

# **2009 *FIRST* Robotics Pneumatics Manual**

The 2009 *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 2009 *FIRST* Robotics Competition Manual.

# The advantages of using pneumatics in 2009...

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 15-30psi 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. These are industrial grade products.
- **Strong** - If you look at the force table in Appendix B, you have the option of using a small 3/4" bore cylinder at 20psi, which will produce a force of around 9 pounds. If you use a 2" bore cylinder at 60psi, you can get 180 pounds of force. As you can see, your options are wide open.
- **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.

# Congratulations on receiving your 2009 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



We have the same compressor provided by **Gardner Denver Thomas** that we've had over the last few years. The compressor 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. They can be screwed directly into the feet of the compressor as shown on the following picture.

In order for these to isolate the vibration, they need to be mounted to a stiff piece of metal such as a 1/4" aluminum plate. The distance between the front feet is 3.5". The distance from the centerline of these feet to the rear foot is 5.19". A Spike Relay should 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!

**Norgren** has supplied the pressure relief valve. It is shown installed on the compressor.

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

## PRESSURE SWITCH



We have included a pressure switch manufactured by **Nason**. These switches are normally closed. The switches will open at approximately 115psi and will not close again until the pressure drops to approximately 95psi. This will allow you to turn off the compressor once you are up to 115psi, saving power in the battery. It should 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.

## TANKS



The kit includes two tanks from **Clippard Instruments**. They should be mounted right after the compressor, before the Norgren primary pressure regulator.

## REGULATORS



**Norgren** has donated the primary pressure regulator. These are relieving regulators. Assume that you extend the cylinder or the apparatus the cylinder is attached to against a wall. Then push against the wall with your robot. That would increase the pressure in the cylinder. The increased pressure will relieve out of the regulator and the cylinder will slowly retract. This regulator has a maximum output pressure of 60psi. This regulator must be placed in-line right after the tanks to limit the pressure to all working circuits to 60psi. It is adjustable and the outlet pressure may be reduced at your discretion. Look at the top of the regulator. You will note that one port extends out a little bit more than the others. It also has an arrow on it 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. You will have to plug the other gauge port with the enclosed hex plug.



**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. The gauge may be placed in either of the other ports. The Monnier bag provides you with plugs to put into the gauge ports.

## ELECTRIC VALVES



**FESTO** has also supplied one single solenoid valve. In order to wire the valves you must remove the white plastic pin protector that comes over the pins. Instructions in the package explain how to wire the valve. The fittings are the push to connect type so all you have to do is push in the tubing. The blue manual-override switch closes the valve for testing, but is spring-loaded and will not maintain the valve's position when released.

## PLUG VALVE



**Parker Hannifin** donated the plug valve. This valve can be used to release all the air in the system.

## 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. Wrap the tape around the fitting, leaving the first two threads free of tape. The recommendation exists because the threads are tapered, and the tape may come loose from the first thread or so and clog up one of your valves.



## TUBING



**Freelin-Wade** has donated the tubing this year.

## CUSTOM BIMBA CYLINDERS

You will again 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 you require. This will significantly increase your ability to design a great robot. Most of the bore and stroke models 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.

There is a PowerPoint presentation on [www.pneumaticsfirst.org](http://www.pneumaticsfirst.org) that contains some great discussions on how to design your cylinders in order to get the proper height for a lift mechanism.

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>

## Calculating the retracted/extended length of a cylinder...

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, do the following:

