Training L2

Pneumatics

Objectives

Understand:

- ❑ To understand the pneumatic components used on a FIRST robot
- ❑ To understand the required FIRST pneumatic component configuration and electrical system
- ❑ To understand pneumatic assembly techniques

Note: References for this training is listed in the mechanical handbook

Safety Considerations

Safety glasses are required when working on mechanical systems

Electrical to Mechanical Energy Conversion

Energy Conversion:

From the “Electricity Training Module” we know that we can convert electrical energy to mechanical energy via a Solenoid or a Motor (magnetic’s).

In a “Pneumatic Air System” electrical energy is converted to mechanical potential energy.

Pneumatics Process:

We use a motor to run piston in a “Compressor” to compress air, then use an electro-magnet to move a gate in a “Solenoid Valve” to let the compressed air exit and push a rod in a cylinder.

Definitions

Pneumatics – uses compressible gas, typical operating pressure range 20 to 100 psi

Applications: Machinery, robots - claws, lifters, pushers, levers, shifters, etc

Hydraulics – uses non-compressible fluids like oil, typical operating ranges 2,000 to 4,000 psi

Applications: Construction equipment (cylinders on earth excavation equipment), amusement rides(cylinders, motors),

Why Use Pneumatics?

pros:

- Power density – a lot of pushing force in small package
- Easy to add more valves and cylinders
- Cylinders can be stalled indefinitely without damage
- More rugged: Resistant to impacts
- Simple mounting compared to motors
- Cylinders are much lighter than motors
- Simple positioning sensing with end of travel reed switches.
- Simple speed control with flow control
- Low Weight? – Needs to be compared to the components needed by a motor

cons:

- Leaks – Good assembly improves this
- Limited high pressure supply – only two air tanks allowed, small compressor
- Initial weight? Needs to be compared to the components needed by a motor
- Cylinder rods can only be extended or retracted
- Cylinder rod can be easily damaged
- Requires fine tuning for optimum use(air flow controls)

