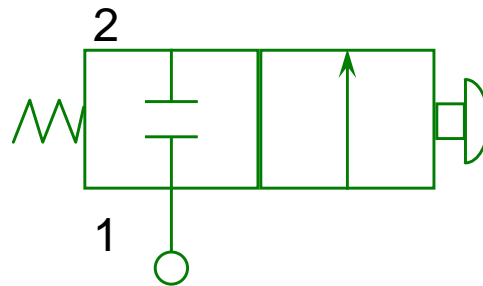


Blow Gun

- When the button is pushed, air flows through the device
- Release the button, air does not flow through the device because a spring provides a force to return the valve to its initial or original closed condition
- We say: At rest the spring is in command
- At rest is the normal position of the valve
- There are two conditions for the blow gun -- each has its own box
- A complete symbol shows both conditions

Two Way

2/2



Description

2 Way	2 Flow directions
2 Position	Actuated/At rest
Normally non-passing	At start condition
Push button, spring return	Operator type
2 Ports	1 and 2

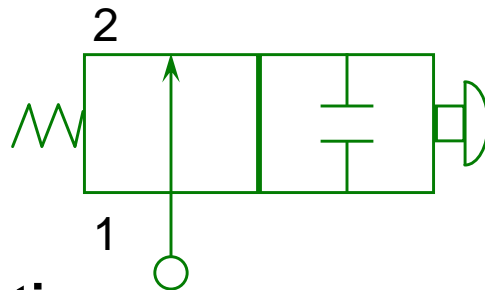
- Two flow directions -- either passing or non-passing
- Start condition (normal or at rest condition) is determined by the spring
- Two ports -- although both conditions are shown, the valve shown has only two ports.

The symbol shows the valve as it is (non-passing) and as it can be (passing)

- Operators appear at both ends of the flow path symbols
 - When the operator is in command, the flow path next to the operator is caused.

Two Way

2/2



Description

2 Way

2 Flow directions

2 Position

Actuated/At rest

Normally-passing

At start condition

Push button, spring return

Operator type

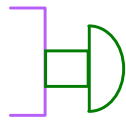
2 Ports

1 and 2

- At rest, this valve allows supply to pass through when actuated, flow is interrupted.
- There is no standard for labeling ports that is universally accepted by all manufacturers.
- Referred to as 2/2 for two ported/two position without regard for flow path.

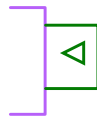
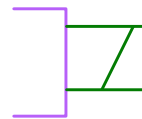
Operators

Common Pneumatic Operators



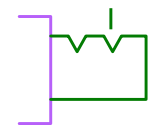
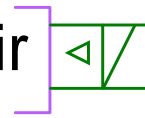
- Push Button

- Solenoid



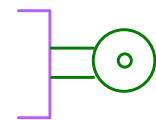
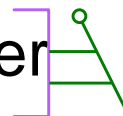
- Air Pilot

- Solenoid/Air Pilot



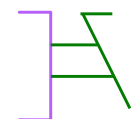
- Detent

- Hand Lever



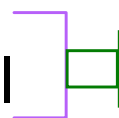
- Cam Roller

- Spring



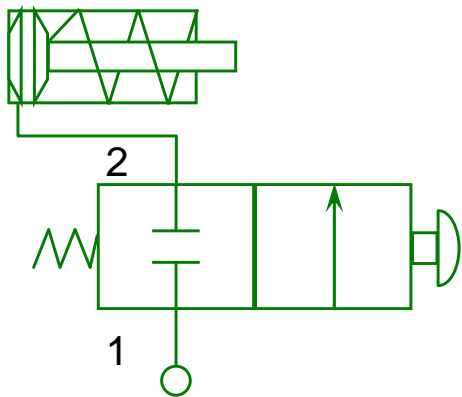
- Treadle/Foot Pedal

- Manual



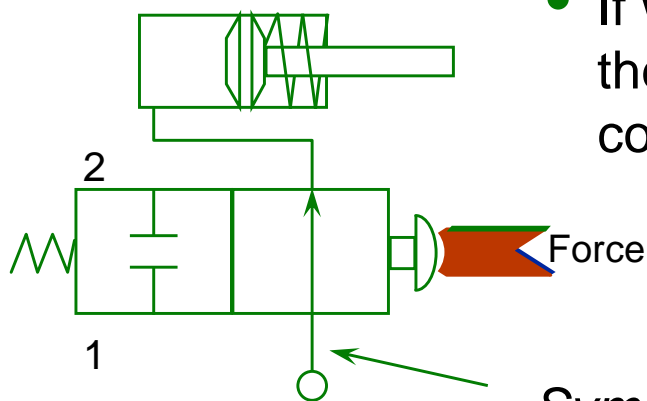
Application

Circuit #1



Single acting air cylinder

- Requires air pressure to extend -- spring will retract the cylinder
- Only one port, rod end open to atmosphere -- vented
At Rest



- If we push the button, the cylinder extends, compressing the spring

Symbol shows valve actuated

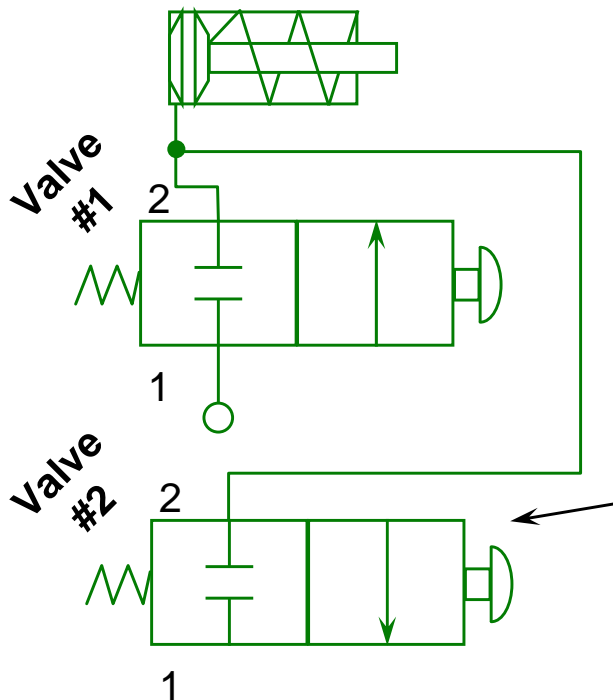
IF, as shown above, we now release the button --after shifting the valve and extending the cylinder ...

**WHAT
HAPPENS?**

Are You Certain?

Why?

Application



Note: Arrow has changed direction indicating correct flow direction

The only way to retract the cylinder is to exhaust (vent) the trapped air downstream of valve #1

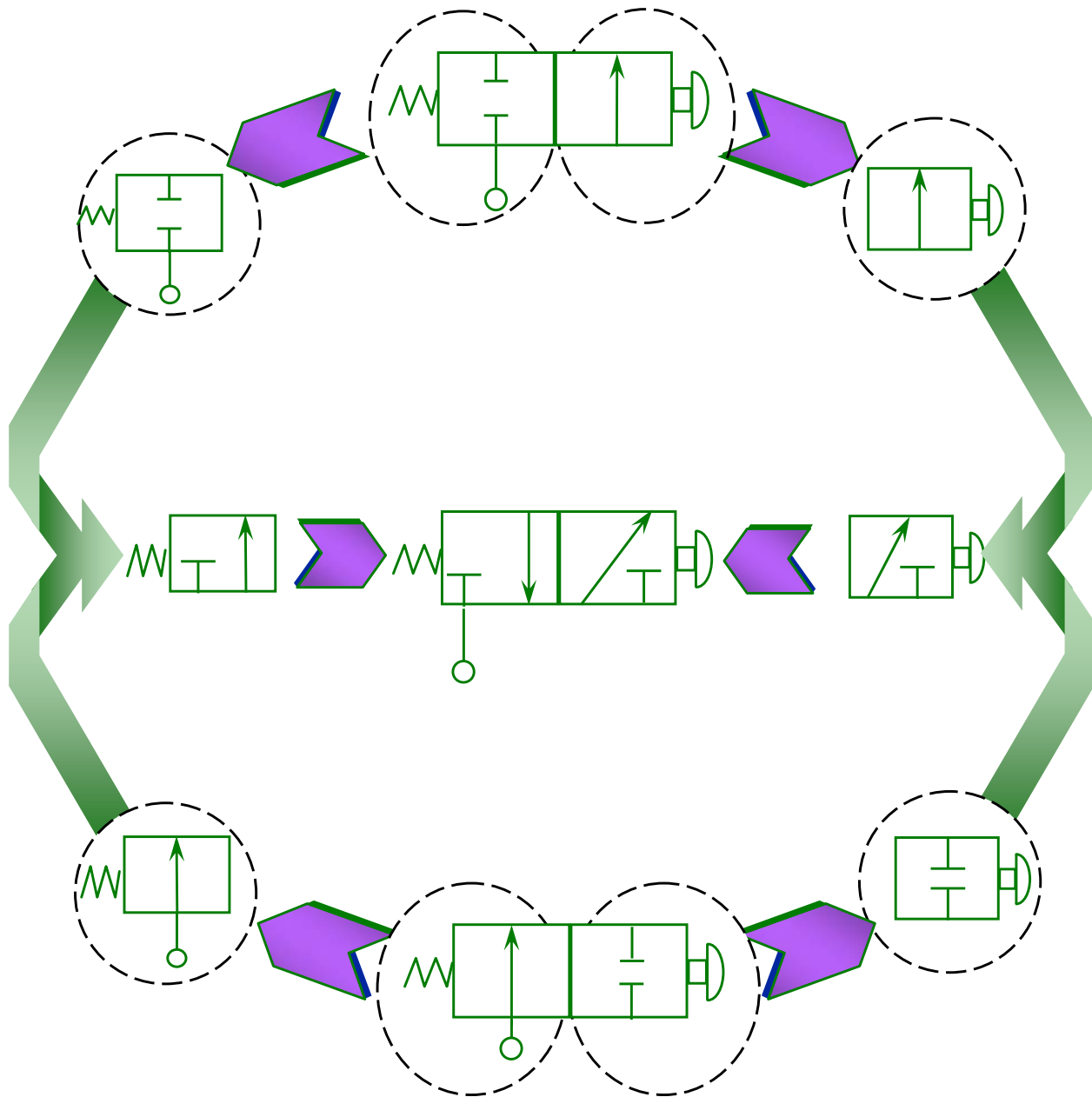
Now -- @ Start:

Valve #1 at rest Cylinder is retracted (spring)
 Actuate Valve #1 Cylinder extends
 Release Valve #1 Cylinder stays extended
 Actuate Valve #2 Cylinder retracts
 Release Valve #2 No action

THINK

If the cylinder was a double acting air cylinder -- we'd have to do this at both ports...

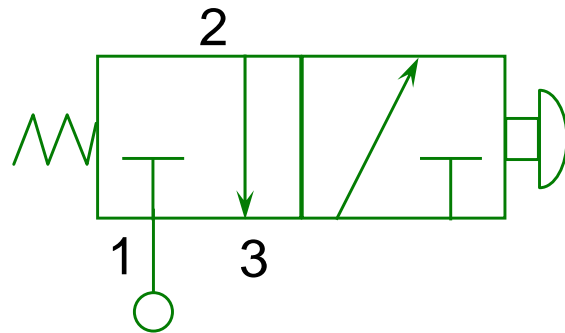
Flow Paths --- Three Way Valves



**Combine a normally non-passing 2-position 2-way
and
A normally passing 2-position 2-way**

Three Way

3/2



Description:

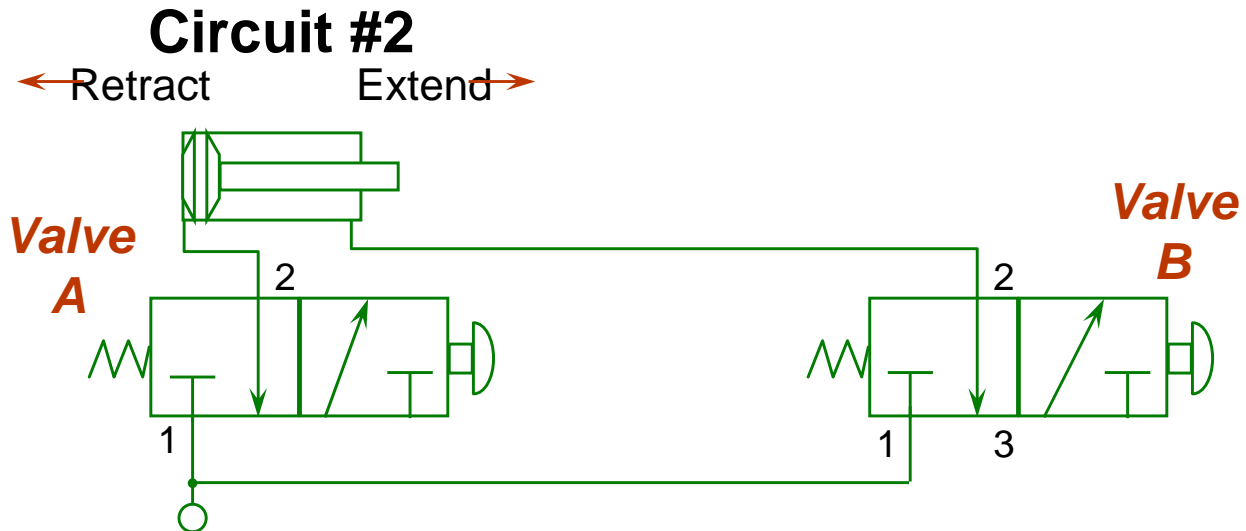
3-Way	3 flow directions
2-Position	Actuated/At rest
Normally Non-Passing	At start condition
Push Button, Spring Return	Operator type
3 Ports	1, 2, and 3

3 Flow Directions --- Non-passing,
flow from 2 to 3,
flow from 1 to 2

Start condition determined by spring

3 Ports --- there is no one standard --- may be identified as P, C, E or P, C, X or various other systems. **You must verify function --- do not assume!**

Application



Note: Supply to both valves is from one source, so pressure at valve A is the same as at valve B

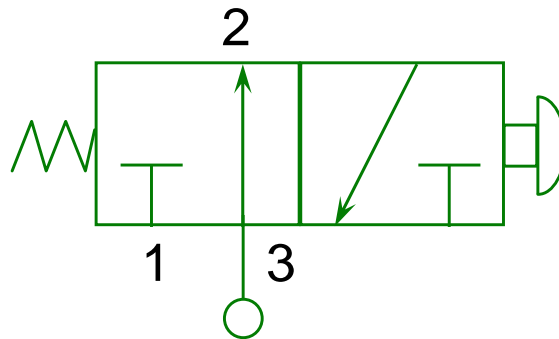
- What is the cylinder's position at start?
(Start is when we've piped the circuit as shown and the first time supply is presented to both valves).
- What happens when we actuate only valve A?
- What happens when we actuate only valve B?
- What happens when we actuate both valve A and valve B?

