



***FIRST® Robotics Competition***

# 2011 *FIRST* Robotics Competition Pneumatics Manual

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The 2011 *FIRST* Robotics Competition (FRC) pneumatic components are outlined in this document. It is being provided as a courtesy, and therefore does not supersede any information or rules provided in the 2011 *FIRST* Robotics Competition Manual. For official questions, please go to the *FIRST* Forums at <http://forums.usfirst.org>.

## Pneumatic Advantages

Fluid power technology encompasses both hydraulics and pneumatics. Hydraulic applications use pressurized fluids, mostly oil, while pneumatic applications use pressurized gases, mostly air. Mobile construction equipment uses a hydraulic pump mounted on the engine. The outlet of the pump is plumbed to a set of valves. Each valve is then plumbed to a cylinder. This allows you to distribute power from the engine all around the equipment. The same is true for a FIRST robot. Once you install the compressor operating one valve and cylinder combination, you've done most of the work. To add an additional valve and cylinder combination, you just tee into the pressure line and add in the additional circuit.

- **Weight** - Compare the weight of several valves and cylinders to that of the motors, gears, belts, and chains used on some lift mechanisms and you will find the weight comparable, if not much lighter.
- **Simple to Design** - Using pneumatics is much easier than building a motor; gear, chain and sprocket lift mechanism. Once you have reviewed the layout in Appendix A, you will find it very easy to build a circuit.
- **Adjustable Force** - To adjust the force of the cylinder, all you have to do is adjust the regulator in front of it. The force is equal to the area of the cylinder piston times the pressure. Remember that the valves need at a minimum of 15 – 30 psi to work properly.
- **Durable** - All of us have problems burning up motors from time to time. You can stall an air cylinder against a load indefinitely and turn off the compressor. The materials provided are industrial grade products.
- **Strong** - If you look at the force table in Appendix B, you have the option of using a small 0.75" bore cylinder at 20psi, a medium cylinder at 1.5" , or a large 2" cylinder. By varying the pressure to the cylinders, you can produce a force from 9 pounds up to 180 pounds, depending on your needs.
- **Custom Cylinders and a Rotary Actuator** - You can order the cylinder you need for the job, listed in Appendix C, and get them in a few days via regular UPS.
- **Last Minute Additions** - At the last minute, you can add a cylinder and valve very quickly.

## Pneumatic Components

This year we have worked very hard to make it easier for you to use pneumatics on your robot. We have also chosen components that match each other. This year, almost all the major components have been manufactured exclusively for this year's competition.

### Compressor



This year, we are providing a new, lighter compressor to **rookie teams**. For years, we have provided the same compressor provided by **Gardner Denver Thomas** to teams. That compressor is still legal for use in 2011. The new compressor is a **Viair 090C Air Compressor**. It will put out approximately 120psi before the relief valve opens. Because the compressor can produce a significant amount of vibration, we recommend that you use vibration isolation mounts that come preinstalled on the compressor. In order for these to isolate the vibration, they need to be mounted to a stiff piece of material, such as a 1/4" aluminum plate. A relay must be used to control the power to the compressor using a 20amp breaker, not a fuse. Ensure that the relay is programmed to provide "forward" power only to the compressor. Do not reverse the compressor!

### Pressure Relief Valve



**Norgren** has supplied the 120 PSI pressure relief valve. It is shown installed on the compressor in the compressor photo, but is shipped loose to teams. It is up to the teams to properly install the relief valve as shown prior to using the air compressor. This is a safety measure meant to ensure proper operation of the pneumatic system.

**Warning: The compressor can get quite hot during extended operation.**

### Pressure Switch



We have included a pressure switch manufactured by **Nason**. This switch is normally closed. The switches will open at approximately 115 psi and will not close again until the pressure drops to approximately 95 psi. This will allow you to turn off the compressor once you are up to 115psi, saving power in the battery. It must be wired directly to a digital input and ground port on the Digital Sidecar. No specific GPIO port is designated for the pressure switch. The cRIO must be programmed to react to the GPIO port that is connected to the pressure switch. The cRIO will activate the designated Spike Relay to turn the compressor "on" and "off". There is no default program in the cRIO to control the compressor power. Do not put the pressure switch in series with the power supply to the compressor.

### Air Tank



The kit includes one 32 in<sup>3</sup> tank from **Clippard Instruments**. It should be mounted right after the compressor, before the **Norgren** primary pressure regulator.

## Regulators



**Norgren** has donated the primary pressure regulator. This is a relieving regulator. This means that they will limit the downstream system pressure and can relieve excess pressure if something in the downstream system causes the pressure to increase. Assume that you extend the cylinder or the apparatus the cylinder is attached to against a wall. This regulator has a maximum output pressure of 60 psi and must be placed inline right after the storage tank to limit the pressure to all working circuits to 60 psi. The pressure is adjustable and may be reduced for use on your robot at your discretion. On the top of the regulator, you will note that one port extends out a little bit more than the others and has an arrow on it. This arrow is to denote the outlet of the regulator. The opposite port is the inlet. A pressure gauge may be placed in either of the other ports if desired, and you will have to plug the other gauge port with one of the enclosed hex plugs.



**Monnier** has donated the secondary regulator, which has a yellow ring around it. This is also a relieving regulator. Its purpose is to allow you to have a reduced pressure leg, if needed. There is an arrow denoting the direction of flow to help you identify the inlet and outlet ports. A gauge may be placed in either of the other ports and you will have to plug the other gauge port with the plugs included in the Monnier bag.

