

***FIRST***<sup>®</sup>

***Pneumatic  
Manual***

***2006***

# The Advantages of Using Pneumatics in 2006

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 on page 15, 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 on page 12, 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 now order the exact cylinder you need for the job and get them in a few days via regular UPS.

## **Last Minute Additions**

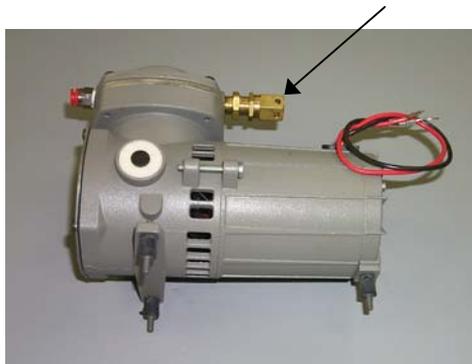
At the last minute, you can add a cylinder and valve very quickly.

## Congratulations on receiving your pneumatic kit for the FIRST 2006 competition.

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. There are some exciting new additions to this year's kit, which we hope will make using pneumatics easier than ever

### COMPRESSOR

We have the same compressor provided by **Thomas Industries** 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 have included vibration isolation mounts donated by the **Lord Corporation**. 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 **The Nason Company**. 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 the robot controller digital input bank with PWM type cable. No specific Digital Input Port is designated for the pressure switch. The Robot Controller must be programmed to react to the Input Port that is connected to the pressure switch. The Robot Controller will activate the designated Spike Relay to turn the Compressor "on" and "off". There is no default program in the Robot Controller to control the Compressor power. Do not put the pressure switch in series with the power supply to the compressor.



## TANKS

We have 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

SMC has provided two double solenoid valves. If you pulse one of the solenoids to make the cylinder extend, you must then pulse the opposite solenoid to make it retract. Either solenoid may be left in the energized state. This is a great valve to use to maintain position when the power is turned off at the end of the match. If you use a single solenoid valve and the power is turned off, the valve would shift back to its original position and the cylinder will retract. A double solenoid valve will maintain its position until you turn on the opposite solenoid. The orange buttons on the top of the valves are manual overrides. With a double solenoid valve you can depress the override and the valve will shift and stay in that position. The valve is pilot operated and requires a minimum pressure of 20 psi to work. The valve comes separate from the mounting block and must be assembled to it. There are 2 gaskets included. Use the one with holes for the mounting screws. Always avoid turning on both solenoids at the same time. While this won't hurt the valve, you cannot be sure which way the spool will shift. There is also a 24vdc double solenoid valve included in the kit as a spare. Should you need to replace one of the 12V solenoid valves, just unscrew the 24V pilot valves from each end of the spare and swap the solenoid bodies. Remount the 12vdc pilot valves. Then remount the solenoid assembly back onto the sub base-mounting block.



FESTO has also supplied two single solenoid valves. 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.



**Bosch-Rexroth** has also provided us with a single solenoid valve. The fittings allow you to push on the tubing and then tighten down on the tubing with the nut. The pressure port is shown on the top of the valve

and marked “P”. Flow comes out the “B” port and switches to the “A” port when the coil is energized. A solenoid connector plug is provided to wire the solenoid. The yellow arm on the opposite side of the valve is the manual override. On this valve you can turn the override on and leave it in that position for testing. Note there is no nut on the “R” port, which is the exhaust port. **Please remove the Black nuts which are for metric tubing and use the Gray nuts which are included.** If you lose a gray nut, drill ¼” hole in one of the black nuts to use instead.



## FLOW CONTROLS

We have flow controls donated by **SMC Pneumatics**. The purpose of a flow control is to control the speed of the cylinder when it is extending or retracting. Always mount these into the ports of the cylinders before you hook up the tubing.

**Warning: Even if flow controls are used or the needle is turned out counter clockwise, the cylinder can extend very quickly. Always stay clear of any cylinder in motion.**



## 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. This is because the threads are tapered and the tape may come loose from the first thread or so and clog up one of your valves.



**QUICK CONNECT FITTINGS**

SMC Pneumatics donated the quick connect fittings. These are really easy to use. All you have to do is push the tube into the fitting. Make sure you push the tubing all the way into the fitting. To release the tubing, just push on the release button and then pull the tubing out. Don't attempt to pull the tubing without first pushing the release button. The picture below shows a representative example of these fittings but does not include all the ones in the kit.



**TUBING**

Freelin-Wade has donated the tubing this year. Coiled tubing was also added this year.



**KIT CYLINDERS**

We have included a cylinder from **Parker-Hannifin Manufacturing**. It is included in the kit for you to get started and understand pneumatics. Hopefully, you will find a use for it on your robot. **Please note: The switches provided by BIMBA will not work with this cylinder, as it has no magnetic piston.**





## 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), 1-1/2" 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.com](http://www.pneumaticsfirst.com) that contains some great discussions on how to design your cylinders in order to get the proper height for a lift mechanism.

