

ALLENDALE ROBOTICS

FRC TEAM 4003 - TRISONICS

PNEUMATICS (BASICS)



Allendale
Robotics



FIRST
LEGO
LEAGUE JR.

K - 3rd
Grade

FIRST
LEGO
LEAGUE

4th - 5th
Grade

VEX 
CHALLENGE

6th
Grade

FIRST
TECH
CHALLENGE

7th - 8th
Grade

FIRST
ROBOTICS
COMPETITION

9th - 12th
Grade

AGENDA

- What is a Pneumatic System
- Pneumatic System Components
- How Valves and Cylinders work
- System Demonstration
- Q&A (Time Remaining)

WHAT ARE PNEUMATICS

- Pneumatics use **pressurized gas** to effect a mechanical motion
- Uses the power of Compressed air to create force
- Typically gases such as air, Nitrogen, CO₂
- In FRC air is used
- Typically used for linear motion



HYDRAULICS VS. PNEUMATICS (IN INDUSTRY)

Hydraulics

- Incompressible working fluid
- Typical Fluids – oils, water
- 1000 to 5000psi working pressure
- Good at transmitting and multiplying force
- Not used in FIRST



Pneumatics

- Compressible working fluid
- Typical fluids-Air, Nitrogen
- 100 to 500 psi working pressure
- Good at transmitting power
- Can store energy
- Used in FIRST

WHAT ARE NOT PNEUMATICS

Closed-loop systems:

- Pneumatic tires
- Inflatable game pieces
- Linear dampers (aka “gas shocks”)



APPLICATIONS FOR PNEUMATICS

- Air brakes
- Air tools
- Linear Motion
- Rotary Motion
- Vacuum

- And Robotics



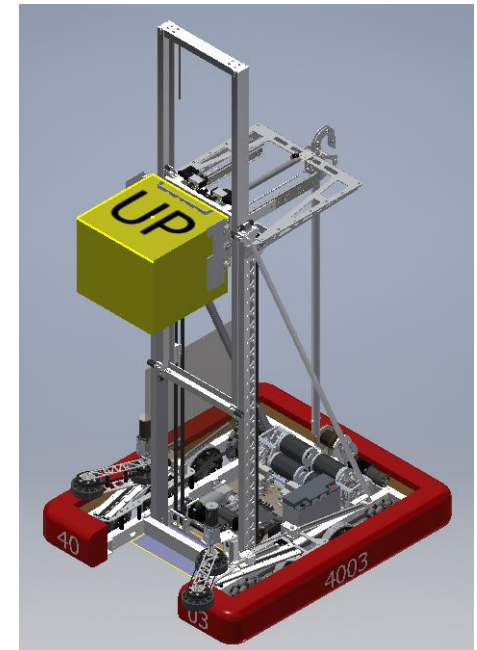
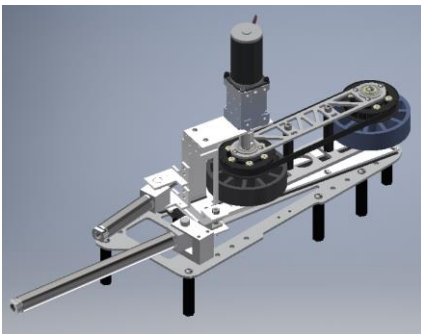
Pneumatic Air
Cylinders