Are You Certain?

Can You Explain Why?

Three Way

3/2



Description:

3-Way

3 flow directions

2-Position

Actuated/At rest

Normally Passing

Start condition

Push Button, Spring Return

Operator type

3 Ports

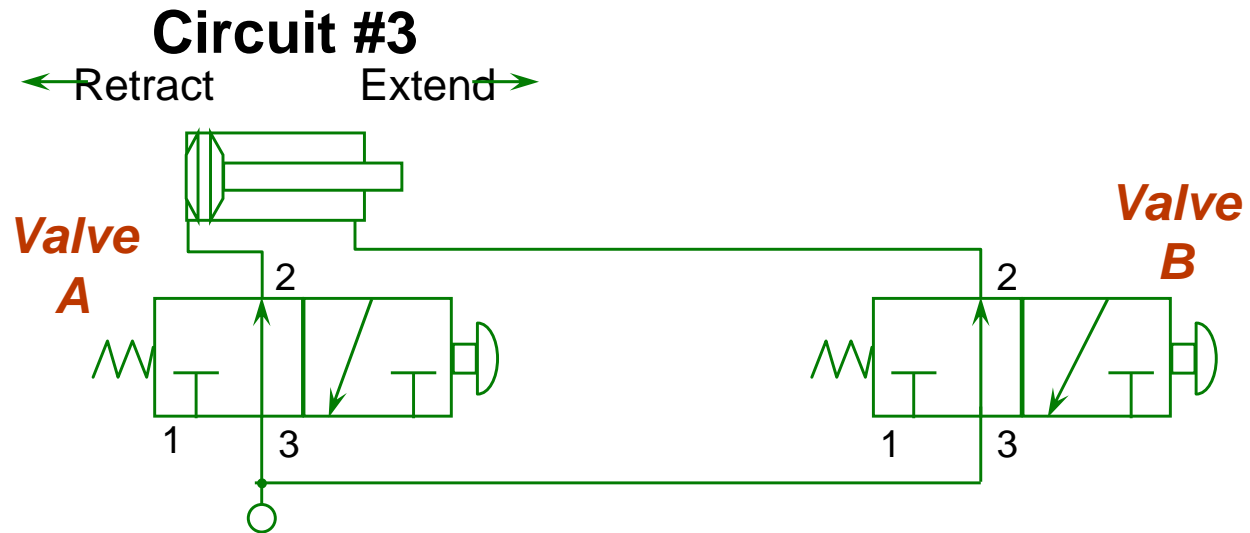
1, 2, and 3

3 Flow Directions ---Non-passing,
 flow from 1 to 2
 flow from 2 to 3

Start condition determined by spring

Ports may be labeled in different ways

Application



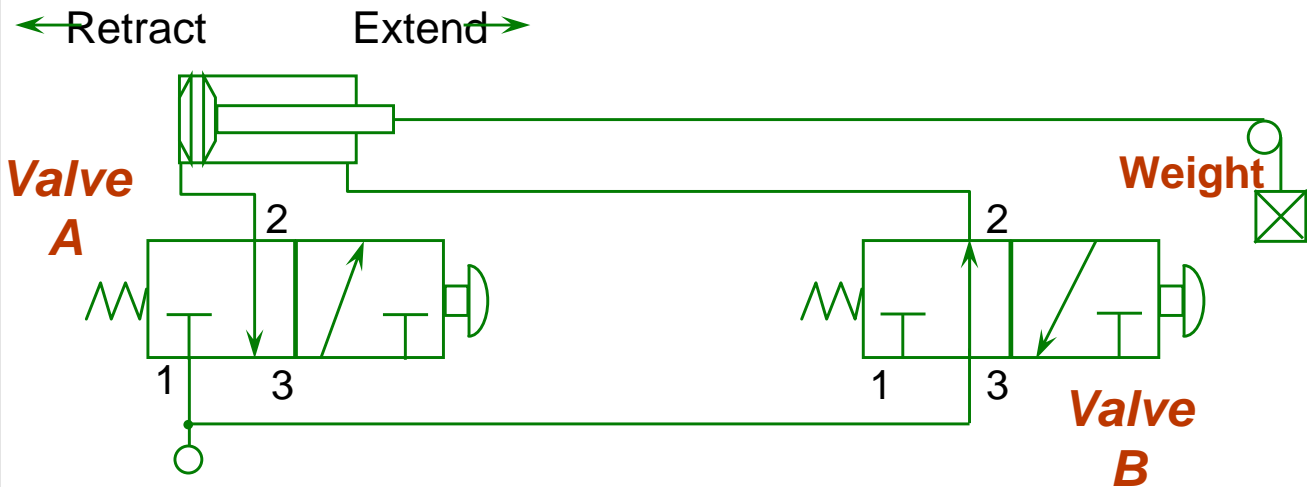
Note: Supply pressure identical at both valves

Observe arrows representing correct flow directions

- What is the cylinder's position at start?
- What happens when we actuate only valve A?
- What happens when we actuate only valve B?
- What happens when we actuate both valve A and valve B?

Application

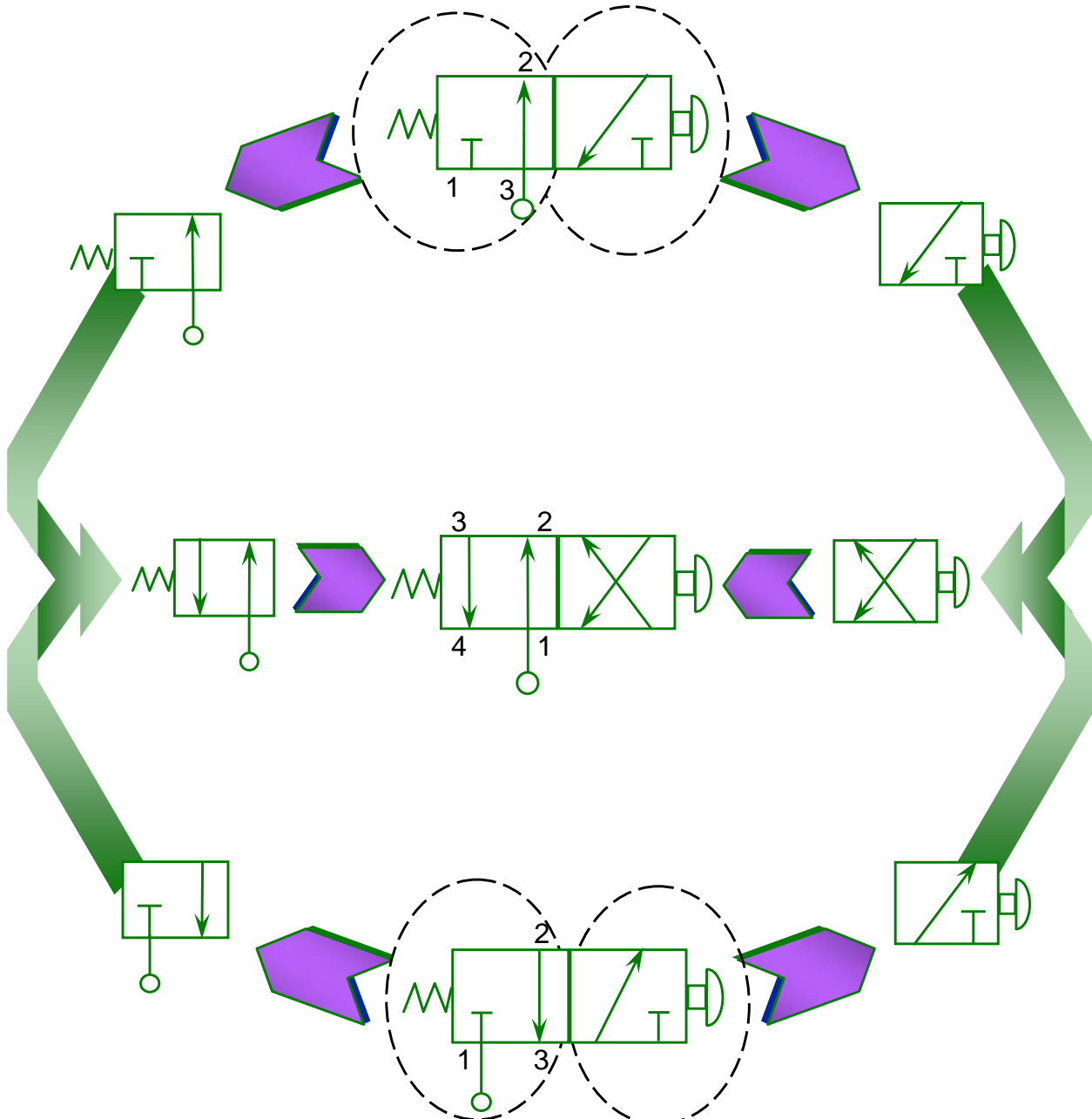
Circuit #4



Note: Supply pressure identical at both valves;
 note also -- piping determines function
 Observe arrows representing correct flow directions

- What is the cylinder's position at start?
- What happens when we actuate only valve A?
- What happens when we actuate only valve B?
- What happens when we actuate both valve A and valve B?

Flow Paths --- Four Ported Four Way 4/2

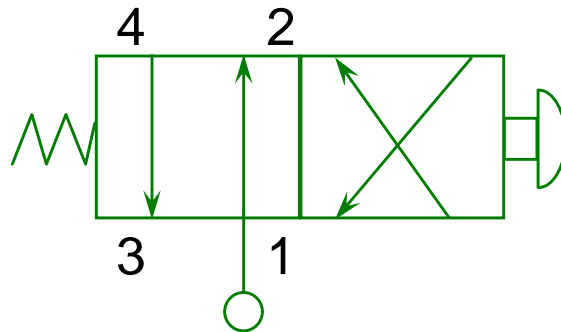


Two 3-Ways Combined = One 4-Way, 4-Ported
 One Normally Non-Passing 3-Way
 + One Normally Passing 3-Way
 = One 4-Ported, 4-Way

Four Way

4/2

4-Ported/2-Position



Description:

4-Way

4 flow directions

2-Position

Actuated/at rest

Normally Passing Classification N/A

Push Button, Spring Return

Operator type

4 Ports

1, 2, 3, and 4

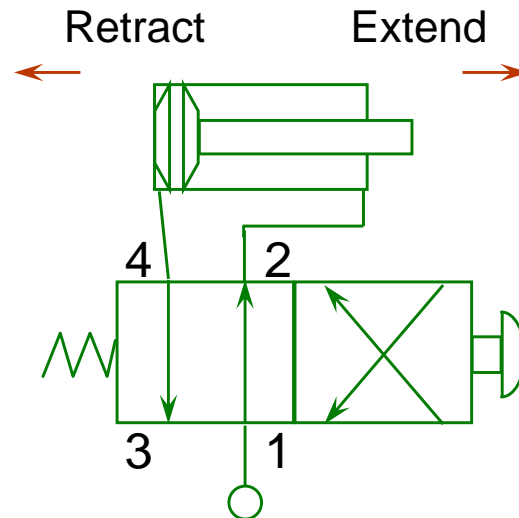
4 Flow Directions ---1 to 2, 3 to 4, 1 to 4, 2 to 3

Ports may be labeled in various ways. Verify function at each port --- do not assume.

Application

4/2

Circuit #5



Observe arrows indicate correct flow directions

- What is the cylinder's position at start?
- What happens when the valve is actuated?

THINK

Does the cylinder extend and retract at the same speed?

?

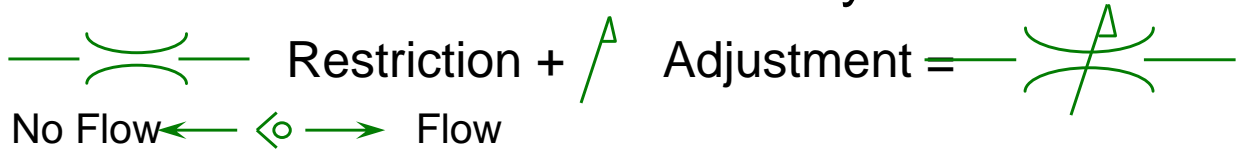
→ At what point would a metering device need to be installed to make extend and retract speeds identical?