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 or Parker-Hannifin Distributor. You can find a distributor in your area by going to:

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

or

<http://www.parker.com/distloc/english/search.asp>

## How to calculate the retracted and extended length of a cylinder

Look at the drawing of the 1-1/2" bore cylinder (page 10). 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:

Base dimension	= 4.38"
Stroke	= 8.00"
Locking nut width	= 0.25"
<u>Clevis dimension</u>	= 1.31"
Pin-to-Pin Retraction	= 13.94"

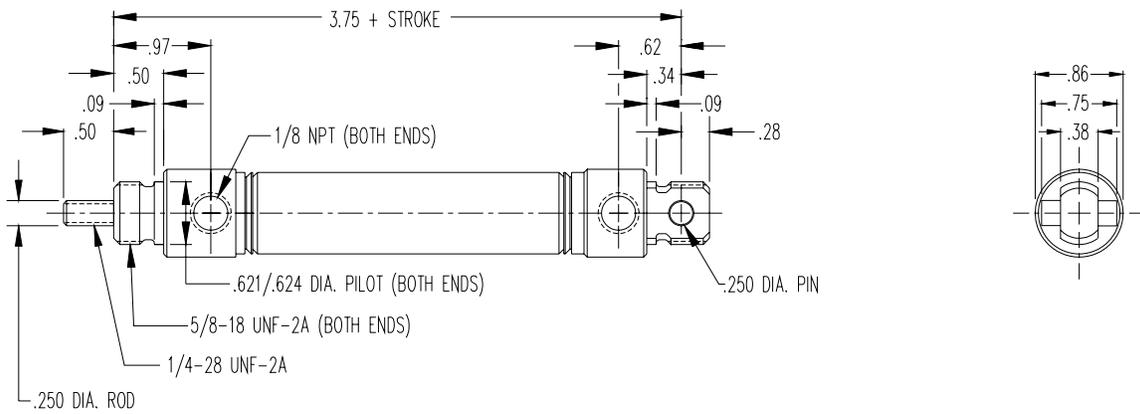
To find the extended pin-to-pin dimension, just add the stroke:

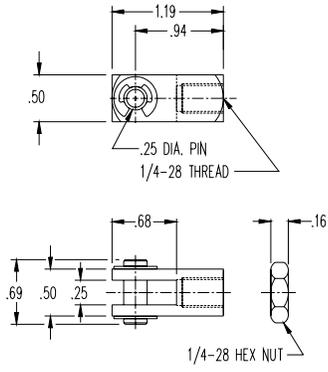
Pin-to-Pin retracted	= 13.94"
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Stroke = 8.00"  
 Pin-to-Pin Extended = 21.94"

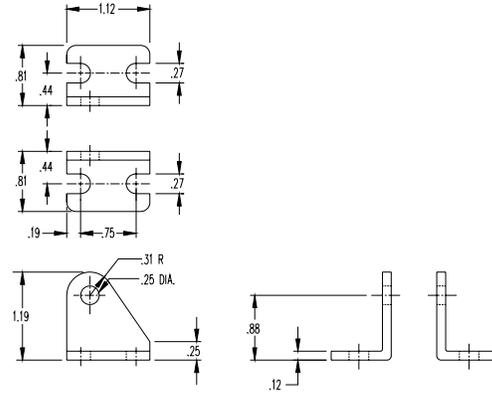
Note: The retracted length may be somewhat longer by not tightening the clevis all the way to the end of the thread.

### 3/4" BORE



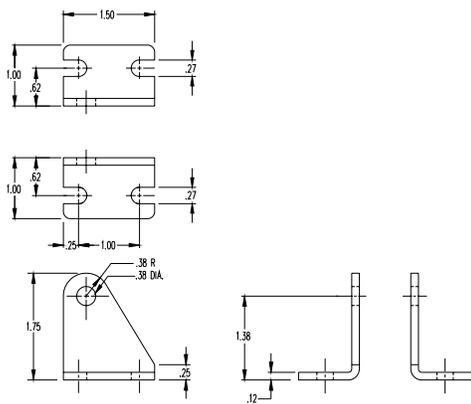
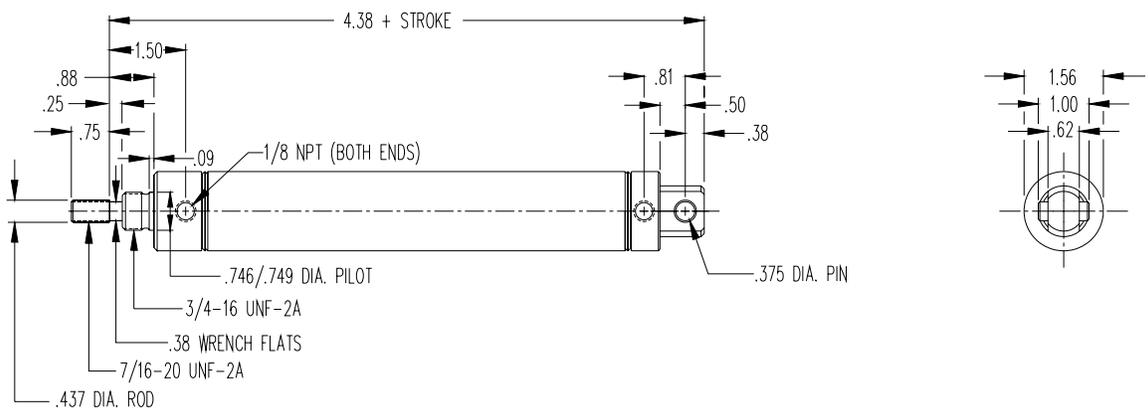