Pneumatic Rotary
Actuators & Grippers



wiseGEEK



STRENGTHS & WEAKNESSES

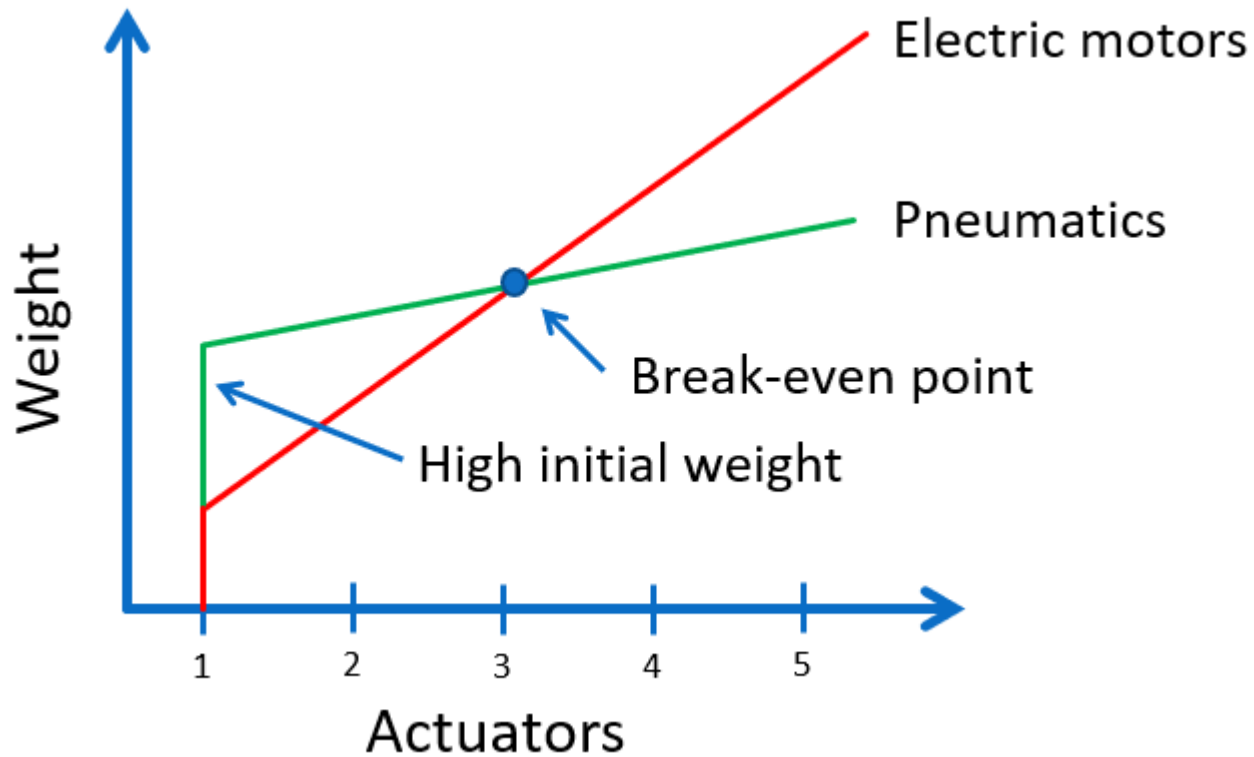
Strengths

- Reliability
- Consistency
- Can be very fast
- Simple
- No damage if stalled
- Linear motion
- Adjustable force and speed
- Good stall behavior
 - (Can maintain high force, even with no motion)
- Easy to configure
- Low marginal weight

Weaknesses

- High initial weight
- Severely limited available positions
- Difficult to produce rotary motion
- Capacity limits
- Complex troubleshooting
- Vibration from Compressor
- Excessive use can lead to shortage

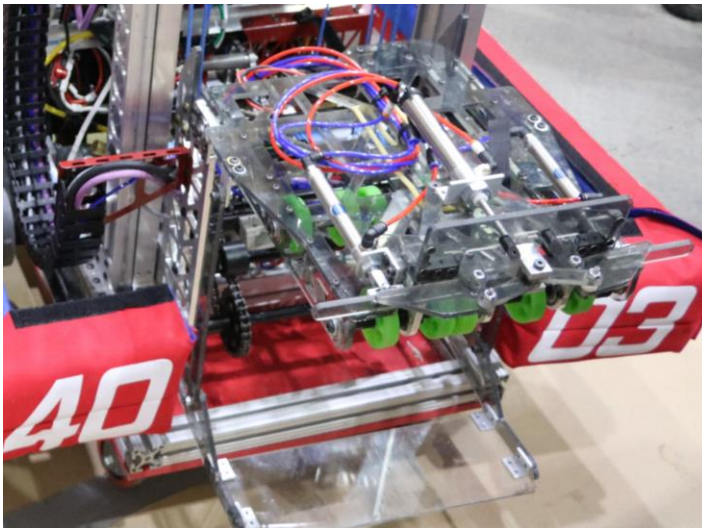
WHAT IS MARGINAL WEIGHT?



WHEN TO USE ...

Pneumatics

- To repeatedly move something full stroke
- Linear motion
- Mechanism rotation of less than 135 dg.
- No damage if stalled or jammed



Motors

- Continuous rotary motion
- Multiple stop positions
- May require sensor feedback