Flow Controls

Metering Devices: used to restrict flow--- making a cylinder slower ONLY.

Adjustability is determined by a tapered needle valve. Addition of a checked flow path allows a greater flow in one

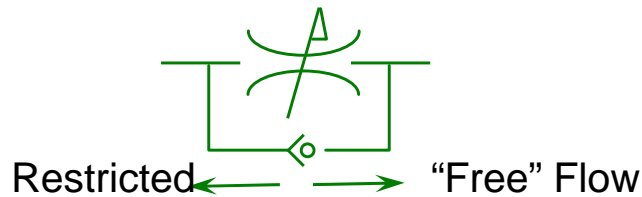
direction “Free Flow” into cylinder.



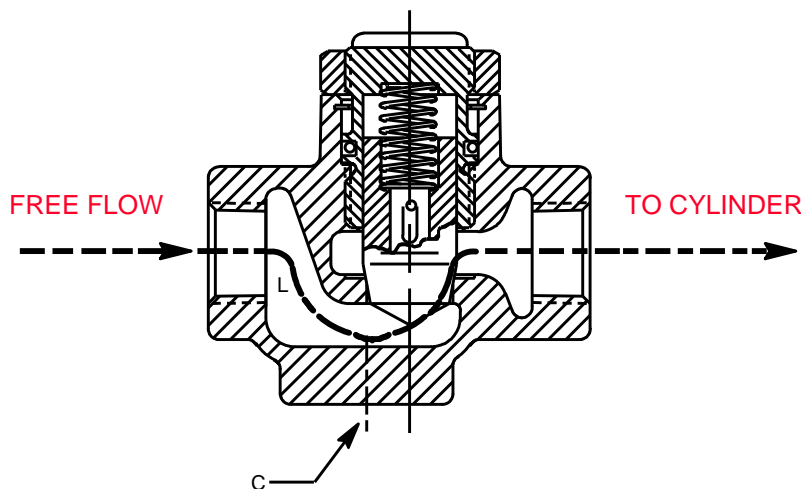
Check Valve

Needle Valve

Needle + Check = Flow Control



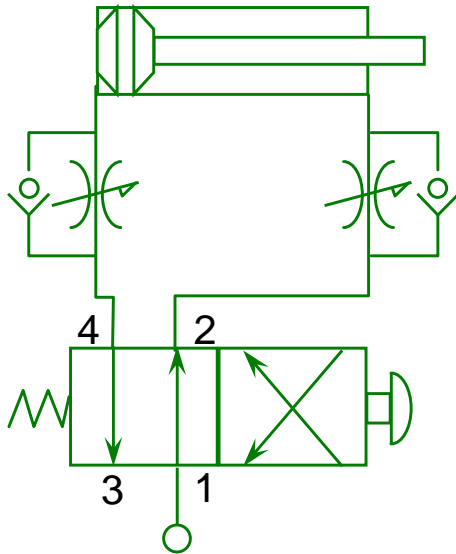
Flow Control



Application

4/2

Circuit #6



Controlling Cylinder Speed

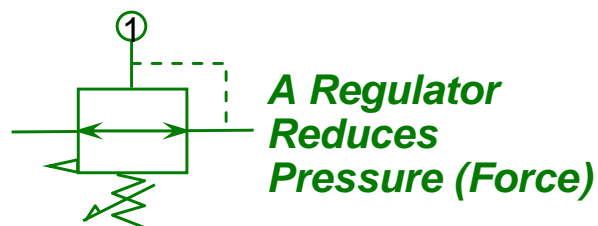
Objective: Extend and retract at the same speed

Observe arrows indicate correct flow directions

- Flow controls restrict exhaust at each cylinder port.
- While adjustments can be made to the flow controls to achieve the objective of making extend speed equal to retract speed, there is a penalty for doing so. The cylinder is slowed in both directions (extend more than retract) to make the speeds equal.
- Even at “free flow” the flow control is a restriction to flow of the circuit.

What if our objective is to have equal thrust in both directions?

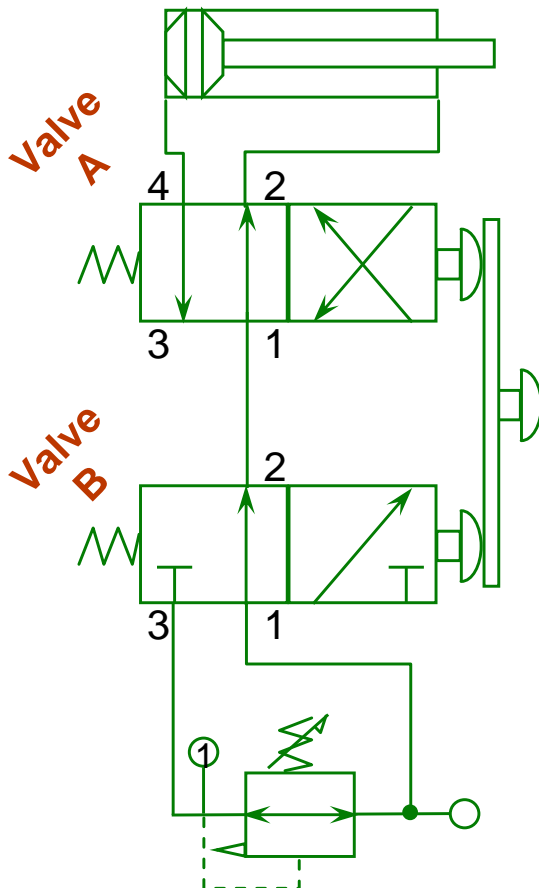
Where would we use a regulator in the circuit?



Application

4/2

Circuit #7



Objective:
and retract
same force

Extend
with

3-way valve used as
Selector
Selects line pressure
or

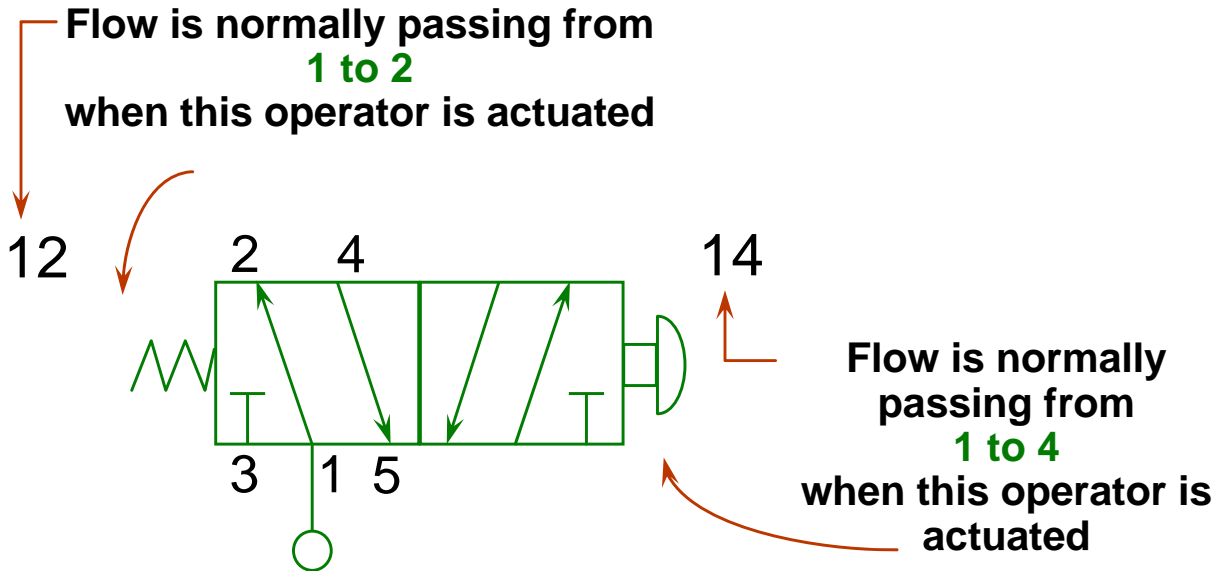
- reduced pressure
Regulators are not
designed for exhausting a
cylinder --- unless they are
equipped with an “internal
check” bypass.
- Do not use a regulator
down-stream of a valve
without verifying
“check/bypass” function.

Note: Both valves are simultaneously
actuated

- Which port is the exhaust port for the circuit?
- Regulator is adjusted until extend and retract forces are identical.

Five Ported Four Way

5/2



Description:

4-Way

4 flow directions

2-Position

Actuated/At rest

Normally Passing Classification

N/A

Push Button, Spring Return

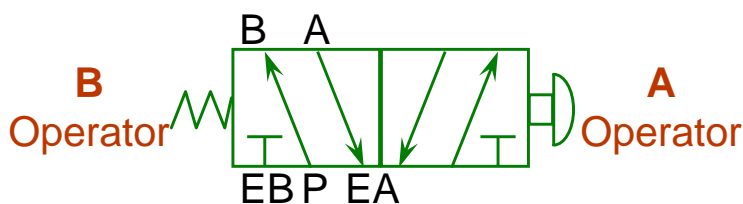
Operator type

5 Ports

1, 2, 3, 4, and 5

- Each cylinder port has its own exhaust

Standard labels apply --- ISO standard shown above, may also be:



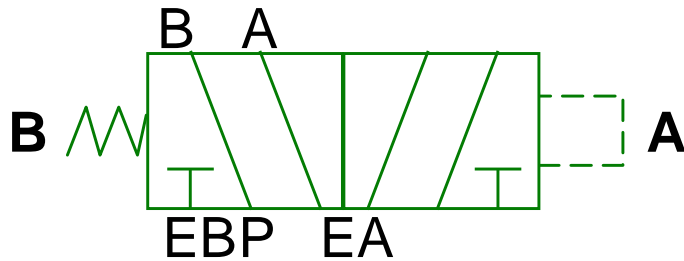
EB = Exhaust of B
EA = Exhaust of A

(NFPA standard, other labels may be found --- verify function)

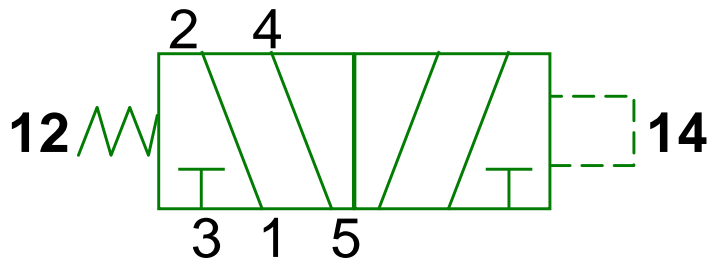
Port Identification

5/2

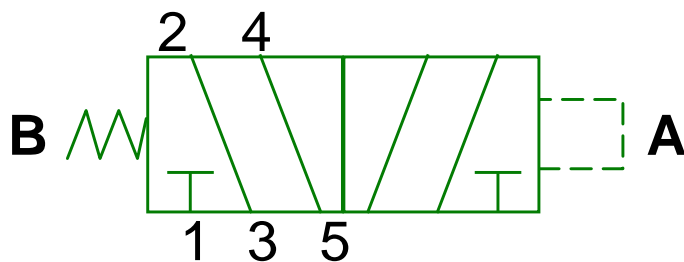
Labeling “Standards”



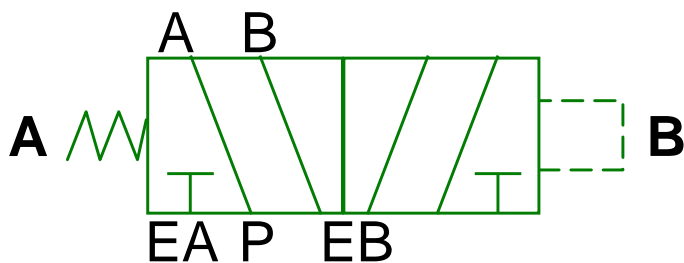
**Conventional
NFPA**



ISO



Numatrol



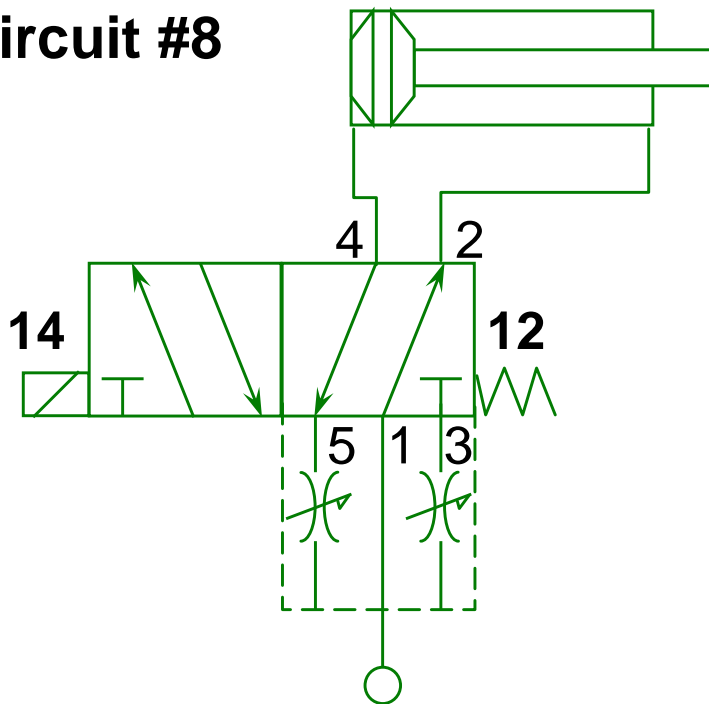
**Some
Automotive
Series**

Application

5/2

Objective: Extend and retract at the same speed

Circuit #8



NOTE:

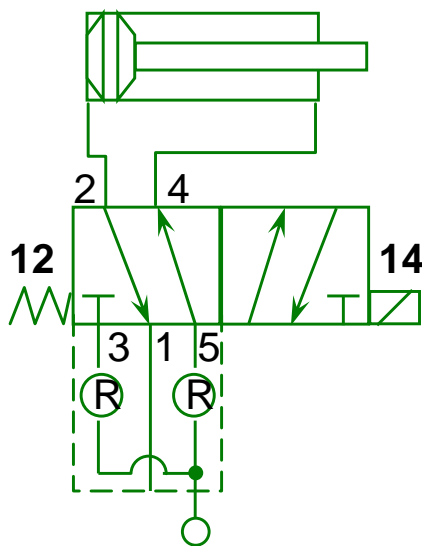
- Dotted line indicates an assembly --- a modular combination of devices; in this case a valve and a speed control sandwich.
- Metering devices are needle valves and serve to restrict only the exhaust --- supply is **full** flow.
- Modular design allows control from the valve (often the cylinder is inaccessible or in a protected cell).
- **Only by restricting both exhaust flow paths can we extend and retract at the same speed**

Application

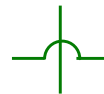
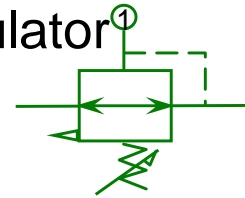
5/2

Objective: Extend and retract with same force

Circuit #9



Is a shorthand symbol for a regulator



A means of showing lines that do not connect



Lines that do connect

NOTE:

- Dotted line indicates an assembly --- a modular combination of devices; in this case a valve and a double regulator sandwich.