**Rod Clevis**  
**Bimba Part Number D-166-3**

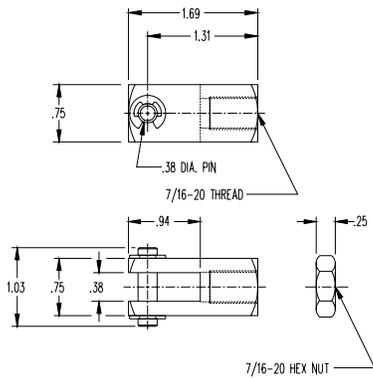


**Rear Pivot Bracket**  
**Bimba Part Number D-167**

**1-1/2" BORE**

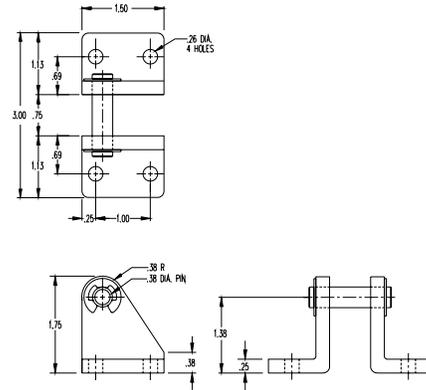
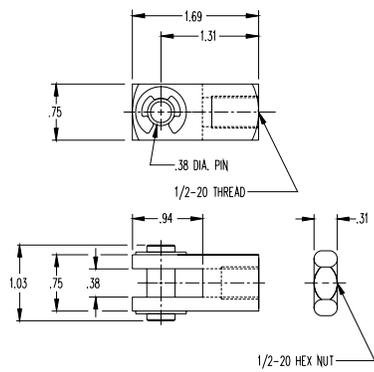
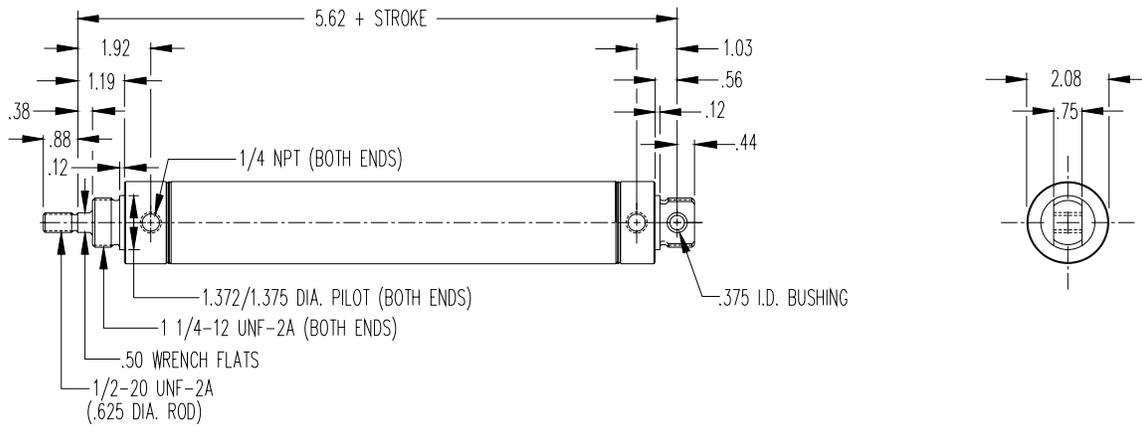