COMPONENTS OF A ROBOTS PNEUMATIC SYSTEM

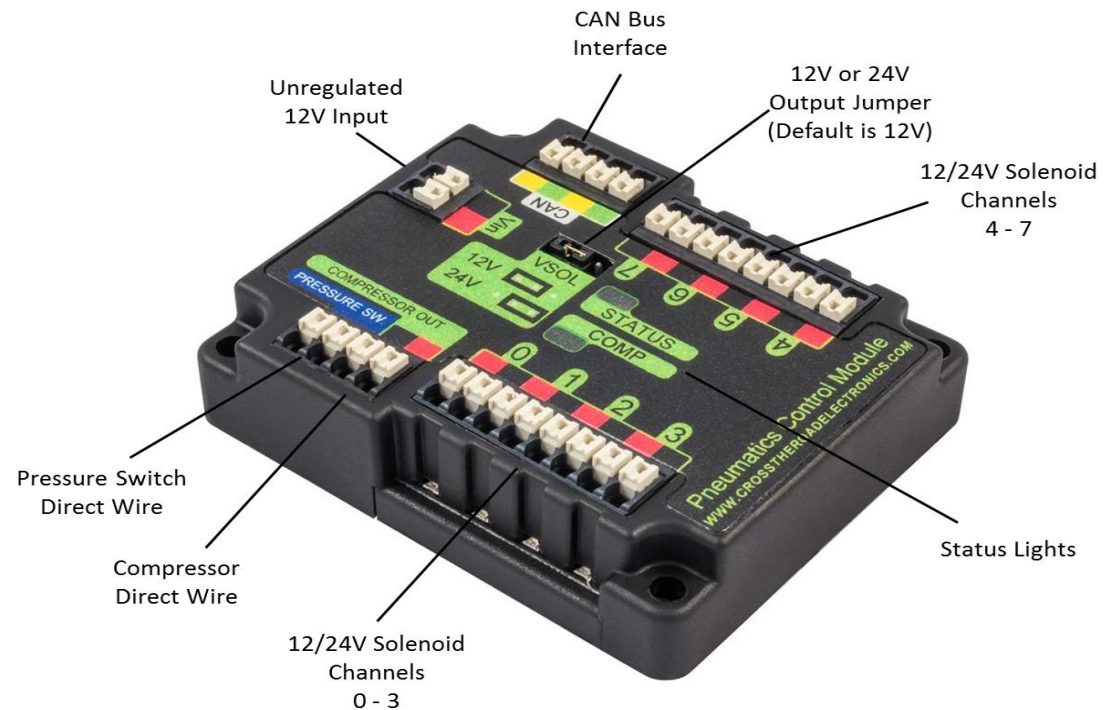
- Control Module
- Compressor
- Storage Tanks
- Relief Valve
- Gauges
- Regulators
- Fittings
- Flow Controls
- Tubing
- Valves
- Etc.



PNEUMATIC SYSTEM COMPONENTS

Pneumatic Control Module (PCM)

- Supplies power to the solenoid valves to shift them
- Monitors the Pressure Switch value and controls the air compressor
- Selectable power for valves (12VDC or 24VDC)



PNEUMATIC SYSTEM COMPONENTS

Air Compressor

- Intakes air and outputs compressed air
- For FIRST this compressor supplies air to the system up to 120 psi
- Can get very hot during use
- Vibrates during use



PNEUMATIC SYSTEM COMPONENTS

Accumulator

- Stores air for cylinders and other pneumatic components to use
- For FIRST air tanks are limited to storing 120psi
- Can be aluminum or plastic
- *Never used a damaged air tank*



PNEUMATIC SYSTEM COMPONENTS

Pressure Relief Valve (part of the system safety)

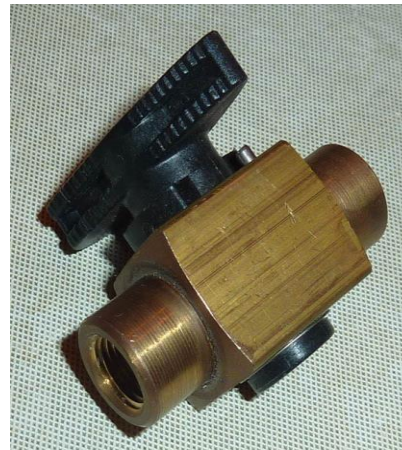
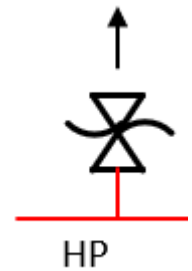
- First item connected to the compressor
- The relief valve opens at a predetermined set pressure and releases air (120 psi for FIRST)
- This is to protect pressure vessels and other equipment from pressures that exceed their design limits
- Required for safety



PNEUMATIC SYSTEM COMPONENTS

Manual Relief (Dump) Valve

- Used to relieve all of the air pressure from a system
- Basically “dumps” the air



