2007 Pneumatics Manual

The Advantages of Using Pneumatics in 2007

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 and are 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.

Why use pneumatics in your FRC application? Here are some design considerations for your review:

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.

Power

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 may order the exact cylinder or rotary actuator you need for the job from Bimba again this year, 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.

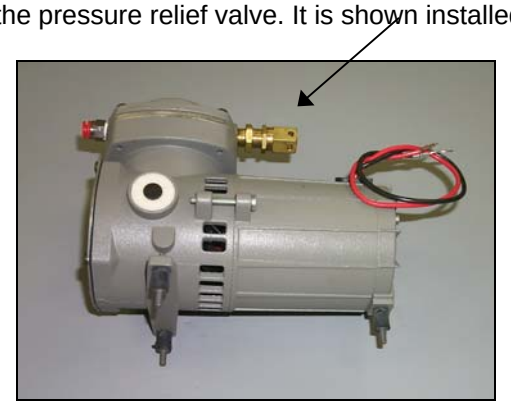
PLEASE NOTE: Information in this guide is intended to provide assistance and advice.
It does not supersede any rules or statements made in the 2007 Robotics Competition Manual.

Congratulations on receiving your pneumatic kit for the 2007 FRC competition!

This year we have worked very hard to make it easy for you to use pneumatics on your robot. We have also chosen components that match each other. There are some exciting new additions to this year's kit, which we hope will make using pneumatics easier than ever

COMPRESSOR

With financial support from the Fluid Power Education Foundation, we have the same compressor provided by **Thomas Industries** that we've had for the last few years**.** The compressor will put out approximately 120psi before the **Norgren** relief valve opens (that would give you 376 pounds of output force on a 2.00" bore cylinder). 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 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! **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 provided two tanks from **Clippard Instruments,** however you are permitted to use up to four tanks on your robot. They should be mounted right after the compressor, before the Norgren primary pressure regulator. The reason for the tanks is to give you a place to store the compressed air that is produced by the compressor. Storing this air gives you the capability of high instantaneous air flow and reduced compressor operation time saving you battery life. Although you're welcome to mount the tanks in series, for best flow output, mount them in parallel with your air supply. The tanks may also be used to pre-charge your pneumatic circuit before a match using the Thomas compressor provided in the kit, resulting in instantaneous pressure and working actuators (instead of having to wait for your compressor to pressurize the circuit).

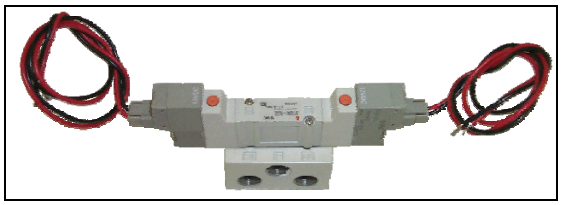
REGULATORS

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. Please note: the specification states that the nominal output pressure range is 0-50psi. However, Norgren has approved the operation of this regulator up to 60psi for *FIRST* teams, based on the operating conditions for a *FIRST* robot. The regulator must be placed in-line right after the tanks to limit the pressure to all working circuits to 60psi maximum. 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. **Norgren** has also included a mounting bracket for the regulator.

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 segment of the circuit if needed. You could use this for reduced pressure on a gripper, a counterbalance valve for a cylinder or any other area where the full force of the 60 psi main circuit can cause damage to your robot or your tooling.. 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 and one single solenoid valve. For the double solenoid, if you energize one of the solenoids to make the cylinder extend, you must then energize the opposite solenoid to make it retract. Either solenoid may be left in the energized state or you may leave it un-energized and the valve will hold its position. This is a great valve to use to maintain position when the power is turned off at the end of the match. 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.



SMC's double solenoid valve.

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.

FESTO has also supplied a 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.

FLOW CONTROLS

SMC Pneumatics donates flow controls**.** 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.