**Rear Pivot Bracket**  
Bimba Part Number **D-229**



**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

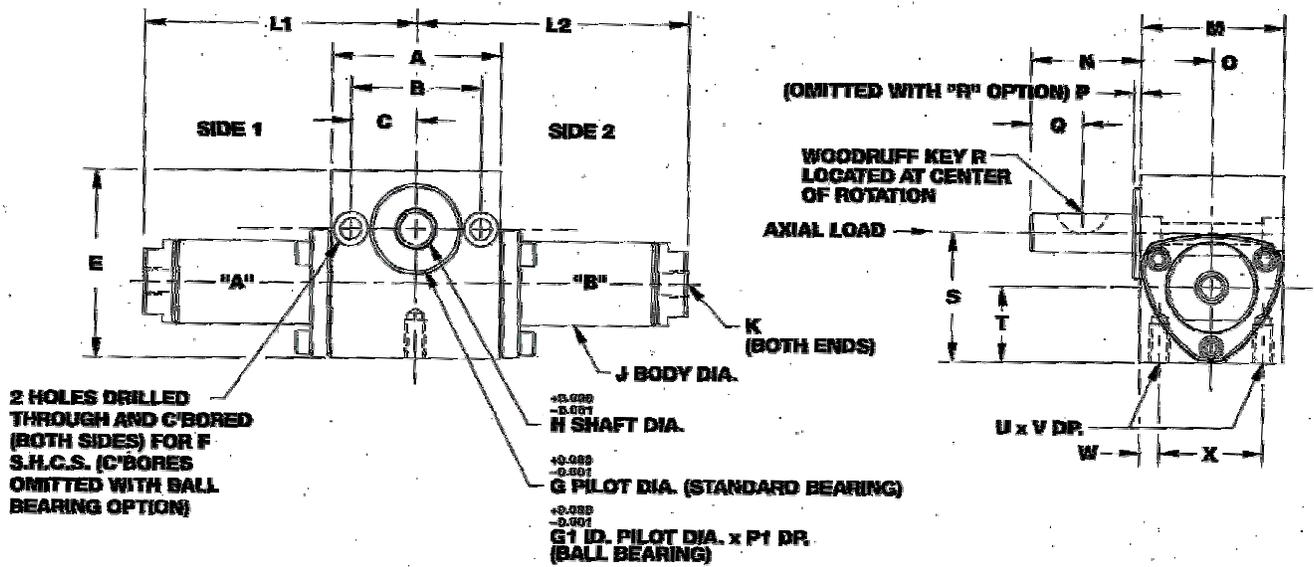
### Rotary Actuator

**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.



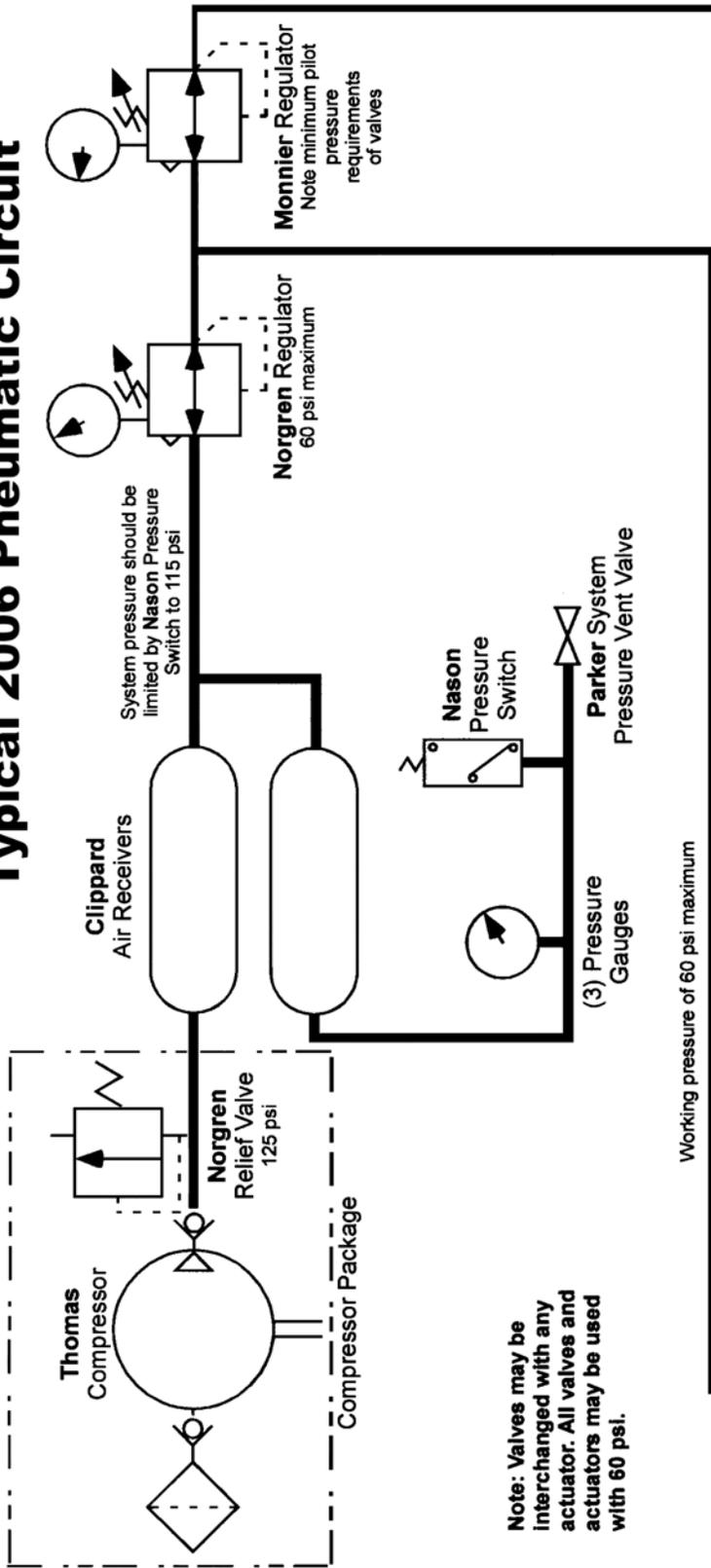
The following are the specifications for the rotary actuator.