PNEUMATIC SYSTEM COMPONENTS

Air Compressor

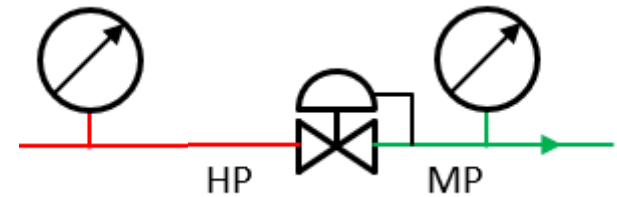
- This switch is normally closed
- Opens at 115 PSI and closes 95 PSI
- When the switch is closed (at 95 psi or below) the compressor is turned on
- When the switch opens (at 115 psi) the compressor turns off
- This allows you to save battery power
- Wires into the Pressure Switch terminal on the PCM



PNEUMATIC SYSTEM COMPONENTS

Pressure Gauge

- Displays pressure on the pneumatic system
- Most have 1 on High Pressure and 1 on Low/Medium Pressure



Pressure Relieving Regulator

- Takes storage pressure and regulates it to a lower working pressure
- For FIRST regulators must have a maximum setting of 60 psi

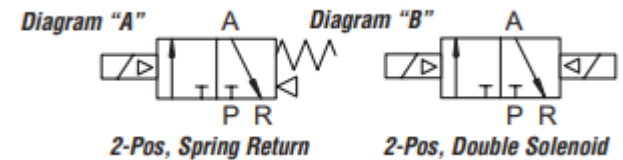


PNEUMATIC SYSTEM COMPONENTS

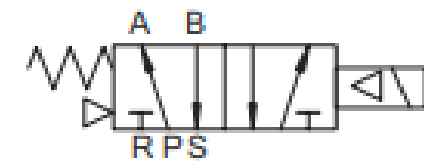
Solenoid Valves

- Diverts input air to different outputs
- A supplied voltage causes the valve to move and divert air in a different direction
- Many different types of solenoids

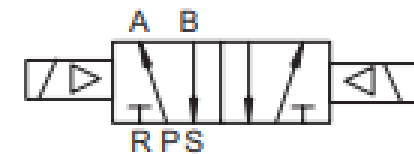
3-port (3-way) spool valves



5-port (4-way) spool valves



2-Pos, Spring Return

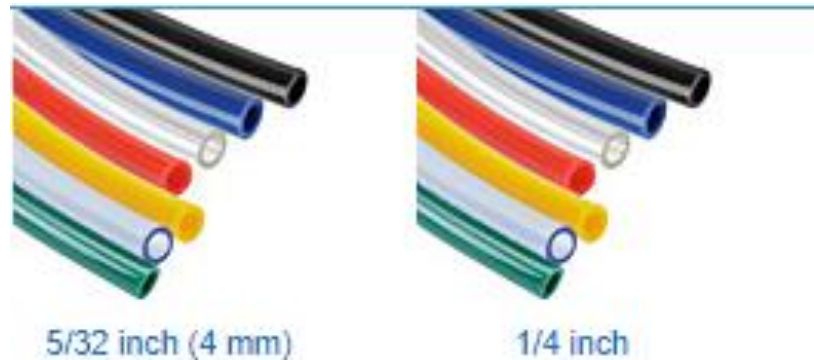


2-Pos, Double Solenoid

PNEUMATIC SYSTEM COMPONENTS

Pneumatic Tubing

- Used to transfer air from one pneumatic component to another
- Comes in different sizes and durometers depending on the desired stiffness
- Most common tubing in FIRST is $\frac{1}{4}$ inch Polyurethane
- Also use $\frac{5}{32}$ " for small and short stroke cylinders



PNEUMATIC SYSTEM COMPONENTS

Fittings

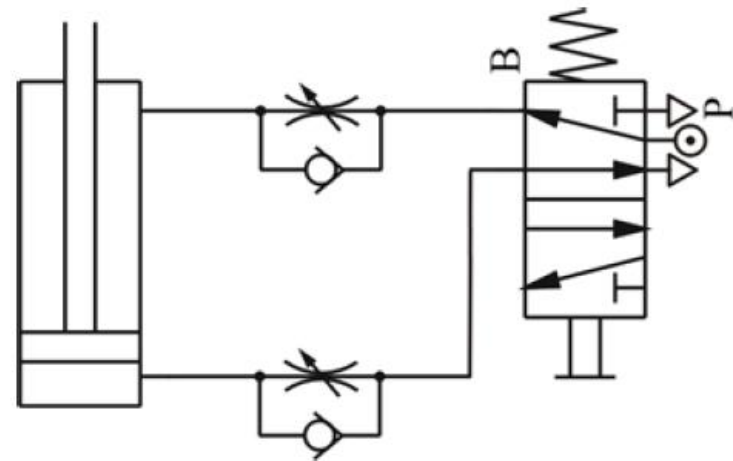
- Used along with tubing to connect pneumatic components
- Most commonly used fitting type in FIRST is push-to-connect
- Common fittings are shown on top right
- Use Teflon tape to seal fitting but do not overwrap