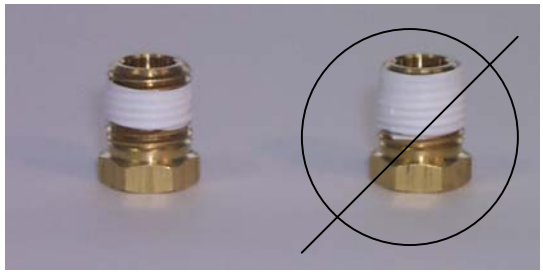
Warning: Even if flow controls are used or the needle is turned out counter clockwise, the cylinder can extend very quickly. Always stay clear of any cylinder in motion.

PLUG VALVE

Parker Hannifin donated the plug valve. This valve can be used to release all the air in the system. It is best to tee it to the Bimba air storage tanks. Additional plug valves are encouraged throughout your circuit enabling pressure to be evacuated quickly and easily if necessary.

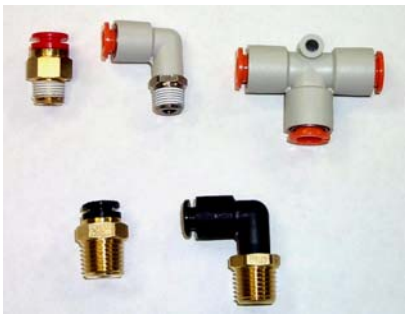
BRASS FITTINGS

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. It is also preferred to wrap the tape in the same direction as the threads. This will prevent the tape from binding up when screwing in fittings.



QUICK CONNECT FITTINGS

SMC Pneumatics donated the quick connect fittings. These are very 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 the plastic colored ring in (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 again this year. They donated 100 feet of ¼" tubing (packed in the tote) to each team for use in your pneumatic circuits. They also donated the smaller tubing included in the **PIAB Vacuum Products** vacuum kit.

CUSTOM BIMBA CYLINDERS

You will again be able to order custom cylinders from **Bimba** for your robot 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 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 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:

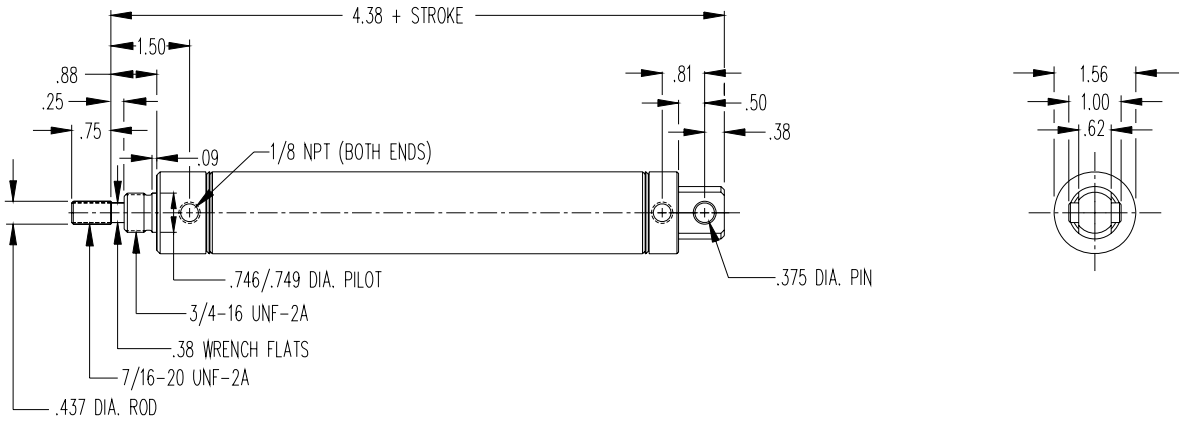
http://www.bimba.com/distrib/distrib.htm
or
http://www.parker.com/distloc/english/search.asp