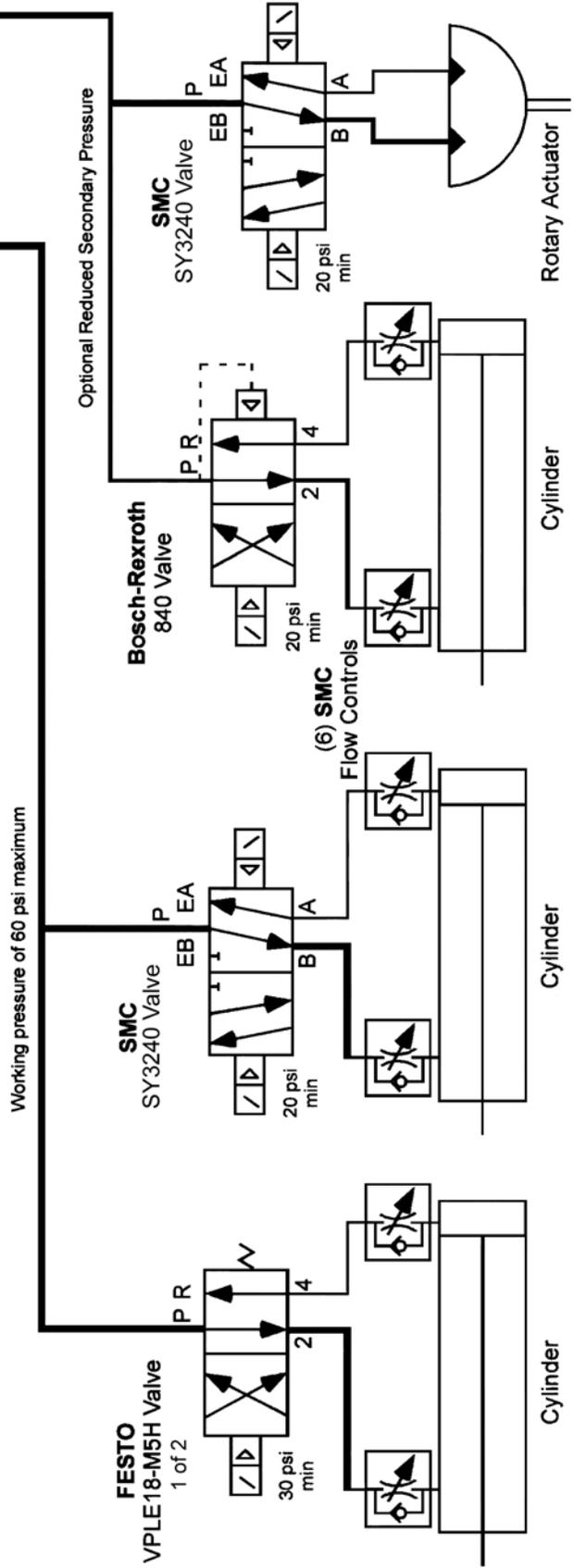
<b>Bore</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>E</b>	<b>F</b>
0.075	1.62	1.25	0.62	1.81	#10 S.H.C.S.
<b>G</b>	<b>G1</b>	<b>H</b>	<b>J</b>	<b>K</b>	<b>M</b>
0.875	0.875	0.375	0.82	#10-32	1.37
<b>N</b>	<b>O</b>	<b>P</b>	<b>P1</b>	<b>Q</b>	<b>R</b>
1.06	0.69	0.06	0.06	0.5	Below
<b>S</b>	<b>T</b>	<b>U</b>	<b>V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