- **IMPORTANT!** Observe that the addition of the sandwich regulator has altered the valve flow paths.

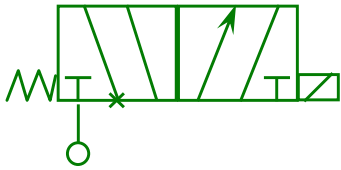
- Modular design allows control from the valve's location.



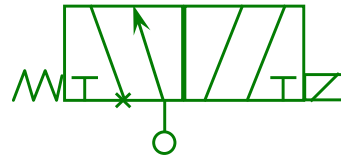
- A direct acting multi purpose valve can have supply and even different pressures at ports other than 1 or P --- achieving different functions.

Common Multi-Purpose Pipings

2-Way NNP



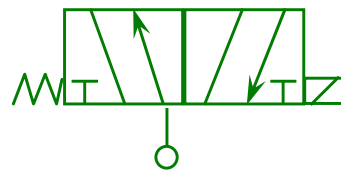
2-Way NP



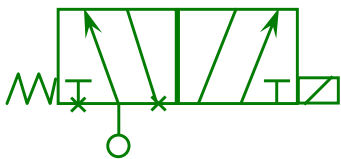
3-Way NNP



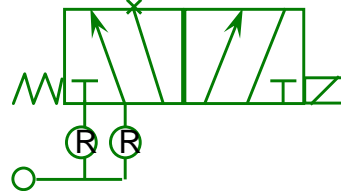
3-Way NP



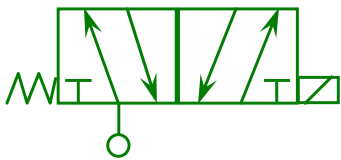
Pressure Diverter



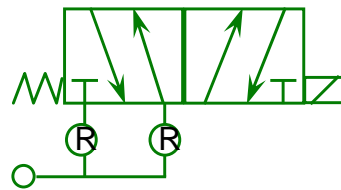
2 Pressure Selector



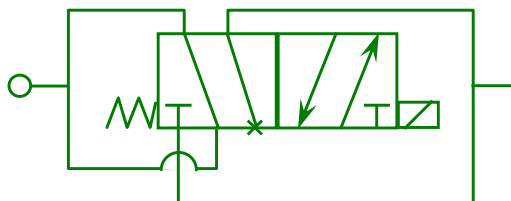
Single Pressure



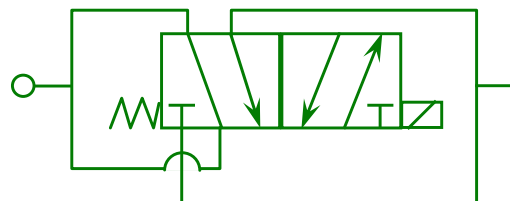
Dual Pressure



Double Capacity, NNP 2-Way

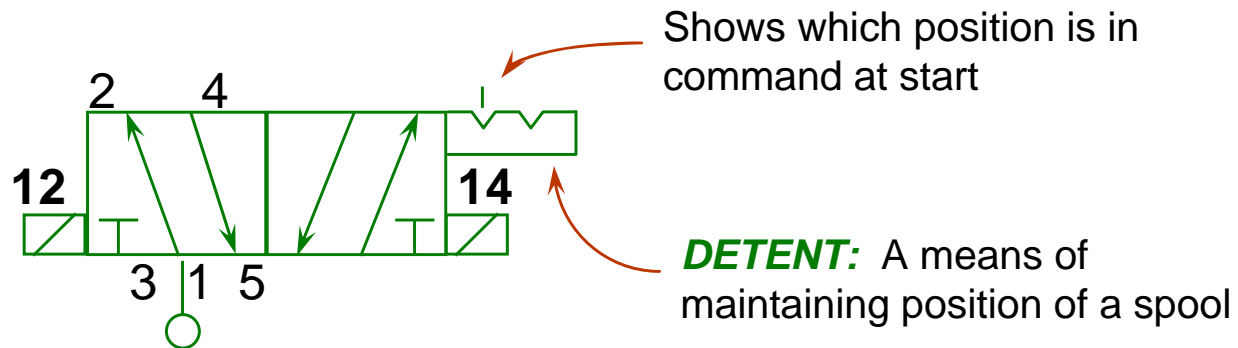


Double Capacity, NNP 3-Way



Double Solenoid Detent

5/2



Description:

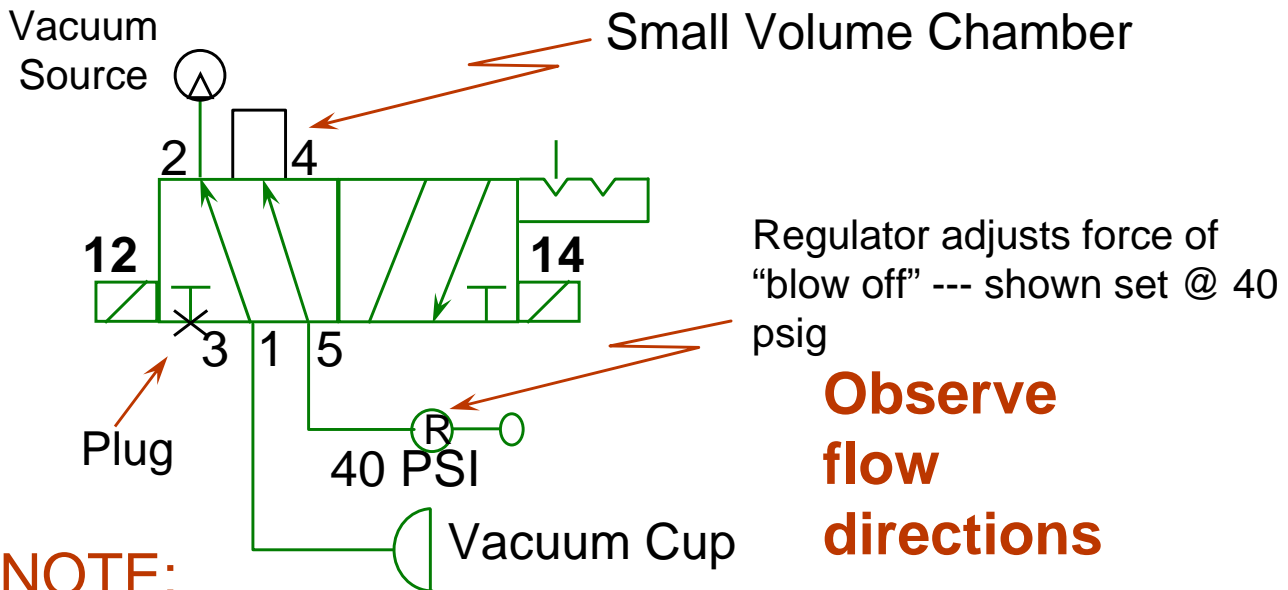
4-Way	4 flow directions
2-Position Detented	Held shifted w/momentary signal
Normally Passing Classification	N/A
Double Solenoid	Operator type
5 Ports	1, 2, 3, 4, and 5

- Advantage the detent offers --- valve stays shifted with a momentary pulse to the solenoid --- no need not be held energized.
- Valve has “memory” -- remembers last signal received.
- Useful in sequencing, reducing energy consumption, or as a safety precaution.

Application

Circuit #10

Objective: Vacuum cup picks up/blows off part



NOTE:

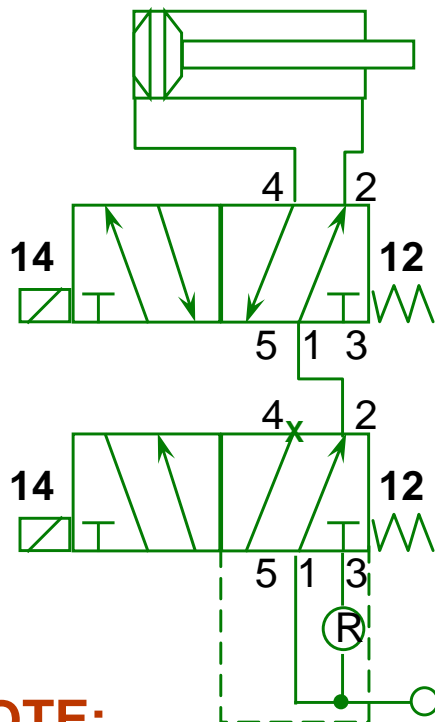
- Valve in "12" condition has vacuum at the cup and regulated air fills a small volume chamber
- Valve in "14" condition has vacuum blocked and a puff of air breaks the vacuum lock and blows off the part. Force is adjustable. Volume chamber is sized for requirement of the circuit.
- Valve selected to maintain position in the event of power failure --- double solenoid detent also only requires momentary pulse of electricity

- Single valve solution: saves energy, adds fail safe function and allows adjustability of the

Application

Circuit #11

Objective: Cylinder Deceleration Circuit or Varying Clamp Force



Main Valve

Selector Valve

observe port #4 is plugged

NOTE:

- Cylinder extends and retracts with signal to main valve
- Pressure to main valve controlled by selector valve
- Cylinder can extend, then, with higher pressure selected, clamp with greater force
- Varying selected pressures can decelerate/accelerate the cylinder

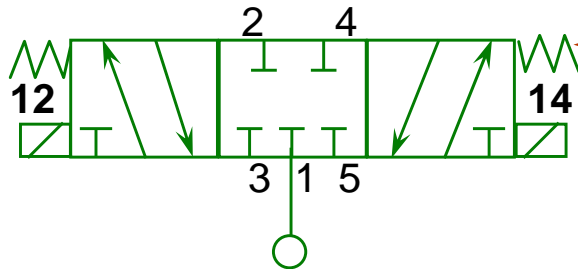
BUT

How can we stop the cylinder in mid stroke?

Three Position

5/3

3-Position Valves --- All Ports Blocked



3-position valves have a center function
The center position is described

Springs center valve when not energized

Description:

4-Way

4 Flow Directions

3-Position Spring Center Energized/Center/Energized

All Ports Blocked at Center Describes at rest condition

Double Solenoid

Operator type

5 Ports

1, 2, 3, 4, and 5

Note: Center is often referred to as MID position

- Useful if some condition other than full extend or full retract is desired.
- Most frequently selected to stop or jog an air cylinder.
- **Be Aware** --- there are limitations with potentially serious consequences. Not always a good choice.
- Best used to stop an air motor, blow-off or where there is no volume of trapped air.

Note: a trapped volume of air is potential energy and should be avoided when possible.



How can you tell the 12 end from the 14 end visually?

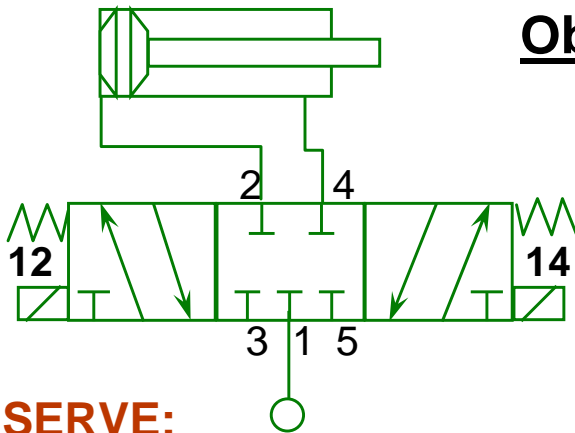
Double solenoid valves can be difficult to determine flow paths --- always verify function.