## Electric Valves



**FESTO** has also supplied one double solenoid valve. Instructions in the package explain how to wire the valve. The pneumatic tube fittings are the “push to connect” type so all you have to do is push in the tubing and then pull back slightly to ensure a snug fit. The valve is a 24V valve and must be connected to a Solenoid Breakout board that is powered from the 24V supply on the Power Distribution Board.



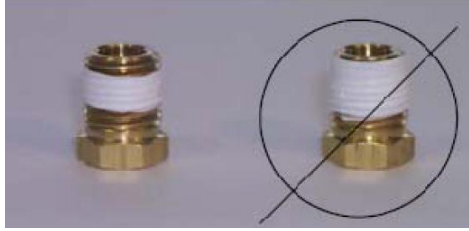
### Plug Valve

**Parker Hannifin** donated the plug valve. This valve can be used to release all of the air in the system. This valve must be installed in a location that will release all system pressure when opened. The valve should be placed in an easy-to-get-to location on the robot.

## Brass fittings



**Parker Hannifin** donated all the brass fittings. These are useful where you want to plug a port or plumb from one size port to another. It is important to note that all male threads require Teflon tape to seal properly. To install, wrap the tape around the fitting, leaving the first two threads free of tape. The best method of wrapping tape is to roll the tape in a direction to match the threads. The recommendation to leave the first two threads open is to avoid tape coming loose from the first thread that can block one of the valves.



## Tubing

**Freelin-Wade** has donated the tubing this year. The tubing is 0.25" outside diameter tubing.

## Custom Bimba Cylinders



You will be able to order custom cylinders for your robot again this year. You have a choice of 3/4" bore (diameter), 1 1/16" bore, 1-1/2" bore and 2" bore. You can order the amount of stroke (length of extension) you require. This flexibility will significantly increase your ability to design pneumatics into robot. Most of the bore and stroke options are in stock and **Bimba** is ready to ship directly to your team. This year all the actuators can be ordered with a magnetic piston and two magnetically operated reed switches. These switches will "close" when the piston is underneath them. It is not recommended to try to sense a mid-stroke position with these switches.

## Rotary Actuator



Bimba is again offering you a rotary actuator. This is ideal for grippers, gear shifters, brakes etc. If you choose to use one of these you will only be allowed to order 2 free cylinders instead of three. As with the cylinders, you may order a magnetic piston, which will activate the switches when the piston is directly underneath the switch. The rotational tolerance of the unit is 90 degrees -0 degrees +15 degrees. Exact angle adjustment should be made with external stops. The theoretical torque of this actuator is 0.166 inch-lbs/PSI. Using the maximum allowed pressure of 60 psi the unit could develop a theoretical torque of almost 10 inch-lbs.

## Resources

There is a PowerPoint presentation on the PneumaticsFIRST website that contains great discussion on how to design your cylinders in order to get the proper height for a lift mechanism. That presentation can be found here:

<http://www.pneumaticsfirst.org>

WPI has saved presentations given on many topics by FRC mentors at The Championship Forums in the past. Presentations geared towards pneumatics can be found here:

<http://first.wpi.edu/FRC/frc-mechanical.html>

Appendix C describes the cylinders available to FRC teams as part of the Bimba donation. These items can be requested online. Please go to [www.bimba.com](http://www.bimba.com) and click on the FIRST link and follow the instructions. Quantities of no charge custom cylinders will be limited to 3 per team. Additional cylinders can also be purchased through a Bimba distributor. You can find a distributor in your area by going to:

<http://www.bimba.com/distrib/distrib.htm>

## Cylinder Length Example

Look at the drawing of the 1-1/2" bore cylinder in Appendix B. You will notice that the cylinder pivots about a pivot pin located in the rear of the cylinder. There is a dimension on the drawing from that pin to the back of the thread on the rod end. That dimension is "4.38 + Stroke". We will use this later.

Look at the drawing of the rod clevis. There is a locking nut shown on the drawing. If you look, there is a dimension of the width that is 0.25". The locking nut threads on the rod first and is used to keep the clevis in place. Lastly, look at the dimension 1.31" on the rod clevis. Therefore, if you thread the locking nut on the rod thread all the way to the bottom of the thread and then tighten the clevis against it, you can calculate the distance from the rear pin to the clevis pin. This is called the pin to pin distance.

Assume you want to move something 8 inches. You will need to order an 8" stroke cylinder.

To find the retracting pin-to-pin dimension, add the following lengths:

$$\begin{array}{r} \text{Base dimension} = 4.38'' \\ \text{Stroke} = 8.00'' \\ \text{Locking nut width} = 0.25'' \\ \text{Clevis dimension} = 1.31'' \\ \hline \text{Pin-to-Pin Retraction} = 13.94'' \end{array}$$

To find the extended pin-to-pin dimension, just add the stroke:

$$\begin{array}{r} \text{Pin-to-Pin retracted} = 13.94'' \\ \text{Stroke} = 8.00'' \\ \hline \text{Pin-to-Pin Extended} = 21.94'' \end{array}$$

Note: The retracted length may be somewhat longer by not tightening the clevis all the way to the end of the thread.

Many thanks to the following FRC Suppliers who provided pneumatic components for the 2011 Kit of Parts:

Bimba Manufacturing (<http://www.bimba.com>)  
Clippard Instrument Laboratory, Inc. (<http://www.clippard.com>)  
Festo Corporation (<http://www.festo.com>)  
Freelin-Wade (<http://www.freelin-wade.com>)  
HPE Automation (<http://www.hpeco.com>)  
Monnier, Inc. (<http://www.monnier.com>)  
Nason Corporation (<http://www.nasonptc.com>)  
Norgren (<http://www.norgren.com>)  
Parker Hannifin, Inc. (<http://www.parker.com>)