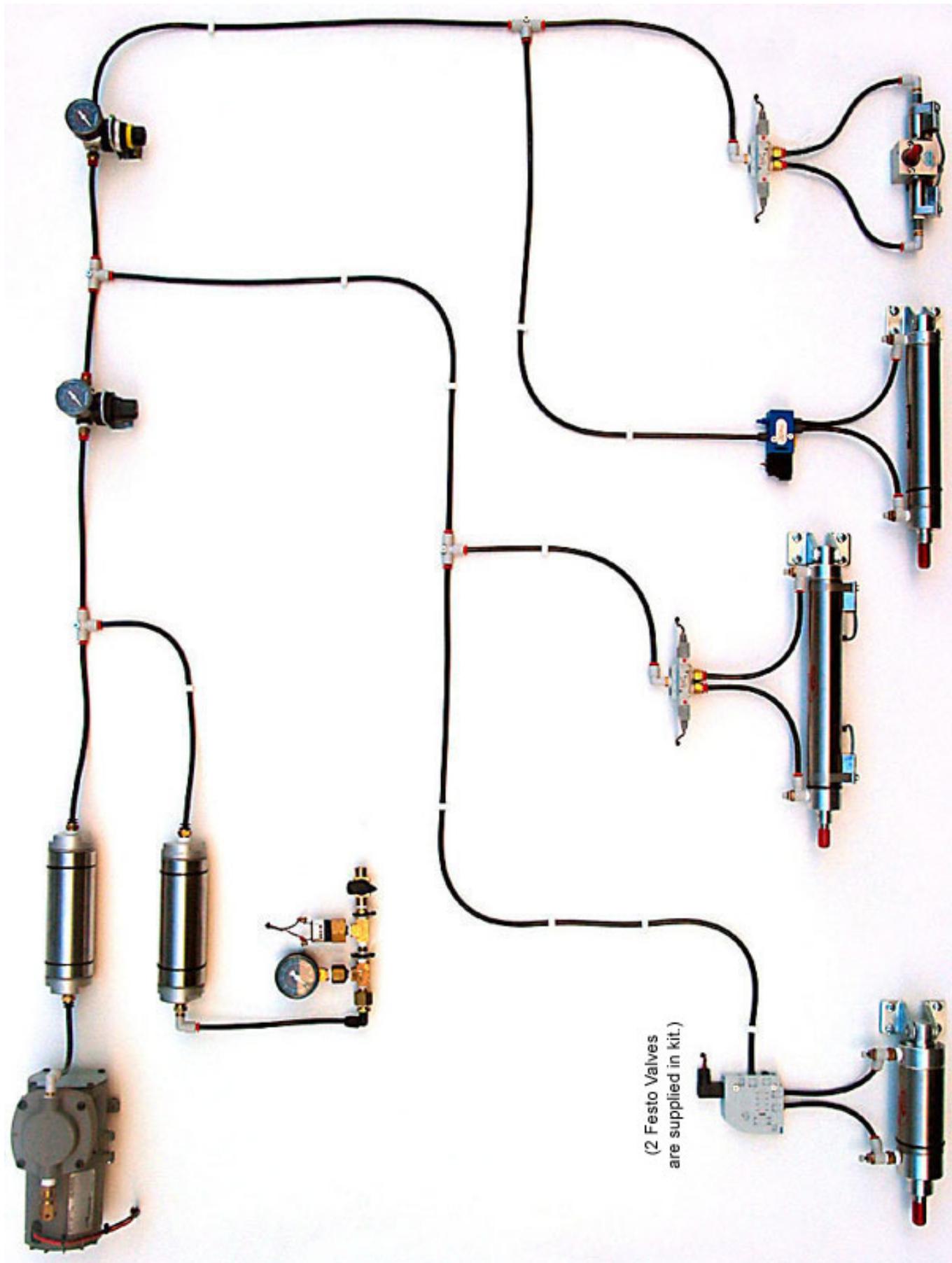
The woodruff key is 0.0625" wide and 0.032 " high