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

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

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

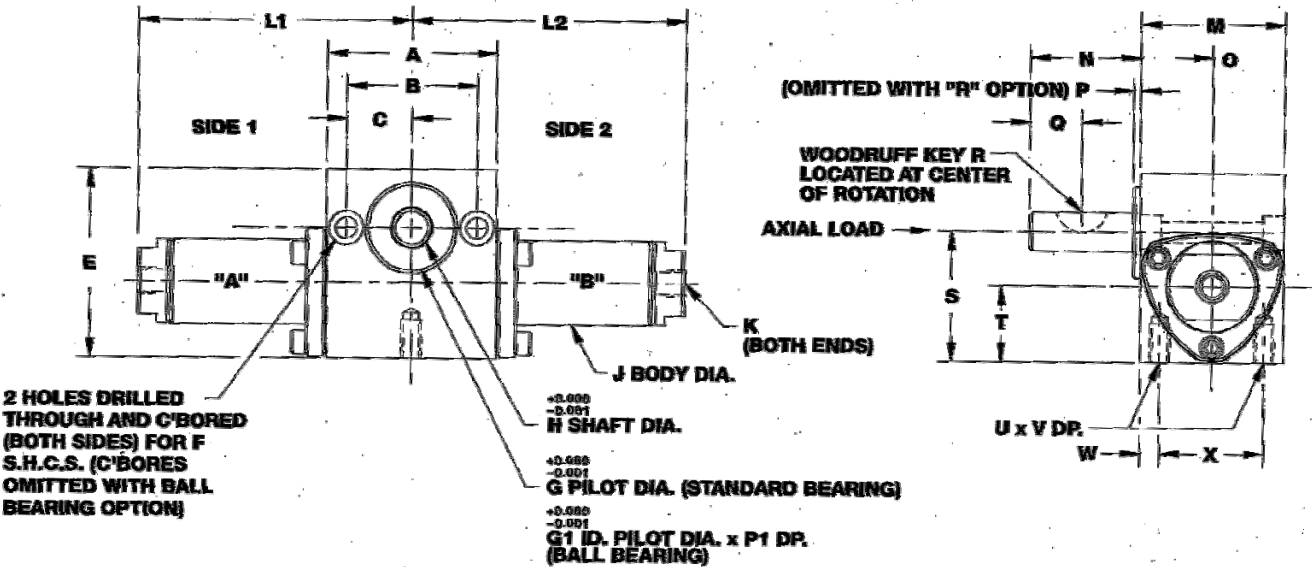
Note: The retracted length may be somewhat longer by not tightening the clevis all the way to the end of the thread.

# 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.



The following are the specifications for the rotary actuator.



Bore	A	B	C	E	F
0.075	1.62	1.25	0.62	1.81	#10 S.H.C.S.
G	G1	H	J	K	M
0.875	0.875	0.375	0.82	#10-32	1.37
N	O	P	P1	Q	R
1.06	0.69	0.06	0.06	0.5	Below
S	T	U	V	W	X
1.25	0.73	#10-24	0.38	0.19	1

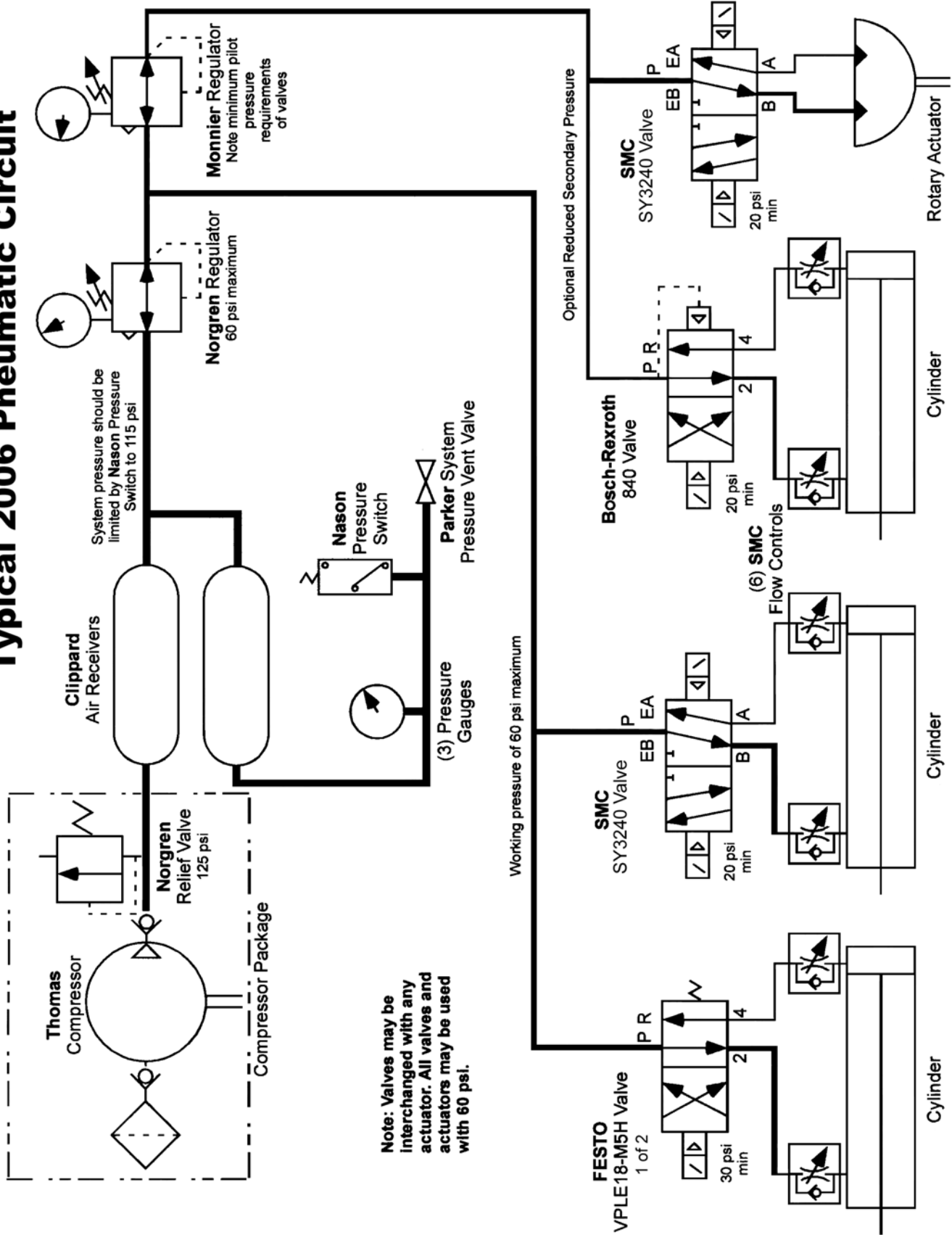
The woodruff key is 0.0625" wide and 0.032 " high