Basic FIRST Pneumatic System

Air Tank

Pressure Regulator
120psi => 60psi

Solenoid Valve

Cylinder

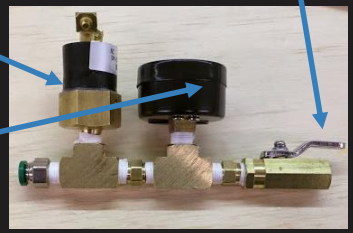
Compressor

Pressure Relief

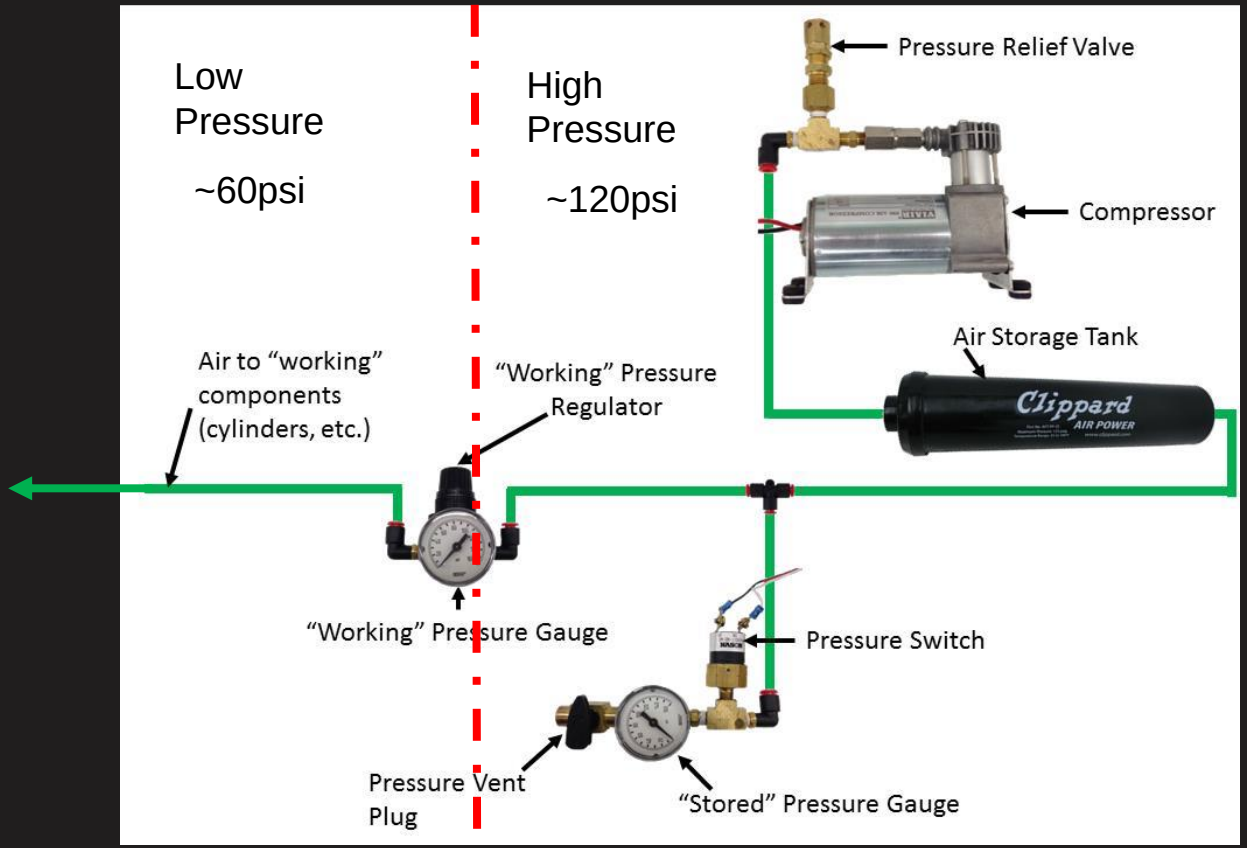
Purge Vent

Pressure switch
Open ~ 115psi
Close ~ 95psi

Pressure Gauge

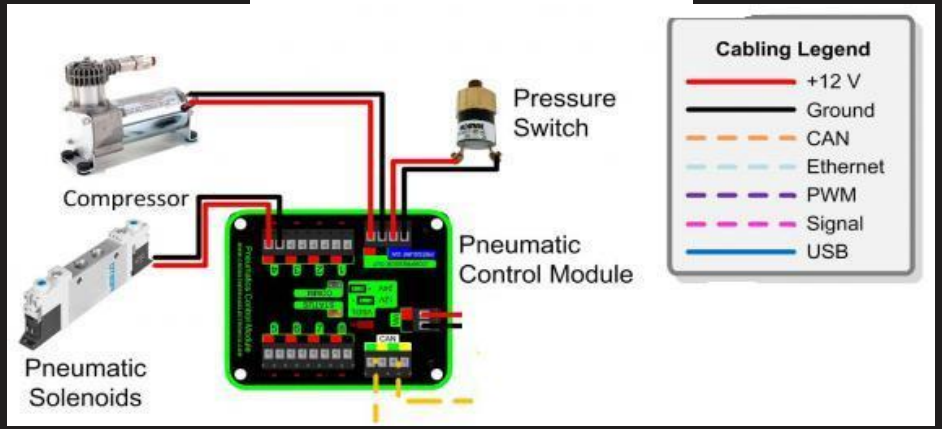


High Pressure – Low Pressure(Working)



Pneumatics – Control Wiring

Pneumatic Control Module (PCM)



High Pressure Components

Compressor:
- Converts electrical energy to potential energy
- Develops 120 Pounds per Square Inch(psi) air pressure

Tips:
- May be damaged if wired backwards
- Compressor is a reciprocating device that vibrates – use the rubber isolation mounts to prevent vibration through the robot
- Compressor gets hot when run for extended periods – use a small fan to cool

High Pressure Components

Pressure Relief Valve:

- Should vents at 120 psi for safety
- Is required to be installed on the output of the compressor
- The pressure relief valve needs to be calibrated

Tips:

- Secure all connection points with wrenches
- Use PTFE tape (Teflon tape) on all threaded connections
- PTFE tape should be wrapped around the threads in a clockwise direction

High Pressure Components

Pressure switch:

- Normally closed switch that opens at approximately 115psi and closes when the pressure drops below 95psi

Plug Valve (manual release valve):

- Install on high pressure side
- Must be able to release all pressure in system
- Must be easily accessed and labeled on your robot

High Pressure Components

Air Volume Tank:

- Other names – accumulator, reservoir, air tank
- Stores pressure to activate actuators
- Tank volume (35in^3)

Tips:

- Air tank available in plastic with quick disconnects
- For threaded air tanks take care when tightening fitting into the plastic neck

Air Pressure Gauge:

- Provide readout of pressure in line
- Place one on high pressure side and one on working pressure side (can attach directly to the primary pressure regulator)

Low Pressure Components

Primary Pressure Regulator:

- Restricts working pressure to 60psi max on output side of regulator

Tips:

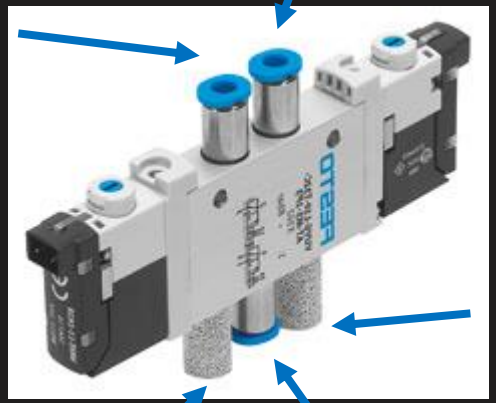
- Make sure arrow points in direction of air flow
- Make pressure adjustment accessible and pressure gauge visible