# Typical 2006 Pneumatic Circuit

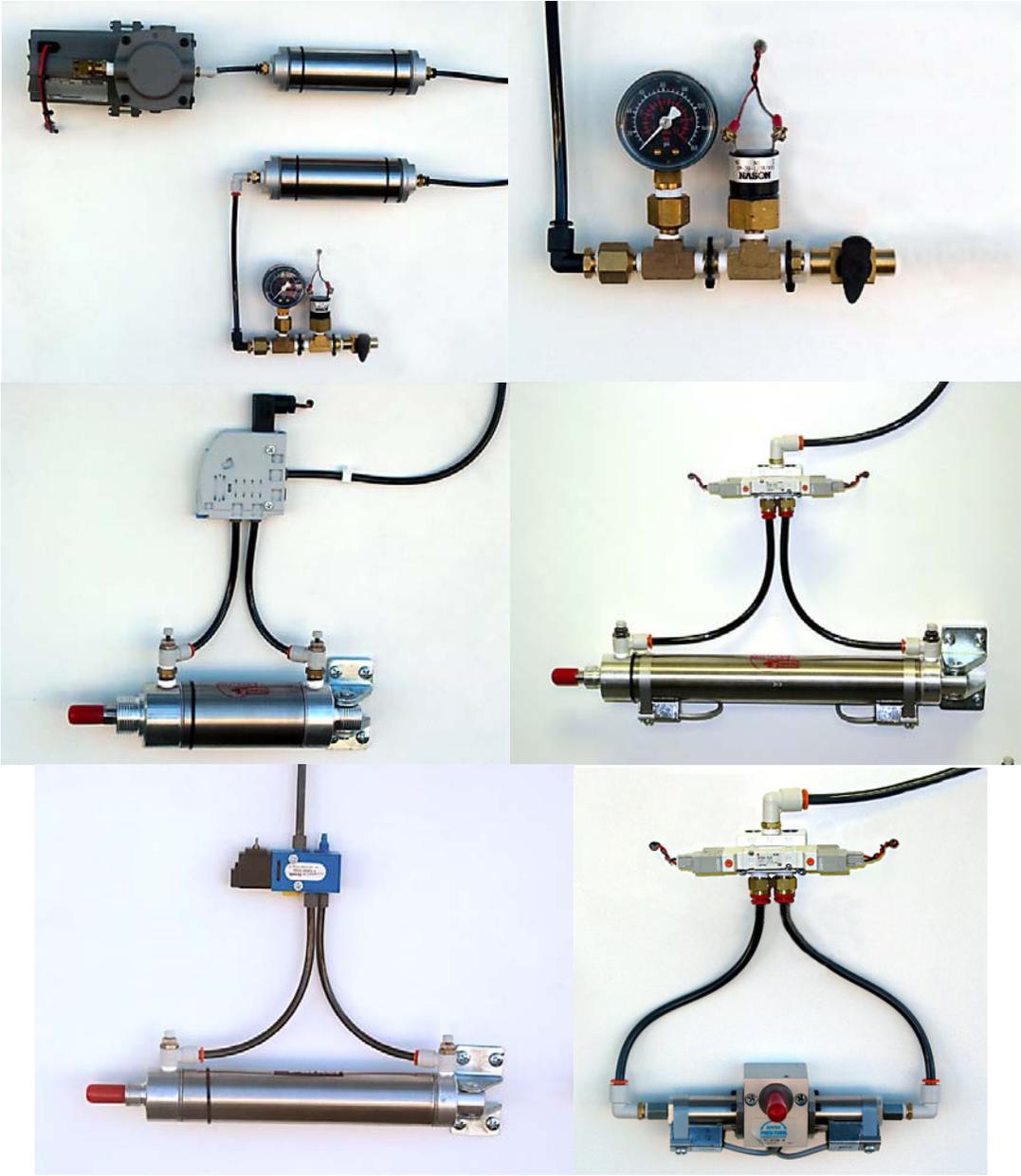


**Note:** Valves may be interchanged with any actuator. All valves and actuators may be used with 60 psi.





(2 Festo Valves  
are supplied in kit.)