Three Position

5/3

Circuit #12

All Ports Blocked Center



Objective: Stop the cylinder in mid stroke

OBSERVE:

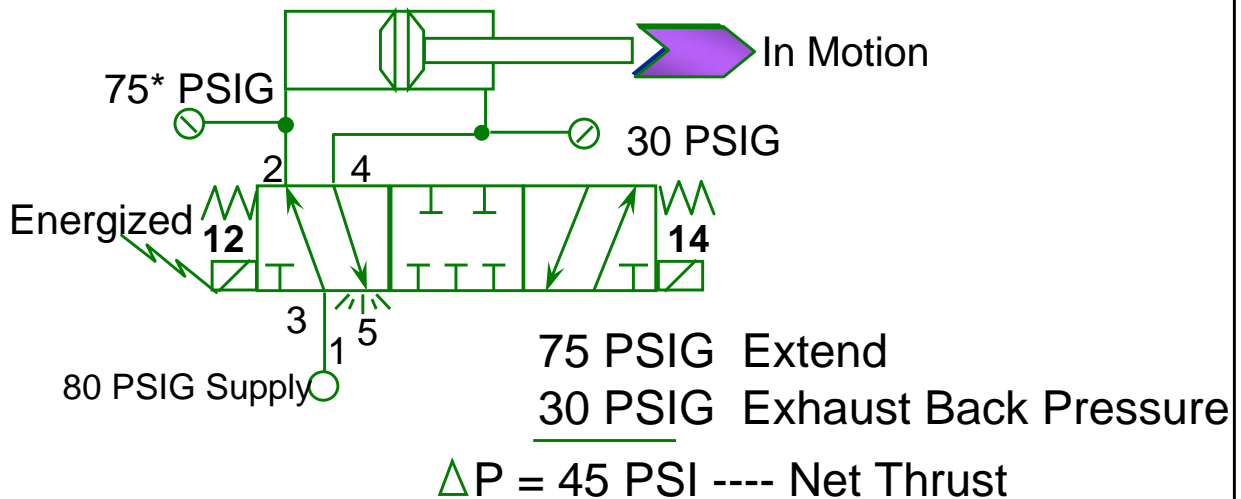
Cylinder will not stop until the back pressure rises high enough to balance the forces on the piston --- analysis follows.

NOTE:

- Air is trapped in the cylinder. Any leakage (fittings, piston seal, rod seal, valve) will allow the cylinder to move or drift
- When air is exhausted by a lockout or dump valve, air will be trapped in cylinder
- If load is vertical --- any cylinder lines' inadvertent exhaust will cause the load to drop unexpectedly
- During start up --- the all ports blocked center valve does not allow the air to pressurize the cylinder. First stroke could be at high speed due to potential lack of air at either end of cylinder
- **Disconnecting any air lines for maintenance may cause unexpected rapid movement of the cylinder --- even if OSHA lock out has been correctly actuated**

Application

Circuit #12 --- Analysis --- Part One



* 75 PSIG (not 80 PSIG) due to line loss, fittings, valve inefficiencies

NOTE: The cylinder is in the process of extending. In a moment, we'll try to stop that movement.

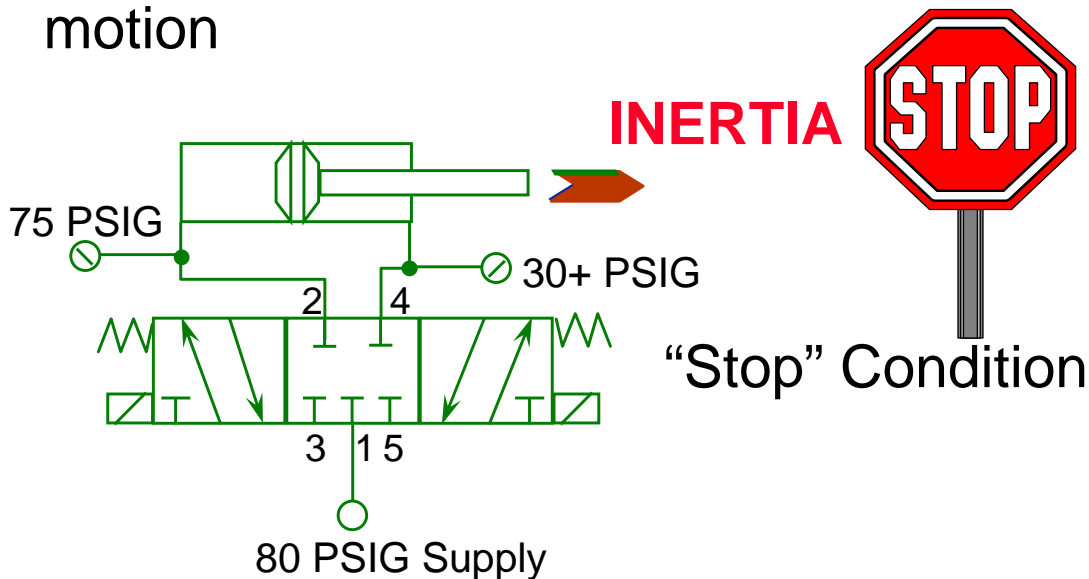
There is resistance to movement in the cylinder caused by the air trying to exhaust. At this exact moment we have a net extend force (Thrust) of 45 psig pushing on the piston.

Now we'll try to stop the cylinder.

Application

Circuit #12 --- Analysis --- Part Two

Inertia -- a body in motion wants to stay in motion



NOTE: Force is a result of Pressure times Volume (another way of thinking about Area).
 On the ROD SIDE, Force will increase as volume is reduced.
 On the BLIND SIDE, Force will decrease as volume is provided.
 Once the Forces are equal, the cylinder will stop.

NOTE: often forces do not equal within a small cylinder body, but will complete end of stroke due to the volume of air in the tube between the valve and cylinder.
 Therefore, Load cannot stop immediately
 The Larger the ΔP = The Greater the Over-travel

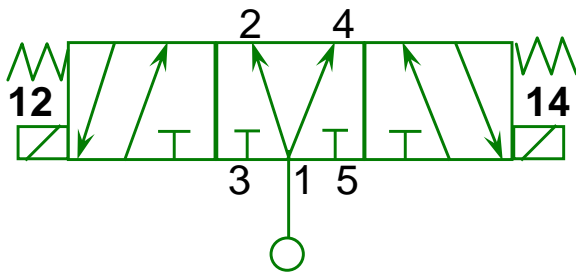
Three Position

5/3

3-Position Valves

and

--- Cylinder ports pressurized
exhaust ports blocked



NOTE: Description related to center position

Description:

4-Way

4 Flow Directions

3-Position, Spring Center

Energized/Center/Energized

Exhaust Blocked, Cylinder

Describes at rest condition

Ports Pressurized

Double Solenoid

Operator type

5 Ports

1, 2, 3, 4, and 5

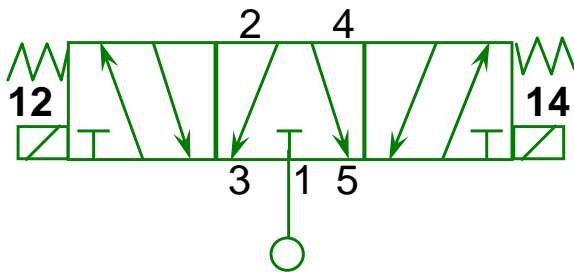
Note: Most often used with single pressure piping to stop and hold a balanced cylinder, such as rodless or double-rod cylinder in a mid-position, with a mechanical rod-lock or carriage-lock.

Three Position

5/3

3-Position Valves

--- Supply blocked, cylinder ports exhausted



NOTE: Description related to center position

Description:

4-Way

4 Flow Directions

3-Position, Spring Center

Energized/Center/Energized

Supply Blocked, Cylinder Ports Exhausted

Describes at rest condition

Double Solenoid

Operator type

5 Ports

1, 2, 3, 4, and 5

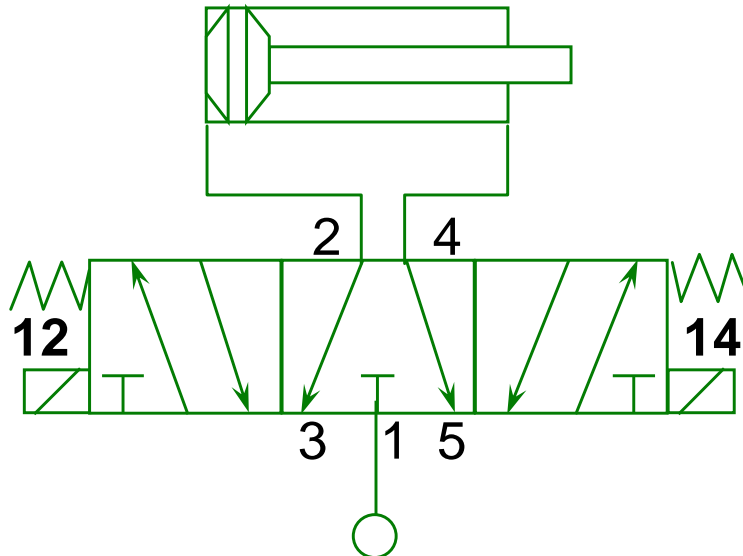
Note: Most often used with dual pressure piping to stop and hold a double acting cylinder in a mid-position, with a mechanical rod-lock.

Application

5/3

Circuit #13

Objective: Stop the cylinder in mid stroke



OBSERVE: Cylinder will over-travel and not hold position against external loads

NOTE:

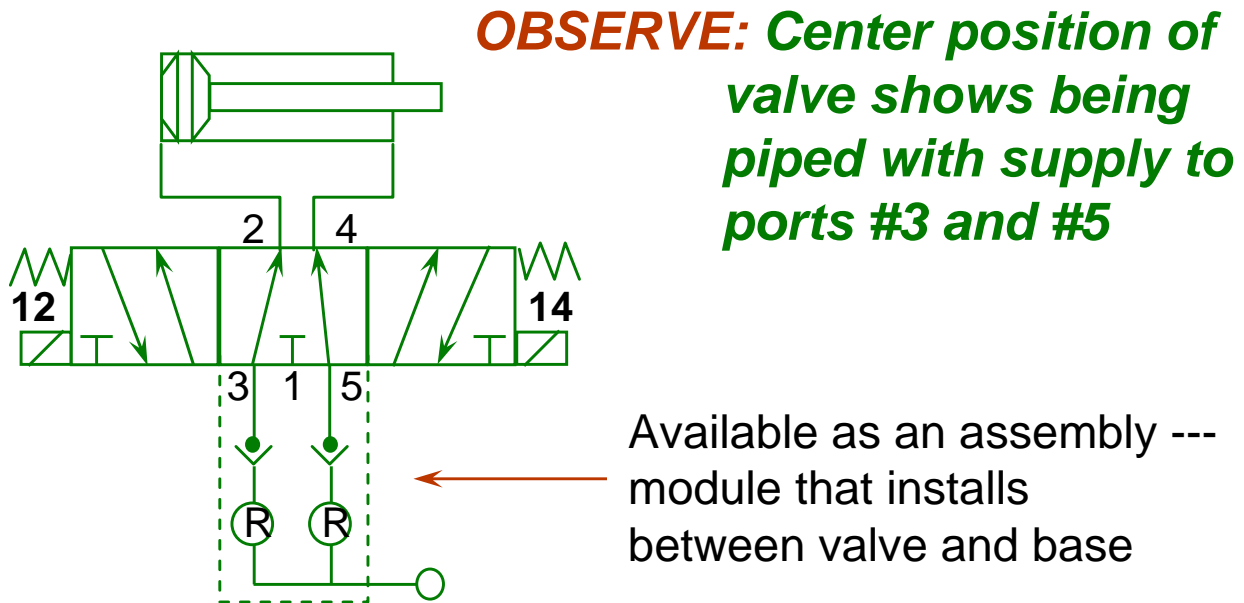
- If cylinder is in mid position, actuating the valve will cause rapid (potentially dangerous) movement due to large ΔP
- Not suitable for vertical loads
- Desirable only for specific applications where center position function applies

What if the valve was able to be piped in another way?