PNEUMATIC SYSTEM COMPONENTS

Flow Control Fittings

- Controls the flowrate of air to slow down a cylinders extend or retract
- Flow controls are directional meaning they only work hooked up a certain way
- One direction restricts airflow completely and the other allows air to pass through
- Should always flow control the exhaust of a cylinder not the inlet
- Higher pressure (psi) \neq faster movements!!!
- Used to slow the flow of air



Elbow Meter-in
NITRA Flow Control Valves



Elbow Meter-out
NITRA Flow Control Valves

PNEUMATIC SYSTEM COMPONENTS

Air Cylinders

- Uses compressed air to move a piston with a rod
- Comes in many different sizes depending on the required force and stroke length
- Controlled by solenoid valves and the PCM
- Bimba is a common supplier of air cylinders for FIRST (donates cylinders to all teams but limited sizes)



Single-Acting / Spring Return



Double-Acting

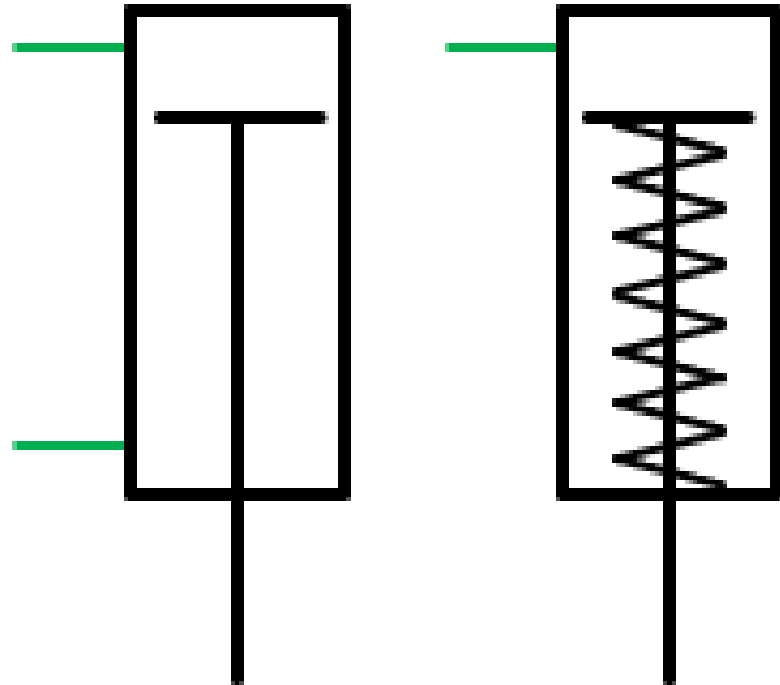


Double-Acting with Magnetic Piston

PNEUMATIC SYSTEM COMPONENTS

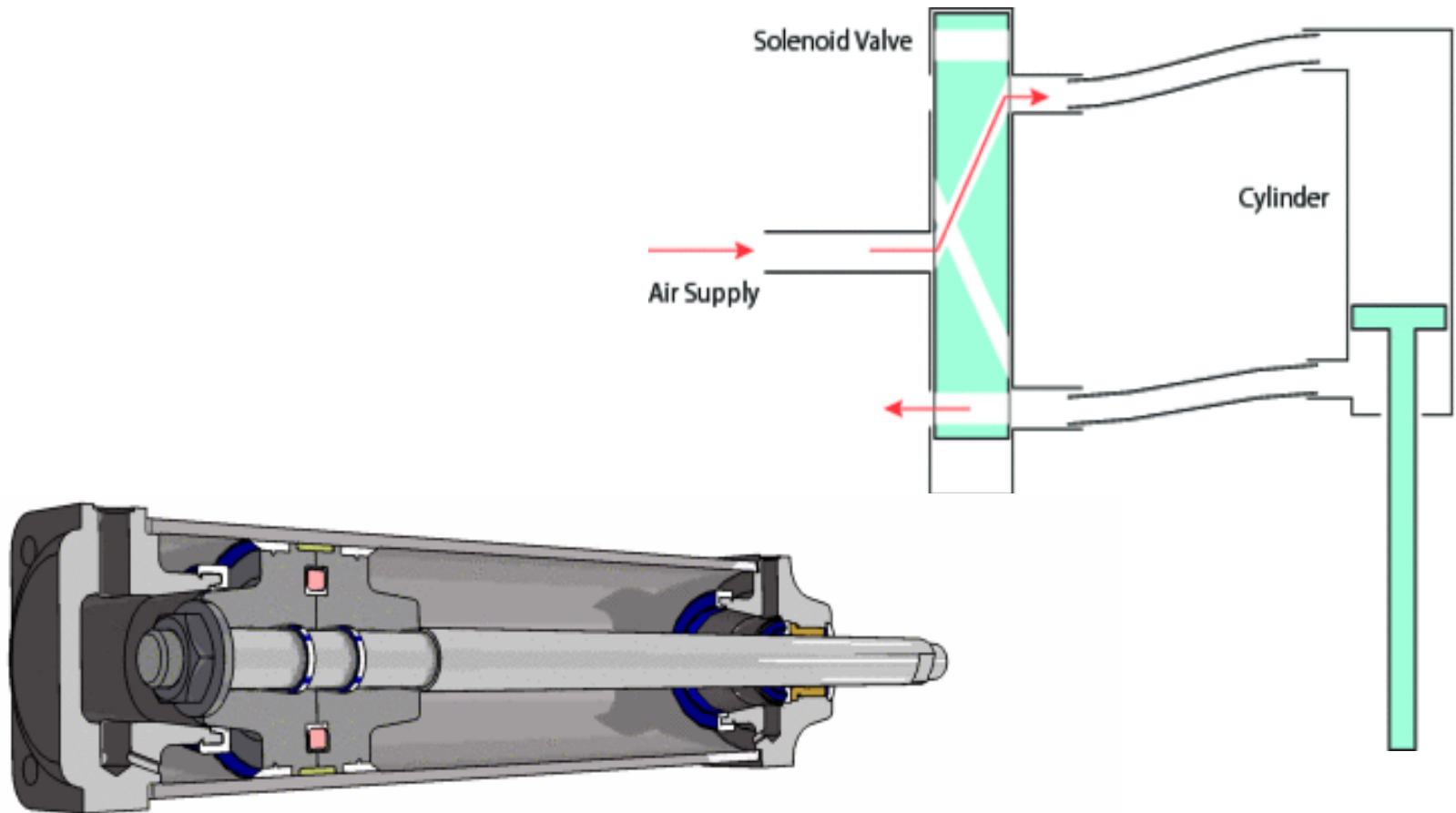
Air cylinder Types

- Spring Acting (Spring Return)
- Double Acting



HOW IT WORKS

Air Flow through Valve and Cylinder

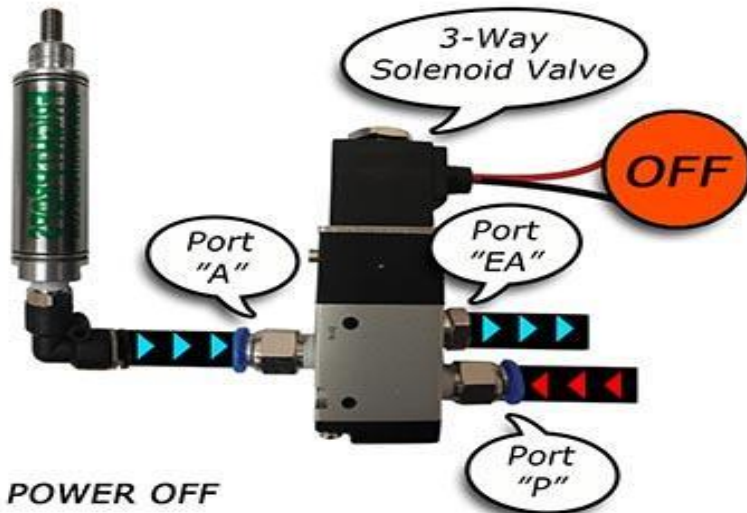


HOW IT WORKS