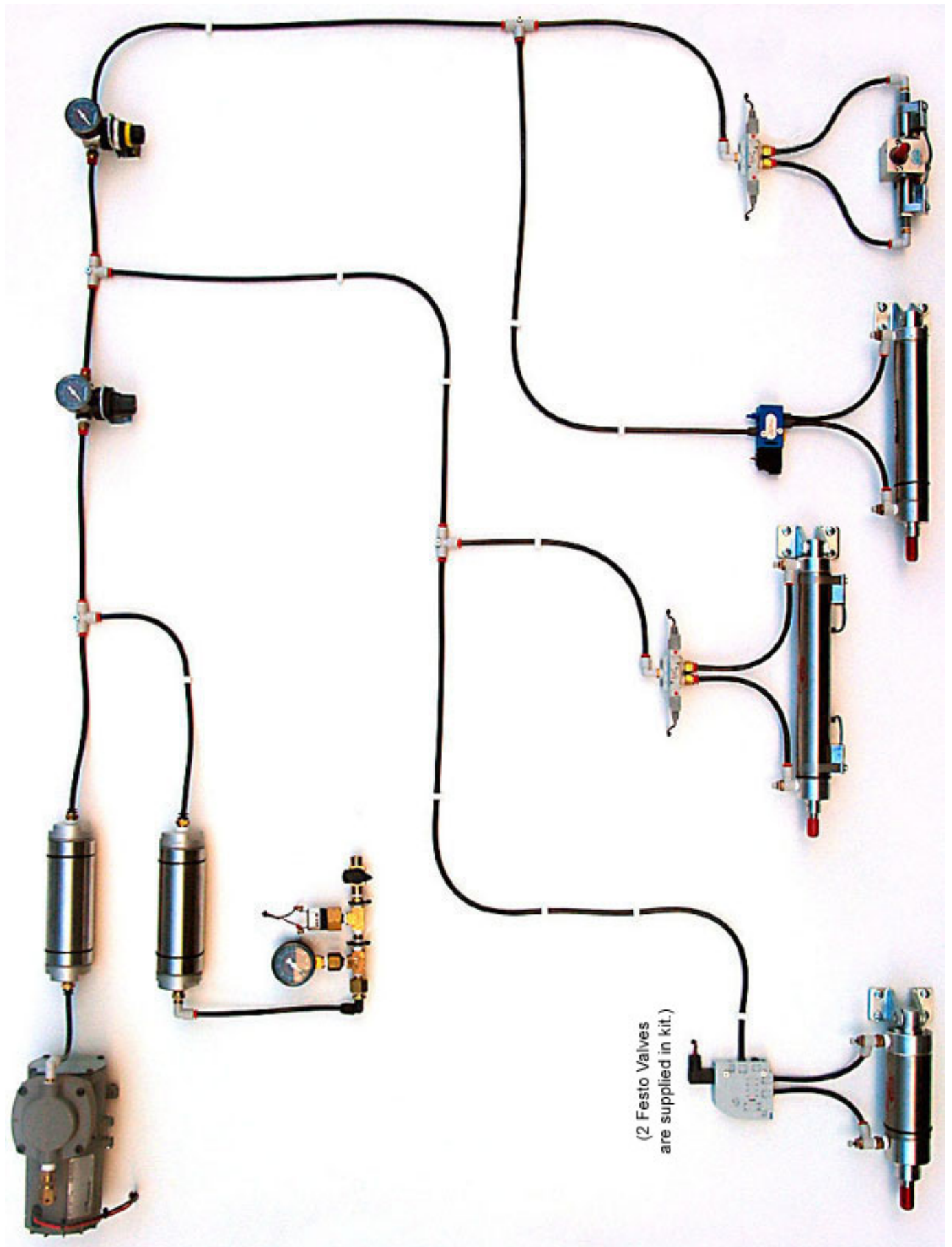
**Many thanks to the following FRC Suppliers who provided pneumatic components for the 2009 Kit of Parts:**