**FIRST  
Pneumatic Component  
Bill of Material**

<b>Vendor</b>	<b>Quantity Per Kit</b>	<b>Part Number</b>	<b>Product Weight</b>	<b>Description</b>
<b>SMC</b>				
SMC	2	SY3240-6HZ-X70	3.0 oz.	Double solenoid valve-12vdc complete
SMC	2	SY3000-27-1T	2.0 oz.	Sub plate for double solenoid valve
SMC	1	SY3240-5LOZ	3.0 oz.	Double solenoid valve- 24vdc, no leads
SMC	6	NAS2201F-N01-07S	0.6 oz.	Flow control
SMC	10	KQH07-34S	0.3 oz.	Fitting, Straight 1/4 Tube
SMC	10	KQL07-35S	0.2 oz.	Fitting, 90 Elbow 1/4 Tube
SMC	5	KQT07-00	0.5 oz.	Fitting, Male Run T 1/8 NPT -1/4 Tube
SMC	1	KQ2L03-34S accidental addition	0.5 oz.	Male, 90 degree Elbow 5/32" tube 1/8"NPT
SMC	1	KQ2H03-34S accidental addition	0.5 oz.	Male Conn., 5/32" tube- 1/8"NPT
<b>Freelin-Wade</b>				
Freelin-Wade	1	1J-151-07P-FW	1.5 lbs.	1/4" OD tubing – 100'
Freelin-Wade	1	2MC-151-5P-FW	4.8 oz.	Coil tubing
<b>Parker Cylinder Div.</b>				
Parker	1	1.5DPSR8.00	7.3 oz.	Cylinder 1.5" bore x 8" stroke
Parker	1	L071310300	1.6 oz.	Cylinder pivot bracket set
Parker	1	L071300400	1.0 oz.	Cylinder rod clevis
<b>Parker Brass Div.</b>				
Parker	1	PV609-2	2.4 oz.	Manual 2-way plug valve
Parker	4	2203P-2	1.3 oz.	Union Tee
Parker	6	222P-4-2	1.1 oz.	Adapter 1/4" female to 1/8" male
Parker	6	216P-2	0.4 oz.	Hex nipple 1/8"npt
Parker	12	209P-4-2	0.4 oz.	Bushing 1/8" female to 1/4" male
Parker	6	218-2	0.3 oz.	Plug 1/8"
Parker	6	218-4	0.7 oz.	Plug 1/4"
<b>Norgren Kit</b>				
Norgren	1	16-004-015	5.1 oz.	120 psi relief valve
Norgren	1	R07-153-RNEA	4.7 oz.	Main regulator w/60psi max output
Norgren	1	18-025-003	0.7 oz.	Regulator mounting bracket and nut
Norgren	1	18-013-212	4.0 oz.	Pressure Gauge
<b>Festo Valve</b>	2	VPLE18-M5H-4/2-1/4	3.3 oz.	Single solenoid valve
<b>Bosch/Rexroth</b>	1	P-026641-00004	2.7 oz.	Single solenoid valve
<b>Clippard</b>	2	AVT-32-16	14 oz.	Volume Tank 2" bore by 6" length
<b>Nason</b>	1	SM-2B-115R	2.1 oz.	Pressure switch
<b>Monnier</b>				
Monnier	1	101-3002-1	3.2 oz.	Secondary pneumatic regulator
Monnier	1	13536	1.2 oz.	Regulator mounting bracket and nut
<b>Wika</b>	2	9690242	4.0 oz.	Pressure Gauges
<b>Lord Corporation</b>	3	SMB003-0100-2	0.3 oz.	Vibration isolators for compressor
<b>HPE Automation</b>	1	HPE	0.2 oz.	1/4" by 100" Teflon Tape
<b>Thomas</b>	1	405ADC38-12	4.75 lbs.	Compressor
<b>Bimba</b>	3	Special order Cylinders		Not included in the kit

## The following companies provided product for the 2006 Competition:

**Bimba Manufacturing**  
**Bosch-Rexroth**  
**Clippard Instrument Laboratory, Inc.**  
**Festo**  
**Freelin-Wade**  
**HPE Automation**  
**Lord Corporation**  
**Monnier, Inc.**  
**Nason Corporation**  
**Norgren**  
**Parker Hannifin, Inc.**  
**SMC Pneumatics, Inc.**  
**Thomas Industries, Inc.**  
**Wika Instrument**

## Web Sites for Product Suppliers and Foundations

Bimba Manufacturing	- <a href="http://www.bimba.com">http://www.bimba.com</a>
Bosch-Rexroth	- <a href="http://www.boschrexroth.com">http://www.boschrexroth.com</a>
Clippard Instrument Laboratory, Inc.	- <a href="http://www.clippard.com">http://www.clippard.com</a>
Festo	- <a href="http://www.festo.com">http://www.festo.com</a>
Freelin-Wade	- <a href="http://www.freelin-wade.com">http://www.freelin-wade.com</a>
HPE Automation	- <a href="http://www.hpeco.com">http://www.hpeco.com</a>
Lord Corporation	- <a href="http://www.lordmpd.com">http://www.lordmpd.com</a>
Monnier, Inc.	- <a href="http://www.monnier.com">http://www.monnier.com</a>
Nason Company	- <a href="http://www.nasonptc.com">http://www.nasonptc.com</a>
Norgren	- <a href="http://www.norgren.com">http://www.norgren.com</a>
Parker Hannifin, Inc.	- <a href="http://www.parker.com">http://www.parker.com</a>
SMC Pneumatics, Inc.	- <a href="http://www.smcusa.com">http://www.smcusa.com</a>
Thomas Industries	- <a href="http://www.thomasind.com">http://www.thomasind.com</a>
Wika Instruments	- <a href="http://www.wika.com">http://www.wika.com</a>
FPEF	- <a href="http://www.fpef.org">http://www.fpef.org</a>

## 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

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

### M - 31 6 - DXP



Air Cylinders

*M-Magnet	Bore	Stroke in inches	Mounting
(Optional) Includes (2) MRS-.087-B position sensors	04 = 3/4"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10	DP for 3/4"
	17 = 1 1/2"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11,	DP for 1 1/2"
	31 = 2"	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12, 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.

### PT - 017 090 - M



90° Rotary Actuators

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.

Technical Help: [fhord@hpeco.com](mailto:fhord@hpeco.com)

Emergency Only—Phone: 954-429-9560

\*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 or accessories can be purchased through your local Bimba or Parker-Hannifin Distributor. To find one in your area go to:

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

or

<http://www.parker.com/distloc/english/search.asp>