3-Port, 3-Way Solenoid with a Spring Return Cylinder

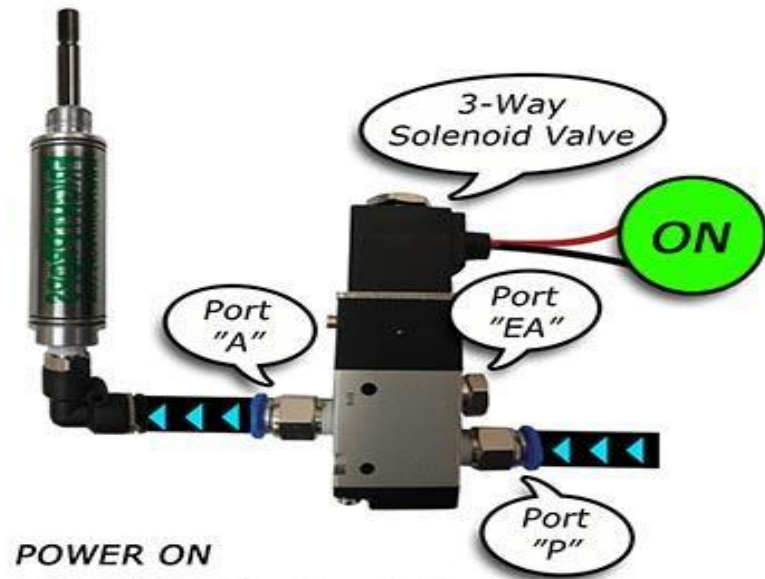


3-WAY SOLENOID VALVE OPERATION



POWER OFF

Air is not allowed to flow in from the compressor "P". Air flows back from the device (such as a cylinder) through port "A" and out through the exhaust port "EA".



POWER ON

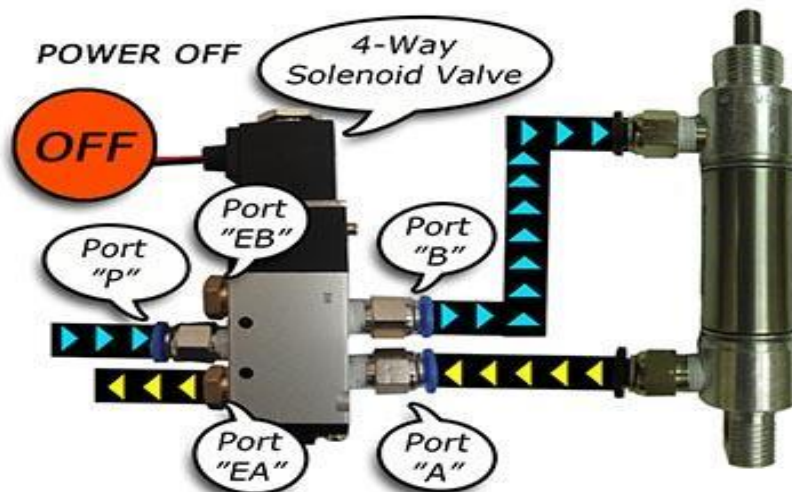
Air is allowed to flow in from the compressor "P". Air flows into the device (such as a cylinder) through port "A". Air is not allowed out through the exhaust port "EA".

HOW IT WORKS

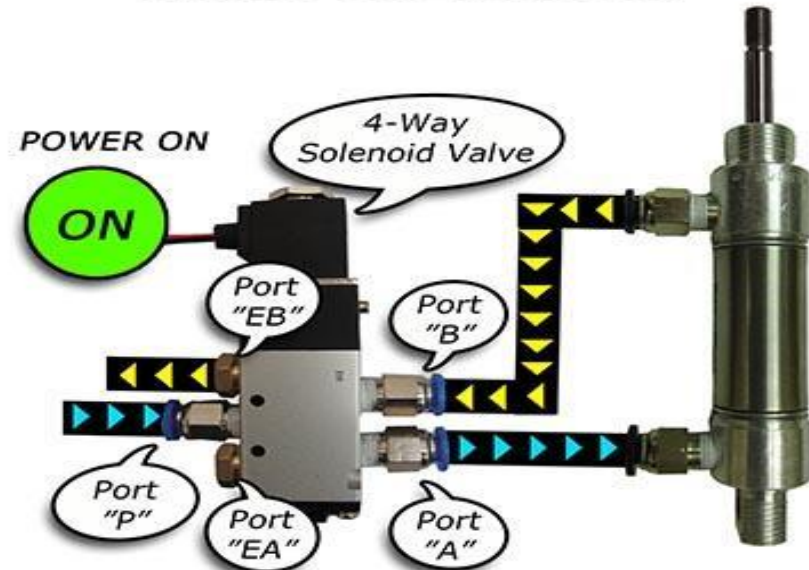
5-Port, 4-Way Solenoid with a Double Acting Cylinder