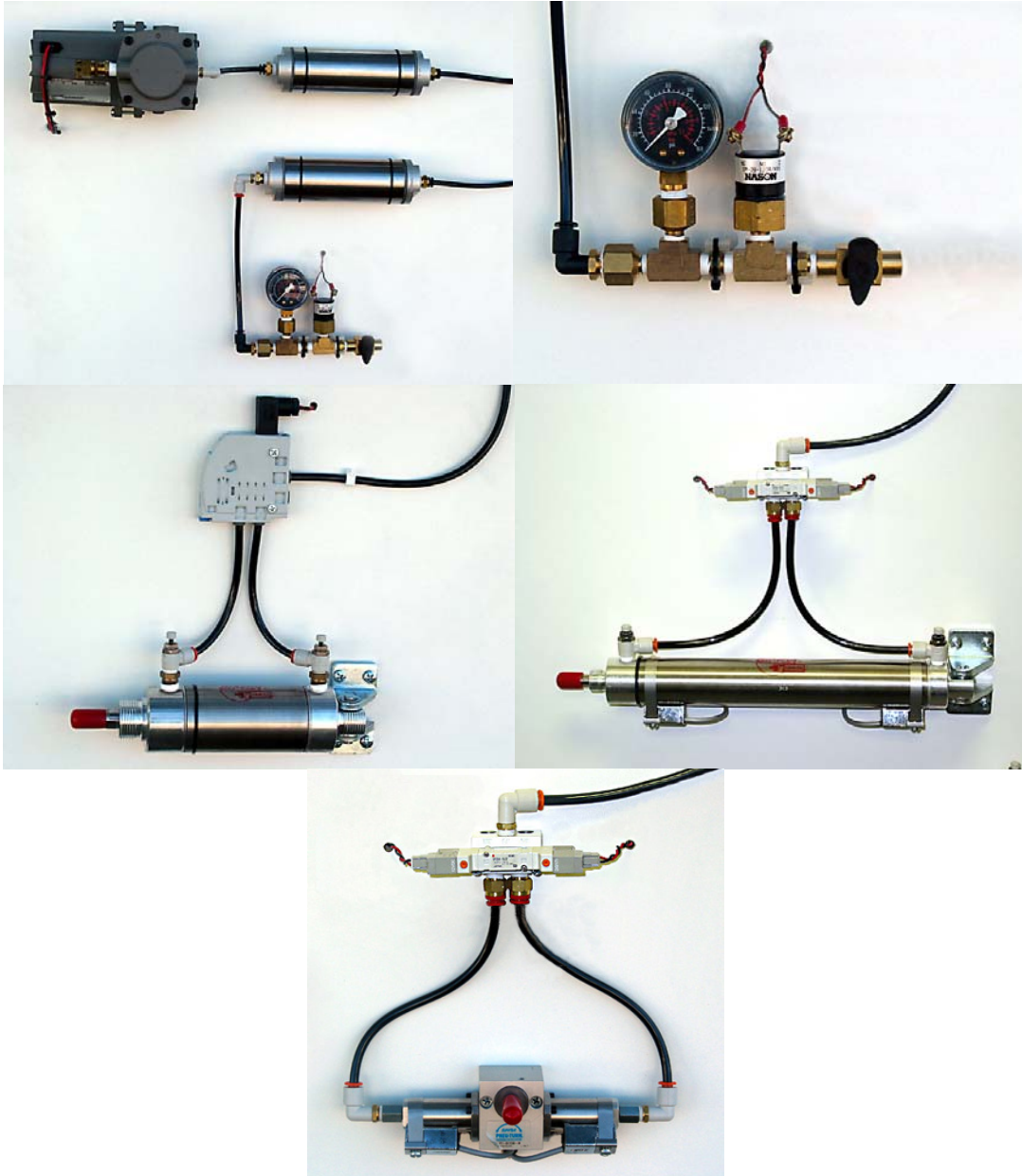
Bimba Manufacturing (<http://www.bimba.com>)  
Clippard Instrument Laboratory, Inc. (<http://www.clippard.com>)  
Festo Corporation (<http://www.festo.com>)  
Fluid Power Education Foundation (<http://www.fpef.org>)  
Freelin-Wade (<http://www.freelin-wade.com>)  
Gardner Denver Thomas (<http://www.thomasind.com>)  
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>)  
Wika Instrument (<http://www.wika.com>)