Application

Circuit #14

Objective: Stop the cylinder in mid stroke



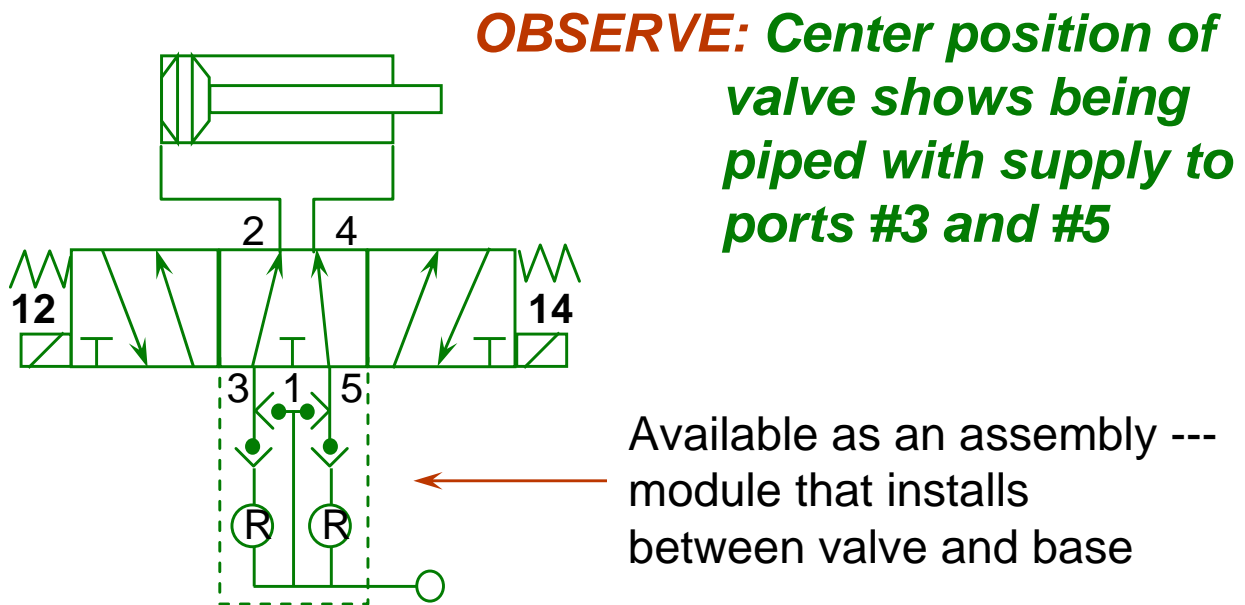
NOTE:

- Check valves stop and hold cylinder in mid position
- Two regulators balance pressures
- In case of electrical failure, valve defaults to mid position, check valves stop and maintain cylinder position
- In case of pneumatic supply failure, valve defaults to mid position, check valves stop and maintain cylinder position
- During start up, first cycle does not cause rapid cylinder motion as pressure is present on both sides of the piston
- **Be aware that air will be trapped even if an exhaust or lock out valve is opened upstream of this valve**

Application

Circuit #15

Objective: Stop the cylinder in mid stroke

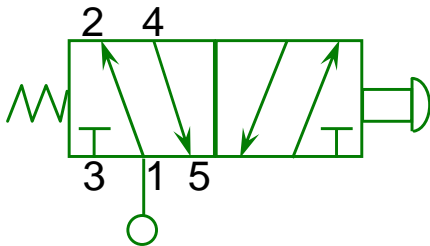


NOTE:

- Two regulators balance pressures
- In case of electrical failure, valve defaults to mid position, dual pressure stops and maintains cylinder position
- During start up, first cycle does not cause rapid cylinder motion as pressure is present on both sides of the piston
- The Quad-check prevents any back flow of air through the regulators, while providing an exhaust path for air during a lock-out procedure after an “e-stop.”
- Should always be applied with a mechanical rod-lock on double acting cylinders.

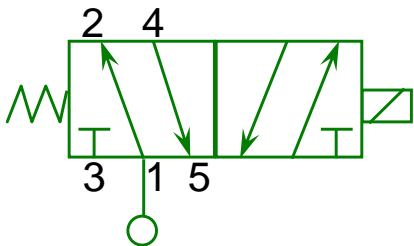
- **BEST “E-Stop” or “jog” circuit**

Actuation Methods



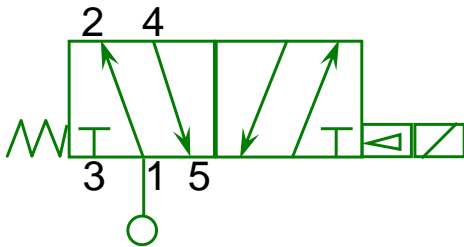
MANUAL (Direct Acting)

Force to shift valve supplied by mechanism -- linkage directly acts on valve



SOLENOID (Direct Acting)

Electromagnet pushes valve. Force is supplied by electrical current -- wattage

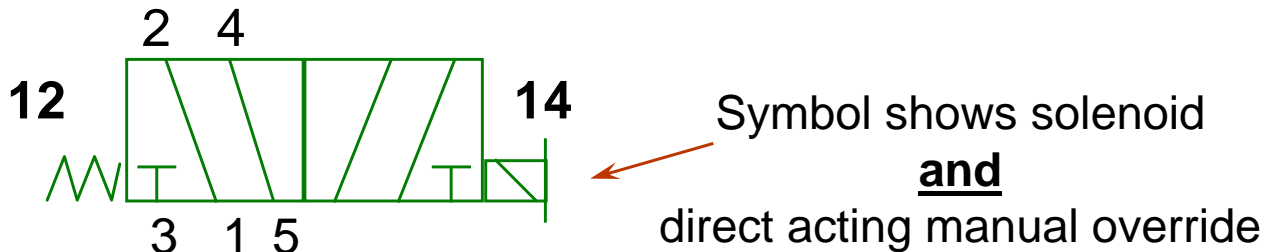


SOLENOID AIR PILOT

(Direct Acting
Solenoid Powers Air
Pilot Valve)

Solenoid air pilot requires minimum supply pressure, or, if not available --- must be externally supplied. Typically, internal supply provided only when supply is provided at port #1. Uses air pressure at inlet to shift main valve element.

Direct Acting



NOTE: Flow path arrows omitted to show multi purpose nature of valve. How the valve is piped will determine flow paths.

Action: Solenoid pushes spool directly, compressing spring

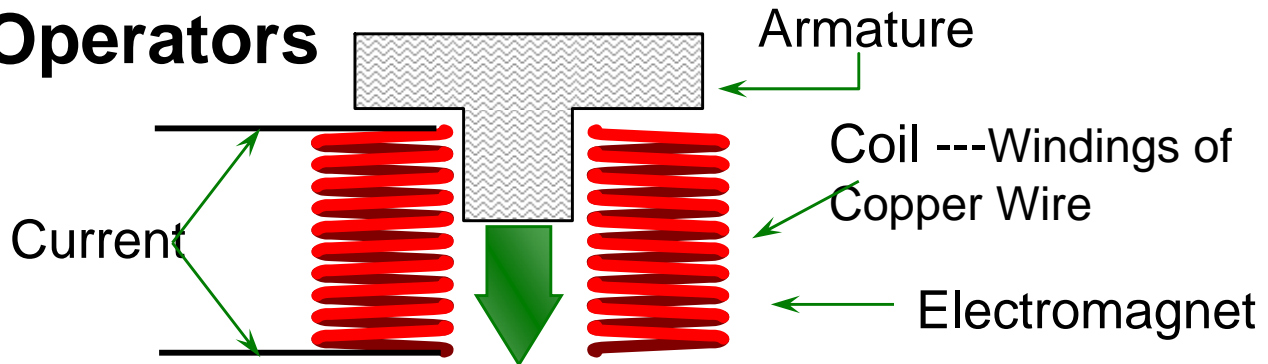
ADVANTAGES:

- Valve shifting force is independent from supply pressure - -- allows multi purpose piping of valve --- constant solenoid force
- Simple design --- three moving parts (solenoid armature, spool, spring)
- Override acts upon spool directly --- positive feedback
- Operates with vacuum, pressure or dual supplies
- Generally faster response time to shift valve, especially in non-rubber packed valves.

DISADVANTAGES:

- Requires low shift force mechanism --- rules out friction seals/dynamic o-rings as valve designs
- Larger solenoid required versus solenoid air pilot - typically requires more electricity (wattage)

Solenoid Operators



With current supplied to the **coil**, an electromagnet is created.

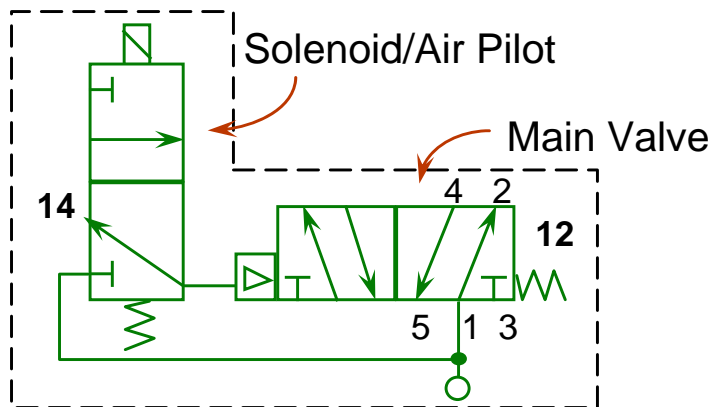
A laminate iron T **armature** is drawn to the electromagnet. It is this force that shifts the valve mechanism.

An electromagnet takes more energy to create the magnetic force. Once created, less energy is required to maintain the circuit once the armature has been drawn completely to the electromagnet. (Similar to the “flywheel concept – it takes more energy to get the flywheel moving than it does to maintain its motion.

Inrush* ----- current required to create the electromagnet
Holding* ----- current required to maintain the electromagnet

* **Peculiar to AC voltage only!**
 AC coils typically are smaller than DC coils. AC coils typically generate more force per winding --- but they get warm in doing so. (135°F is about maximum)

Solenoid/Air Pilot



NOTE: *Internal passage connects supply to the solenoid/pilot section; a minimum pressure is required to shift the main valve.*

ADVANTAGES:

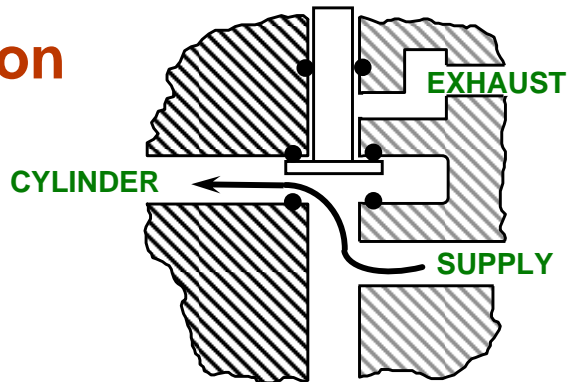
- Main valve shifted with supply air pressure --- typically more shifting force available than with a direct acting solenoid: required by friction seals and various other valve designs
- Smaller solenoid (less electrical power required) -- small three way valve, not much flow required
- May be faster ---depending on supply pressure and net shifting force --- than direct acting valves of similar size.

DISADVANTAGES:

- Valve shifting force is dependent upon supply pressure --- may require external supply
- Requires external pilot supply to become multi purpose
- Solenoid pilot valve has light shifting force with very small air passageways --- susceptible to sticking and failure (some designs/manufacturers)
- Manual override acts upon pilot section only, not the main valve
- More parts

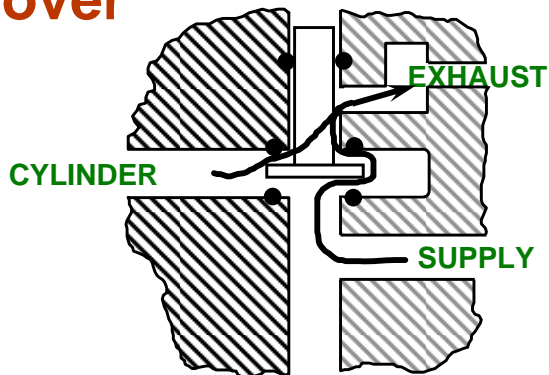
Poppet Type --- Mechanical/Solenoid/Pilot