4-WAY SOLENOID VALVE OPERATION

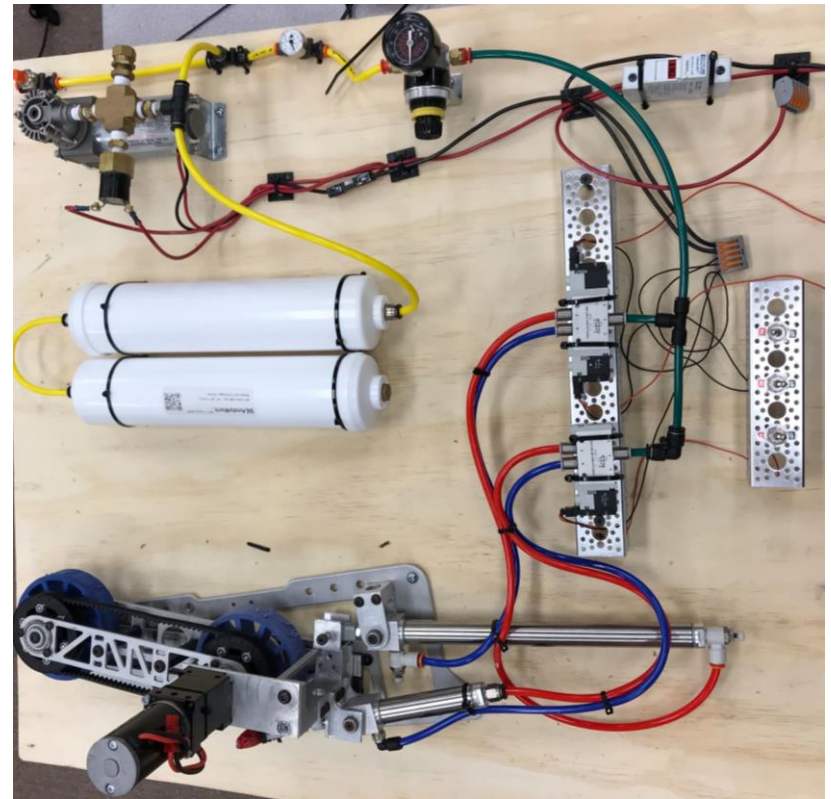
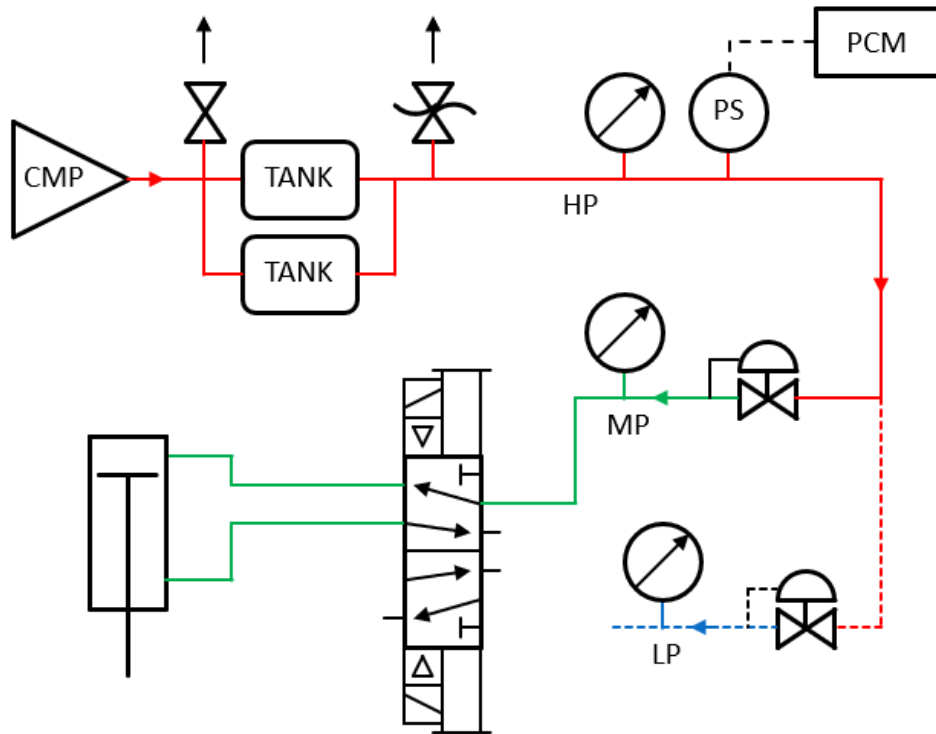


Air flows in from the compressor "P" and out through "B". Air flows back from the device (such as a cylinder) through port "A" and out through the exhaust port "EA".



Air flows in from the compressor "P" and out through "A". Air flows back from the device (such as a cylinder) through port "B" and out through the exhaust port "EB".

PUTTING THE SYSTEM TOGETHER



Q&A



Thank You!