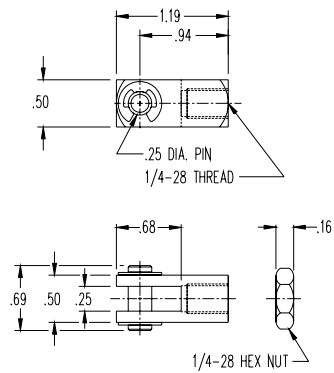
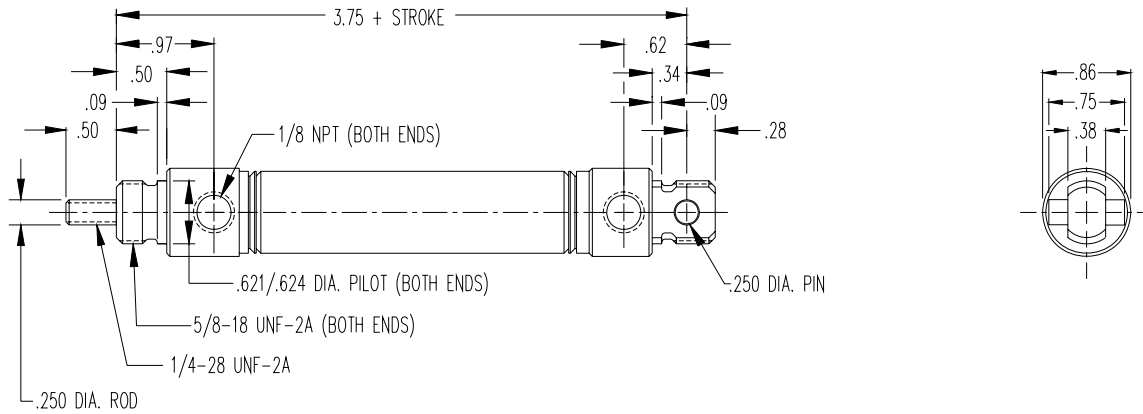
# Typical 2006 Pneumatic Circuit