Position 1

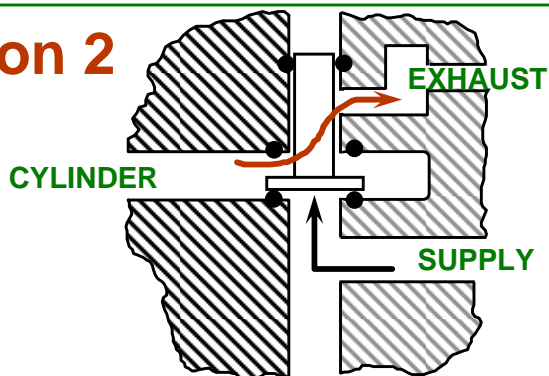


Flow paths when "B" pilot is pressurized or in command

Crossover



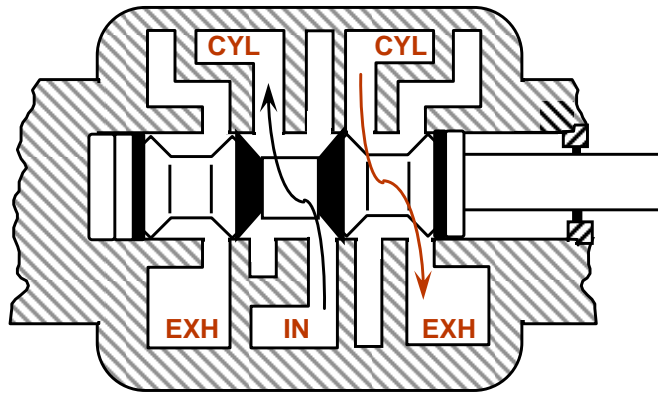
Position 2



Flow paths when "A" pilot is pressurized or in command

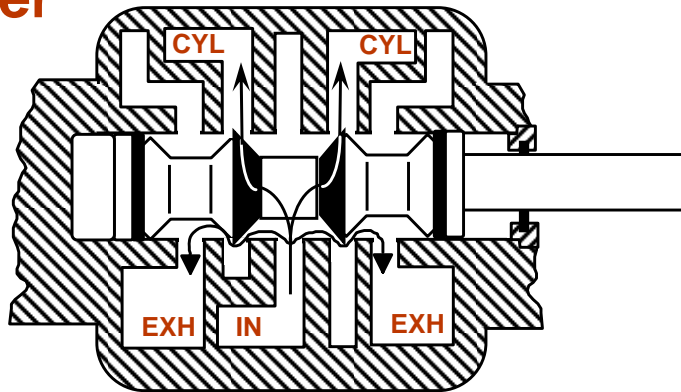
Spoppet Type --- Solenoid Air Pilot

Position 1

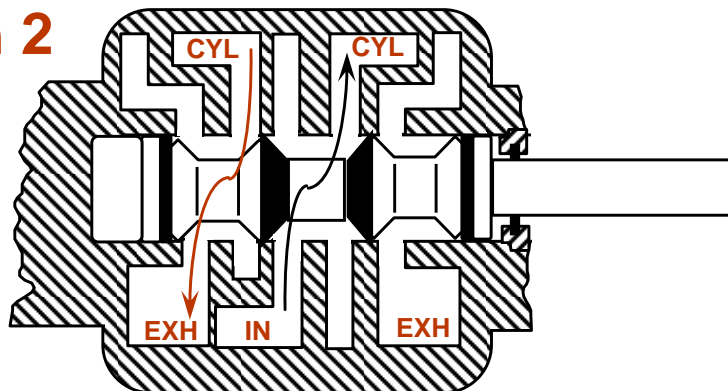


Flow paths when "B" pilot is pressurized or in command

Crossover

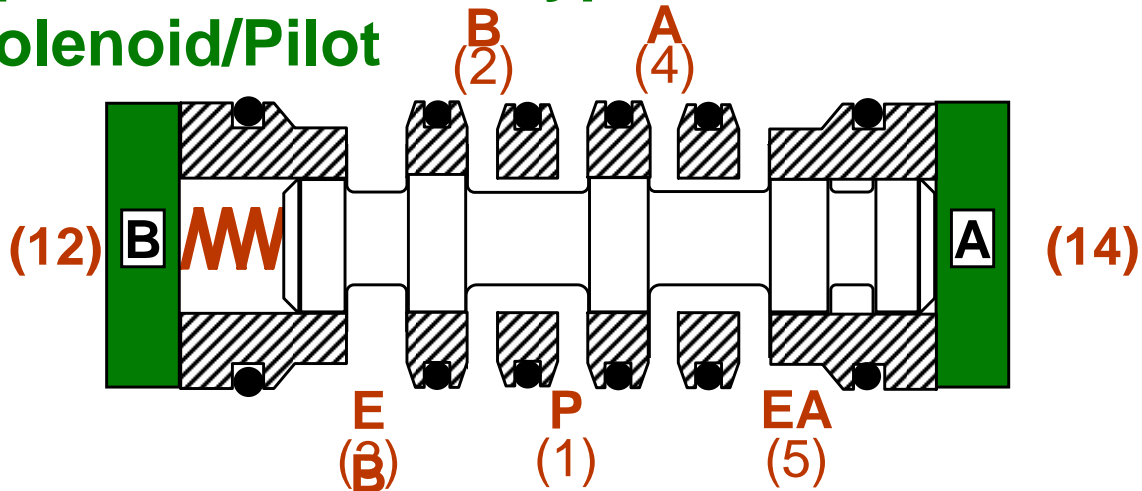


Position 2

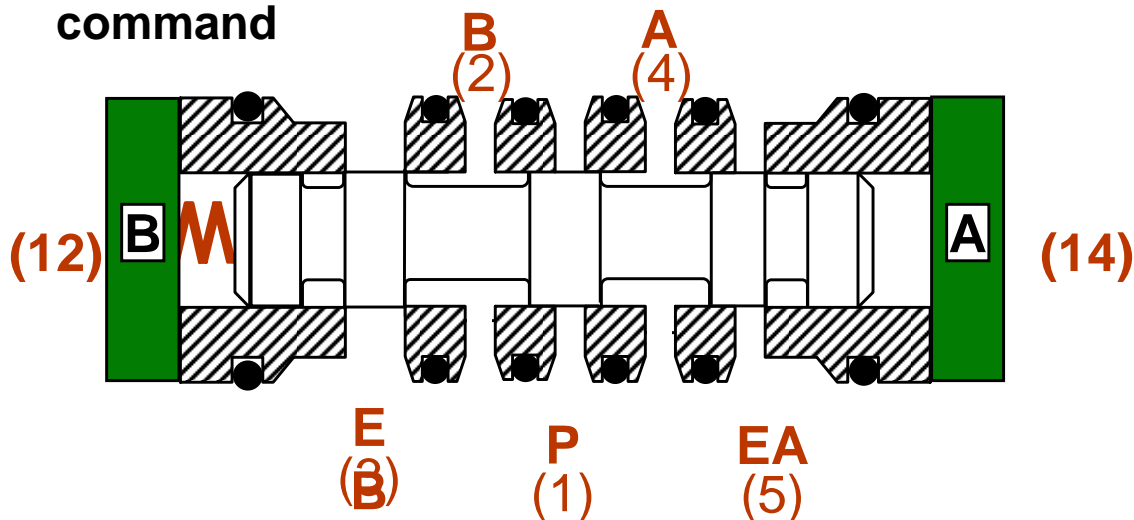


Flow paths when "A" pilot is pressurized or in command

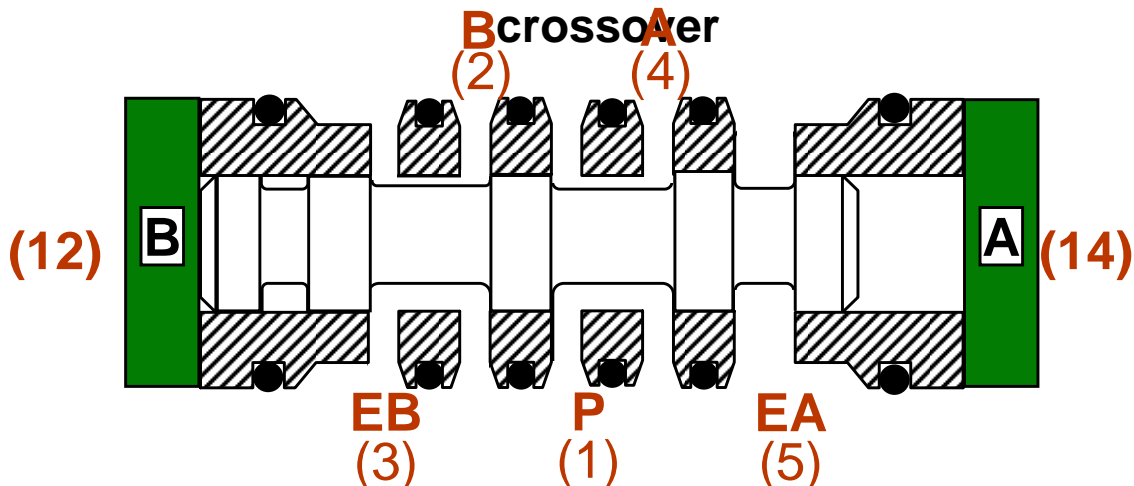
Spool and Sleeve Type --- Direct Solenoid/Pilot



Flow paths when "B" pilot is pressurized or in command

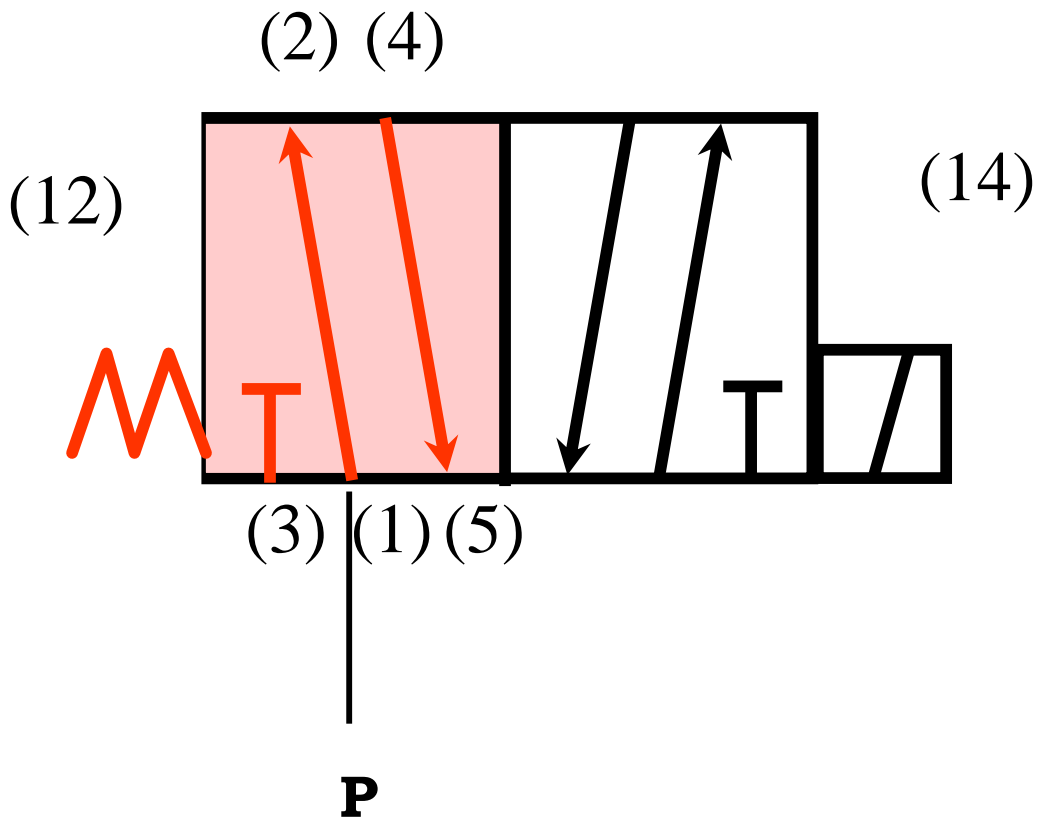
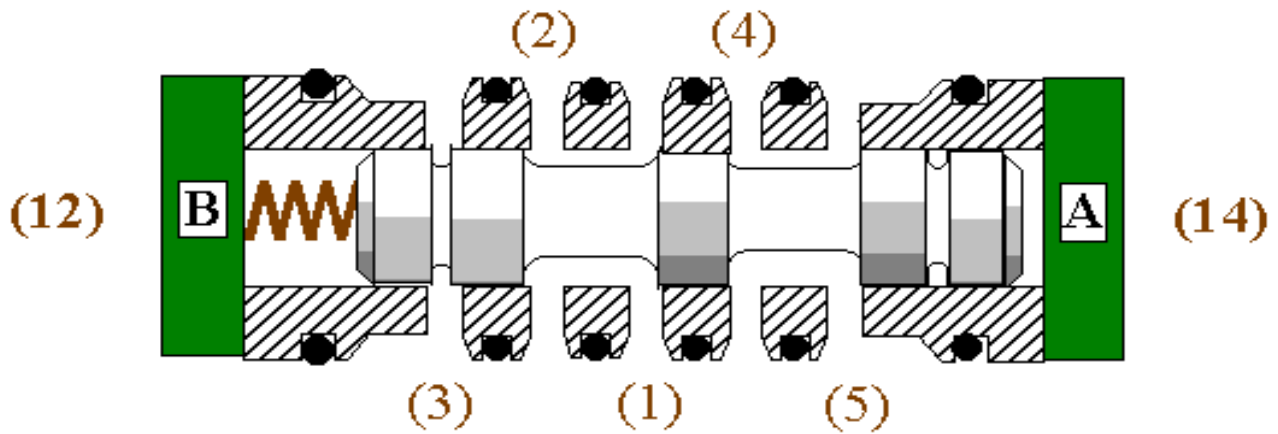


Mid-Position, all ports blocked – closed



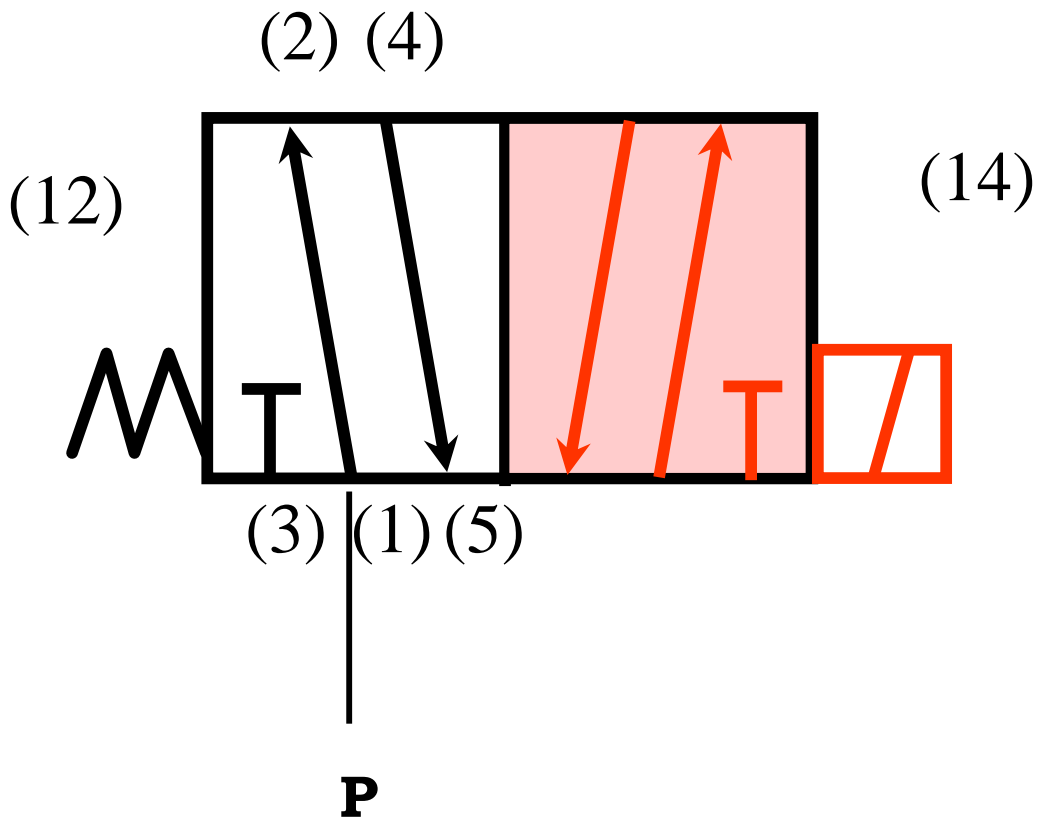
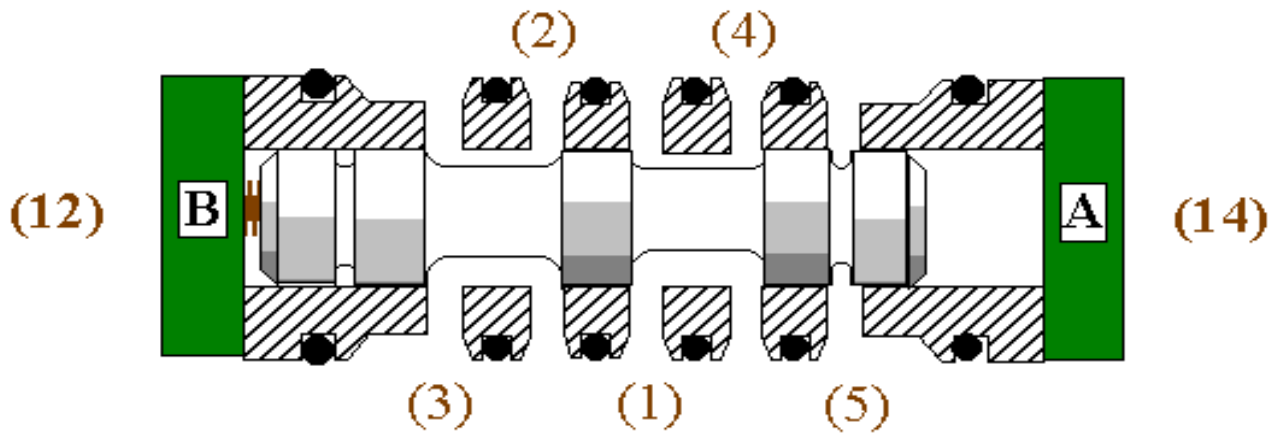
Flow paths when "A" pilot is pressurized or in command