EXAMPLE: How to calculate the retracted and extended length of a cylinder

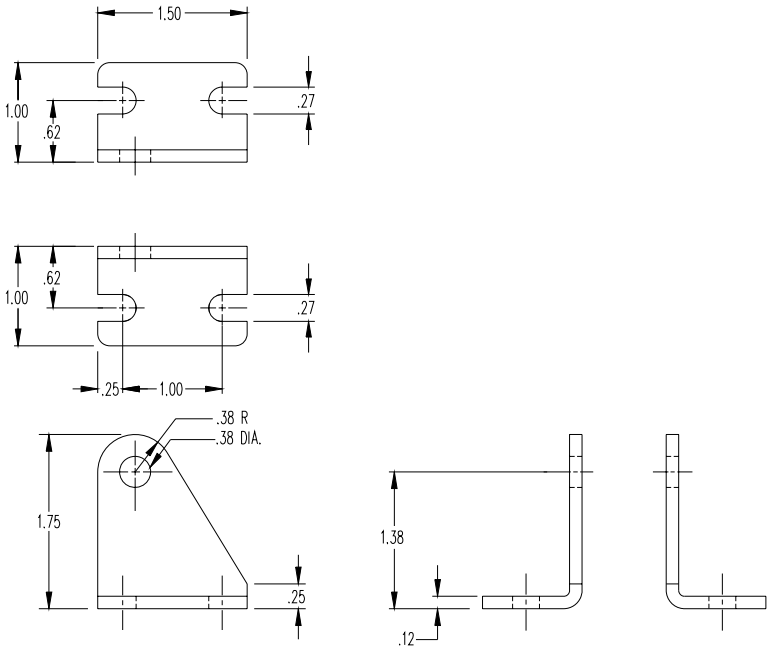
Look at the drawing of the 1-1/2" bore cylinder (for dimensions of other Bimba magnetic position cylinders, you may visit http://www.bimba.com/Products/OriginalLineCylinders/MRSCylinders/). You will notice that the cylinder pivots about a pivot pin located in the rear of the cylinder. There is a dimension 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.

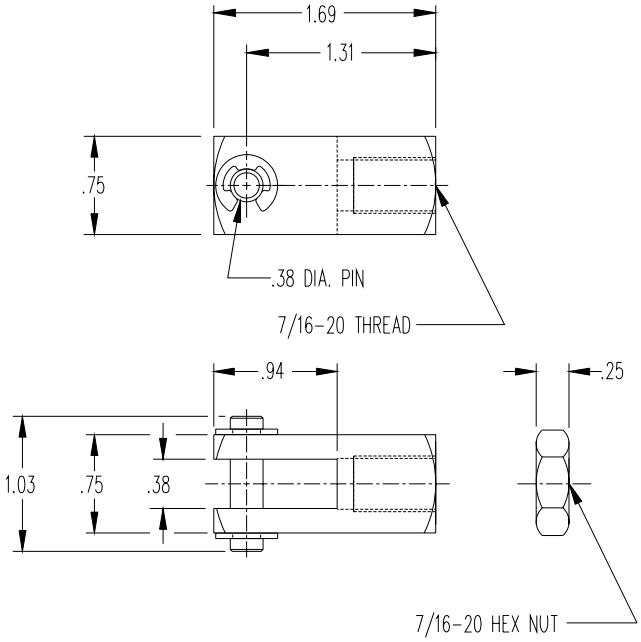
1 ½" Bore Cylinder



Rear Pivot Bracket (Bimba PN D-229)



Rod Clevis (Bimba PN D-231-1)



To find the retracting pin-to-pin dimension, do the following:

Base dimension	**= 4.38”**
Stroke	**= 8.00”**
Locking nut width	**= 0.25”**
Clevis dimension	**= 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”**
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.

If you know the force required to perform a certain activity, you may use the chart below to help determine an appropriate bore size, or vice versa.

Extend and Retract forces of three bore sizes.