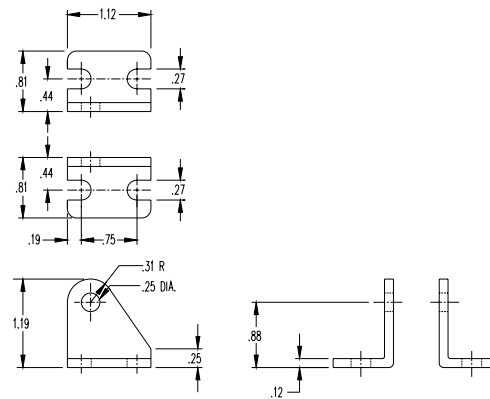




## 3/4" BORE

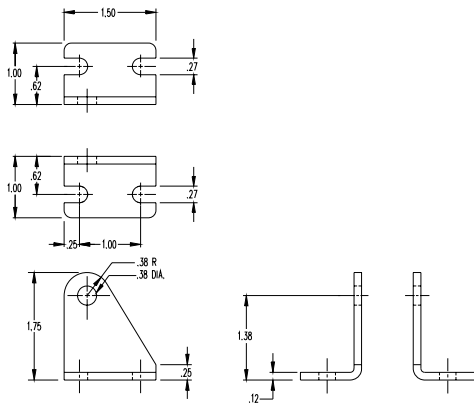
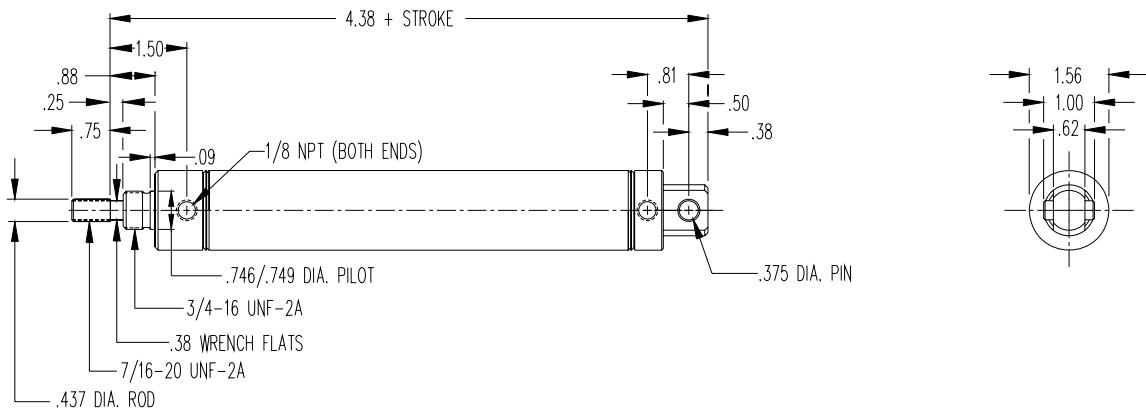


Rod Clevis  
Bimba Part Number **D-166-3**

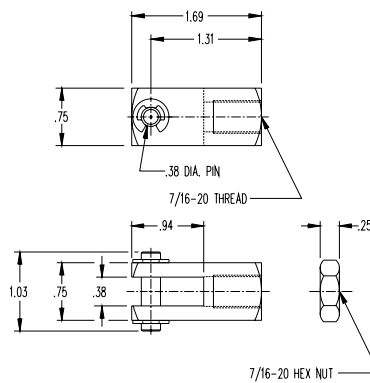


Rear Pivot Bracket  
Bimba Part Number **D-167**

# 1-1/2" BORE

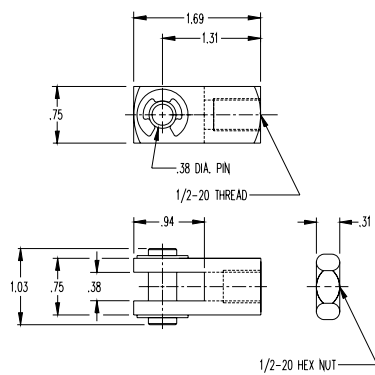
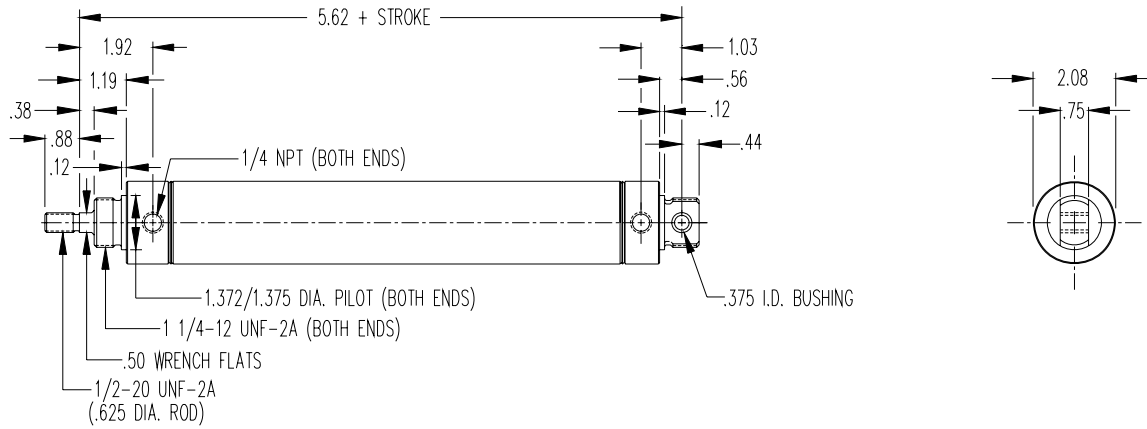