Valves



“12” condition with spring in control

Valves



“14” condition with solenoid energized

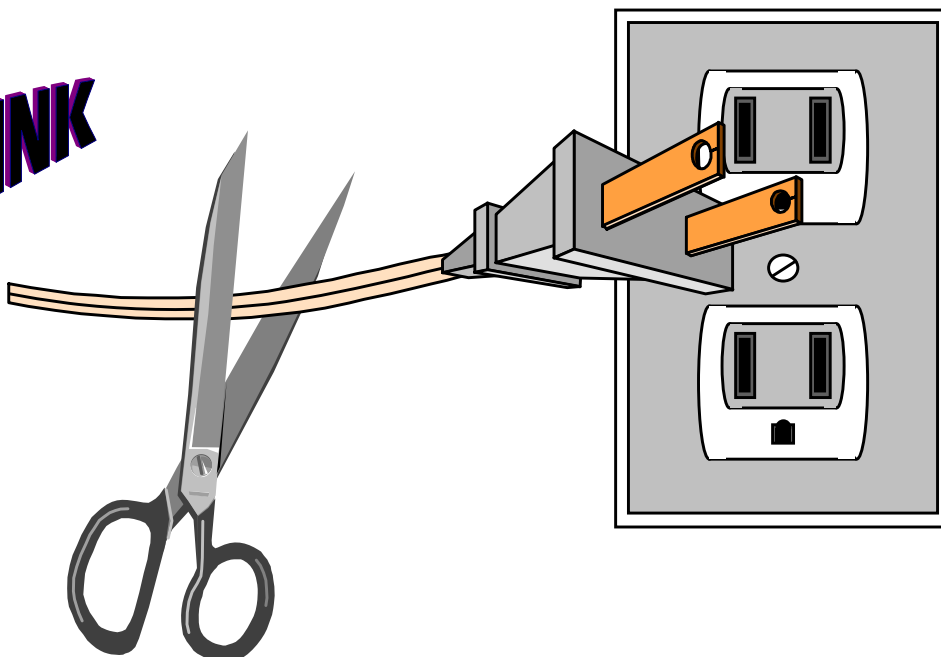
When selecting a valve

What type of valve is best for this application?

Is the circuit design as safe and simple as possible?

What would happen if the lights went out --- will the valve default to a safe condition?

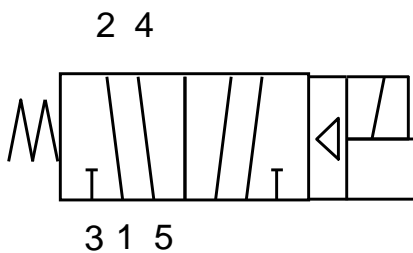
THINK



Basic Symbology

Function

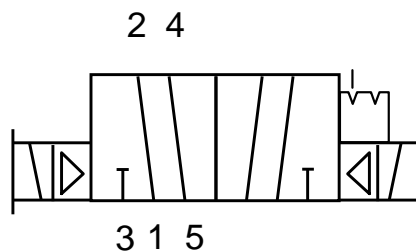
12



14

**2 position, 5 ported,
4 way, Single Solenoid
Air Pilot Actuated,
Spring Return**

12



14

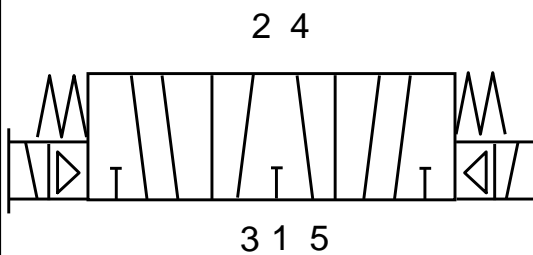
**2 position, 5 ported,
4 way, Double Solenoid
Air Pilot Actuated,
Detented**

Valves

Basic Symbology

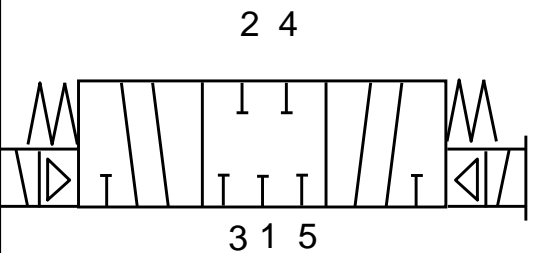
Function

12



14 **3 position, 5 ported,
4 way, Double Solenoid
Air Pilot Actuated,
Spring Centered,
5 Function**

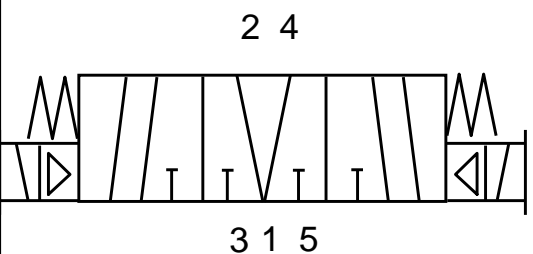
12



14

**3 position, 5 ported,
4 way, Single Solenoid
Air Pilot Actuated,
Spring Centered,
6 Function**

12



14

**3 position, 5 ported,
4 way, Single Solenoid
Air Pilot Actuated,
Spring Centered,
7 Function**

A.N.S.I. SYMBOLS

	SOLENOID	SOLENOID / AIR PILOT	AIR PILOT
TWO POSITION VALVES			
TWO POSITION VALVES			
THREE POSITION VALVES			
THREE POSITION VALVES			
THREE POSITION VALVES			

The circuit requirements determine the valve's function.

Knowing when to use each configuration is the responsibility of the designer and no one else. An educated choice is the first step towards safety, economy, and reliability.

REVIEW

Symbols

Valves

Flow Paths

2 Way

3 Way

4 Way 4 Ported

4 Way 5 Ported

Detent

3 Position

Solenoid

Mechanical

Air Pilot

Cylinders

Single Acting

Double Acting

Calculations

Area

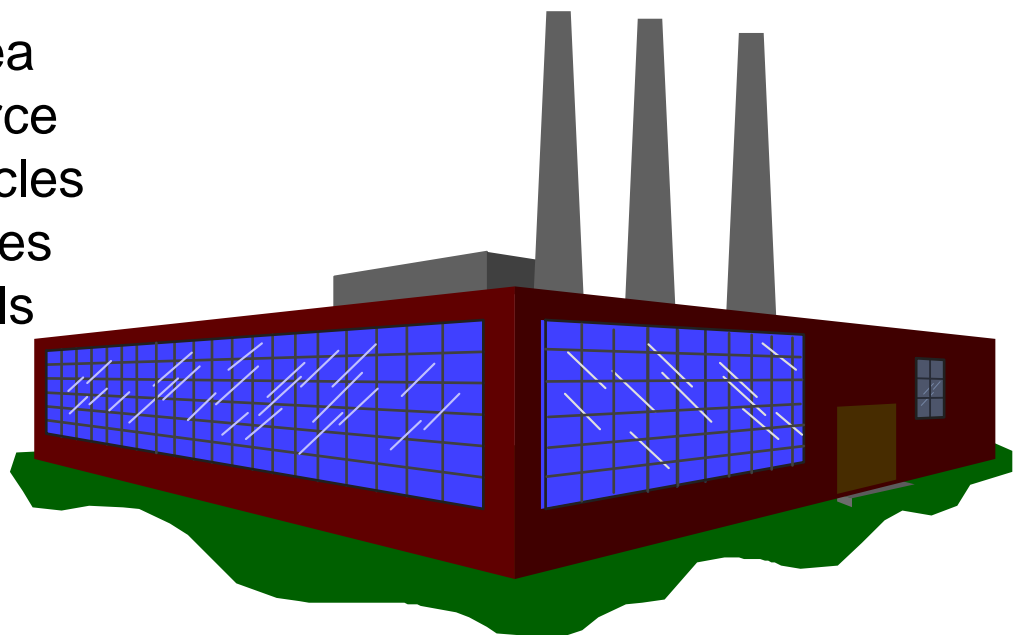
Force

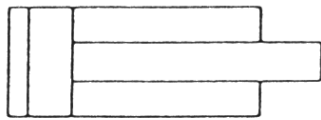
Circles

Needle Valves

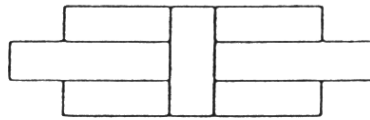
Flow Controls

Inertia

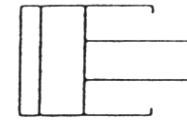




Double-Acting
Cylinder



Double-Acting Cylinder
with Double End Rod

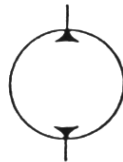


Single-Acting
Cylinder

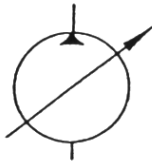
HYDRAULIC PUMPS



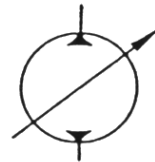
Fixed
Displ.
1-Rotate



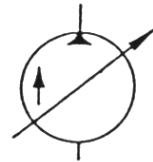
Fixed
Displ.
Bi-Rotate



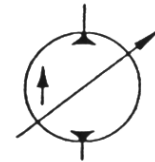
Variable
Displ.
1-Rotate



Variable
Displ.
Over Cntr.

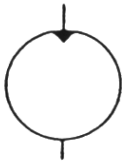


Variable
Displ., Pres.
Compensator

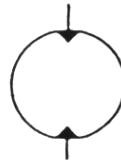


Over
Center
w/Comp.

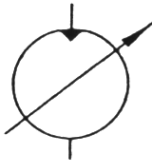
HYDRAULIC & ELECTRIC MOTORS



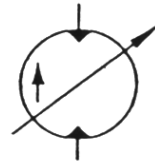
Fixed
Displ.
1-Rotate



Fixed
Displ.
Bi-Rotate



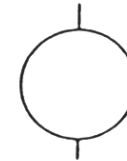
Variable
Displ.
1-Rotate



Over
Center
w/Comp.

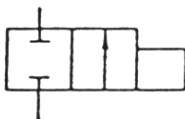


Partial
Revolution
Oscillator

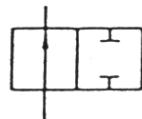


Electric
Motor

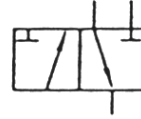
2-WAY & 3-WAY VALVES



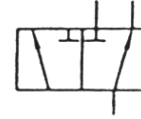
2-Way, N.C.
2-Position



2-Way, N.O.
2-Position



3-Way, Direc-
tional Control



3-Way
Selector

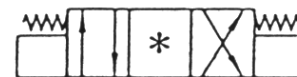
4-WAY VALVES



2-Position
Single Actuator



2-Position
Double Actuator



3-Position
Spring Centered

*SPOOL CENTERS FOR 3-POSITION VALVES



Closed
Center



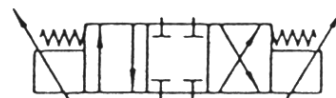
Tandem
Center



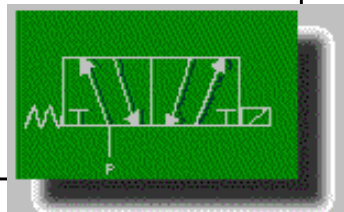
Float
Center



Open
Center



Proportional
Solenoid Valve



Valves

More Symbols