Solenoid valves:

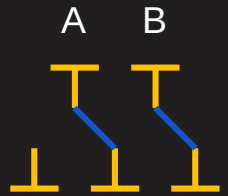
- Switches direction of air flow to drive cylinder motion
- Valves may be single solenoid (spring return) or double solenoid (Extend – Retract)
- Can activate manually with blue buttons

Low Pressure Components

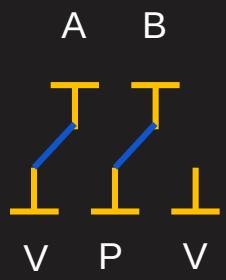
Solenoid Valve



State A
Sol A Active



State B
Sol B Active



Low Pressure Components

Cylinders (aka “Pistons”):

• Single or double acting

Single = spring-based return when vented

Double = air pressure drives both directions

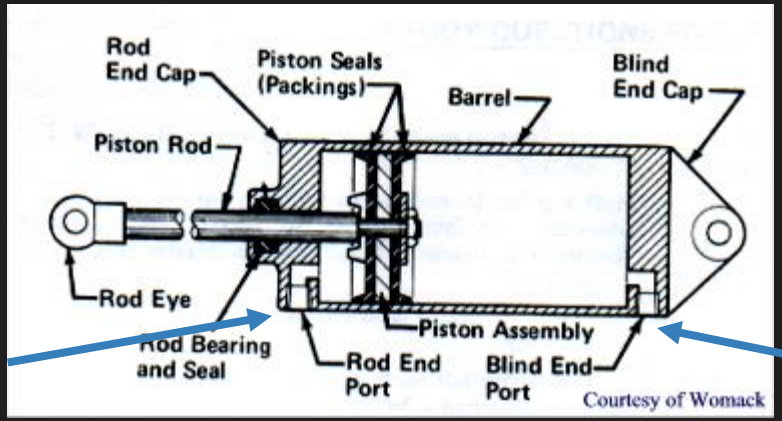
• Force = Pressure(psi) x Piston surface area(in^2)

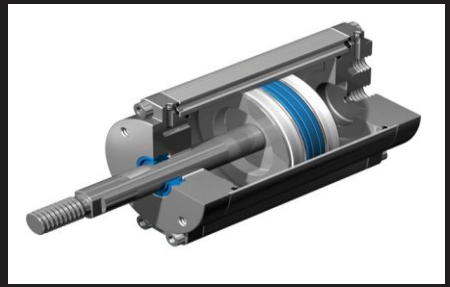
Tips:

• Retraction force is less than Extension force

• Be careful to ensure the piston rod cannot get bent

• Magnetic position sensing option with reed switches





Retract port

Extend port

Pneumatic Plumbing – Air Line

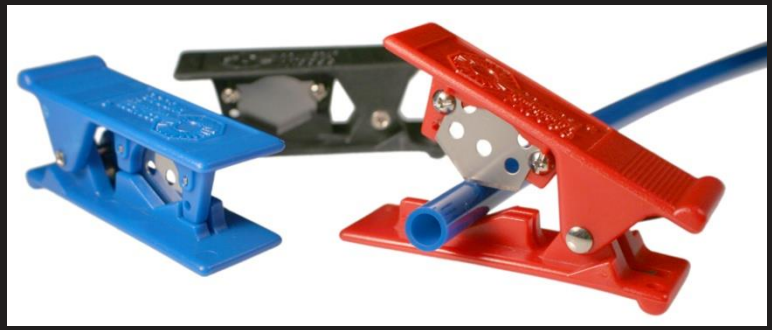
Air line

Cutting the air line:

• Use the proper tool – a hose cutting tool ensures a clean square cut without deforming the air line