Rear Pivot Bracket  
Bimba Part Number **D-229**

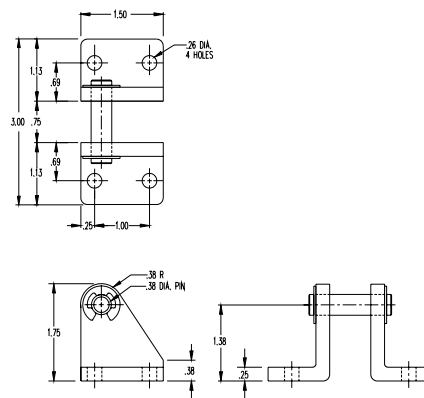


Rod Clevis  
Bimba Part Number **D-231-1**

## 2" BORE



Rod Clevis  
Bimba Part Number **D-231-3**



Rear Pivot Bracket  
Bimba Part Number **D-620**

**Extend and retract forces  
of all three bore sizes**

	3/4" Bore	3/4" Bore
Pressure	Force Extended	Force Retracted
(pounds/sq. inch)	(pounds)	(pounds)
20	9	8
25	11	10
30	13	12
35	15	14
40	18	16
45	20	18
50	22	20
55	24	22
60	26	24
	1-1/2" Bore	1-1/2" Bore
Pressure	Force Extended	Force Retracted
pounds/sq. inch	(pounds)	(pounds)
20	35	32
25	44	40
30	53	48
35	62	57
40	71	65
45	79	73
50	88	81
55	97	89
60	106	97
	2" Bore	2" Bore
Pressure	Force Extended	Force Retracted
pounds/sq. inch	(pounds)	(pounds)
20	63	57
25	79	71
30	94	85
35	110	99
40	126	113
45	141	128
50	157	142
55	173	156
60	188	170



## **FIRST Free Pneumatic Components Order Form**

**\*\* A maximum of 3 free cylinders may be ordered. You may substitute 1 rotary actuator for a cylinder. LIMIT IS 3 ITEMS!** Additional cylinders and rotary actuators may be purchased from local distributors.  
See below for details.\*\*

### **How to Order**



Air Cylinder

The example is a 2" bore x 6" stroke cylinder with a magnetic piston

**M - 31 6 - DXP**

*M-Magnet	Bore	Stroke in inches	Mounting
(optional)	04 = 3/4"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	DP for 3/4"
Includes (2)	09 = 1 1/16"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	DP for 1 1/16"
MRS-.087-B	17 = 1 1/2"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	DP for 1 1/2"
Position sensors	31 = 2"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	DXP for 2"

**Please check the Bimba web site for available strokes in each bore size**

All cylinder orders include clevis, jam nut and pivot brackets. Please allow up to 4 days for shipment

The example is a 3/4" bore, 90° rotary actuator with magnetic pistons.



90° Rotary Actuators

**PT - 017 090 - M**

Model	Bore	Rotation	*M-Magnet
PT	017 = 3/4" (only bore available)	090 (90° is the only rotation available)	(Optional) Includes (2) Mrs..087-B position sensors

**To order, go to: [www.bimba.com](http://www.bimba.com) and click on the *FIRST* link.**

**Shipments are sent UPS Ground Complete at no cost to teams.**

**IF** Express Service is needed, each team is responsible for charges. Supply your carrier and account number

\*After your order is placed, go to [www.bimba.com](http://www.bimba.com) and click on "Order Tracking" to check the status of your order. (Customer PO = Team No.)

\*\*Any additional actuators/accessories can be purchased through your local Bimba Distributor. To find one in your area, visit:

<http://www.bimba.com/OrderInfo/Distributors/>