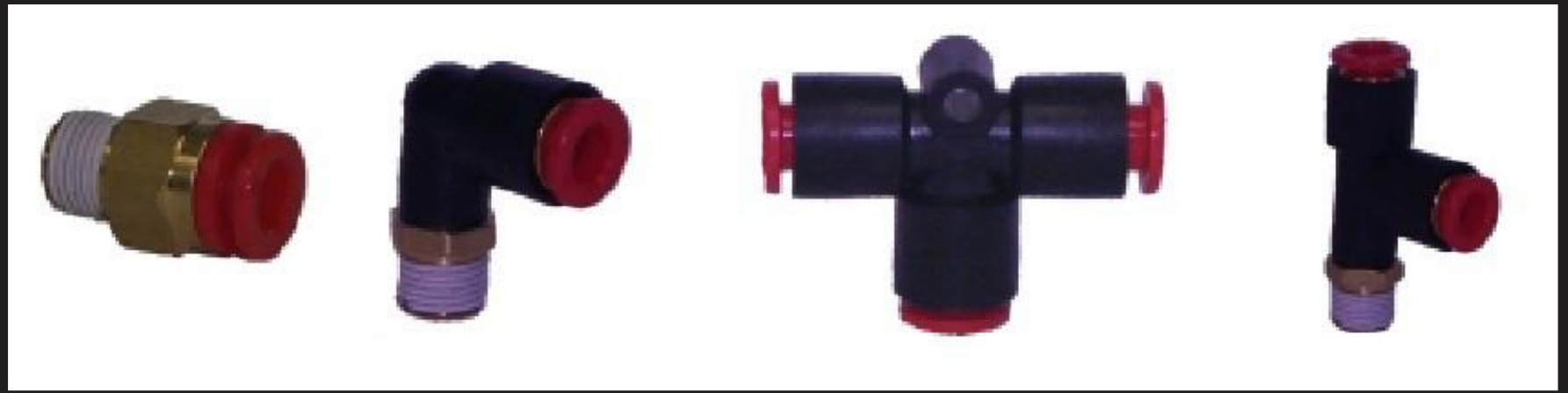
Tips:

• Using any other tool to cut the air line results in an angular cut because the air line is flattened. This is a major cause of leaks at the fitting



Pneumatic Plumbing – Tube Fittings

Pneumatic tube fittings are the “push-to-connect” style



Male Fitting

Male-Elbow Fitting

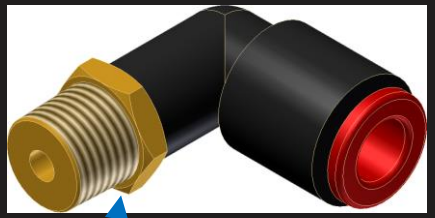
Tee Fitting

Male-Tee Fitting

Pneumatic Plumbing – Taping Pipe Fittings

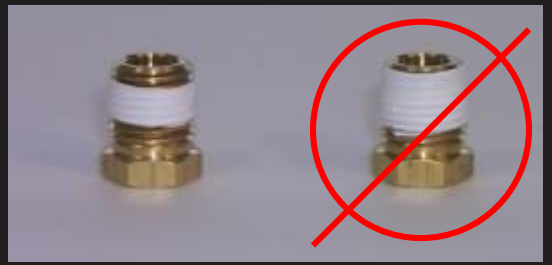
Add sealing tape to pipe fittings:

- Apply in a clockwise direction
- Leave the last two threads on pipe open
- Do not put to much tape on – more is not better



Pipe Fittings

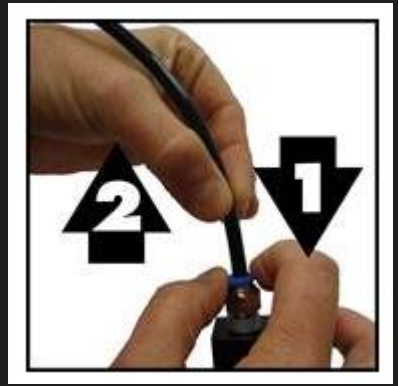
PTFE tape /
Teflon tape



Pneumatic Plumbing – Connecting Air Lines

To connect the air line, push the air line into the fitting while applying a slight turning motion. You will hear/feel a definite “click” as the air line seats past the O-ring against the tube stop - A little lubrication (soapy water solution) on the air line will reduce the effort required.

To remove the air line push the release ring and the air tube down firmly on the connector, pull the tubing



Pneumatic Plumbing – Flow Control

Flow controls are special fittings that allow you to meter the air flow

Tips:

- Always meter out
- Place on solenoid valve vent ports

Flow Adjustment

Safety

- Purge air system before working on robot - Pressurized air has a lot of potential energy
- When the robot is powered up and enabled stay clear of an mechanisms that have cylinders

Best Practices

- Read the manual every year for any changes
- For cylinders the push force is greater than the retract force
- Keep number of cylinders and volumetric demands in mind when designing the robot – compressor and air tanks can only keep up with a finite demand
- Design mechanisms such that the piston rod is protected from being bent
- Prevent leaks by:
  - ✓ Cut the air line with the correct tool
  - ✓ Tape pipe threads correctly

Troubleshooting

Air Leaks are the main contributor to poor performance of the pneumatic system –

To detect leaks:

- Put soapy water on suspect connections and watch for bubbling
- In a high noise environment the use of a stethoscope is very effective in hearing air leaks

Stethoscope

Revisions

160612 – RJV – updated to Team 2228 format
151018 – RJV, review update
151012 - Original