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

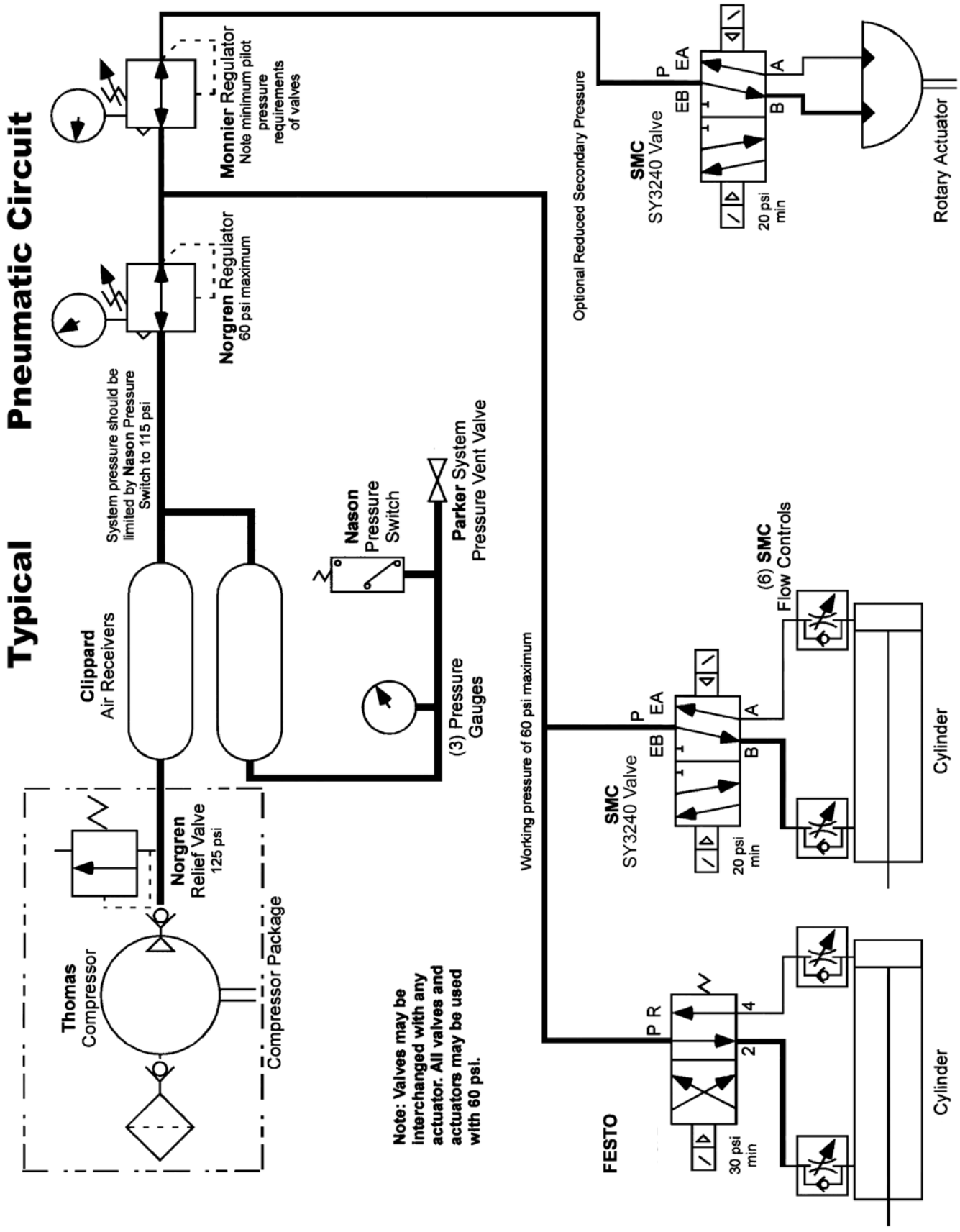
The catalog for the rotary actuator (which includes its dimensions) can be found at
http://www.bimba.com/Products/PneuTurn/PneuTurnActuators/

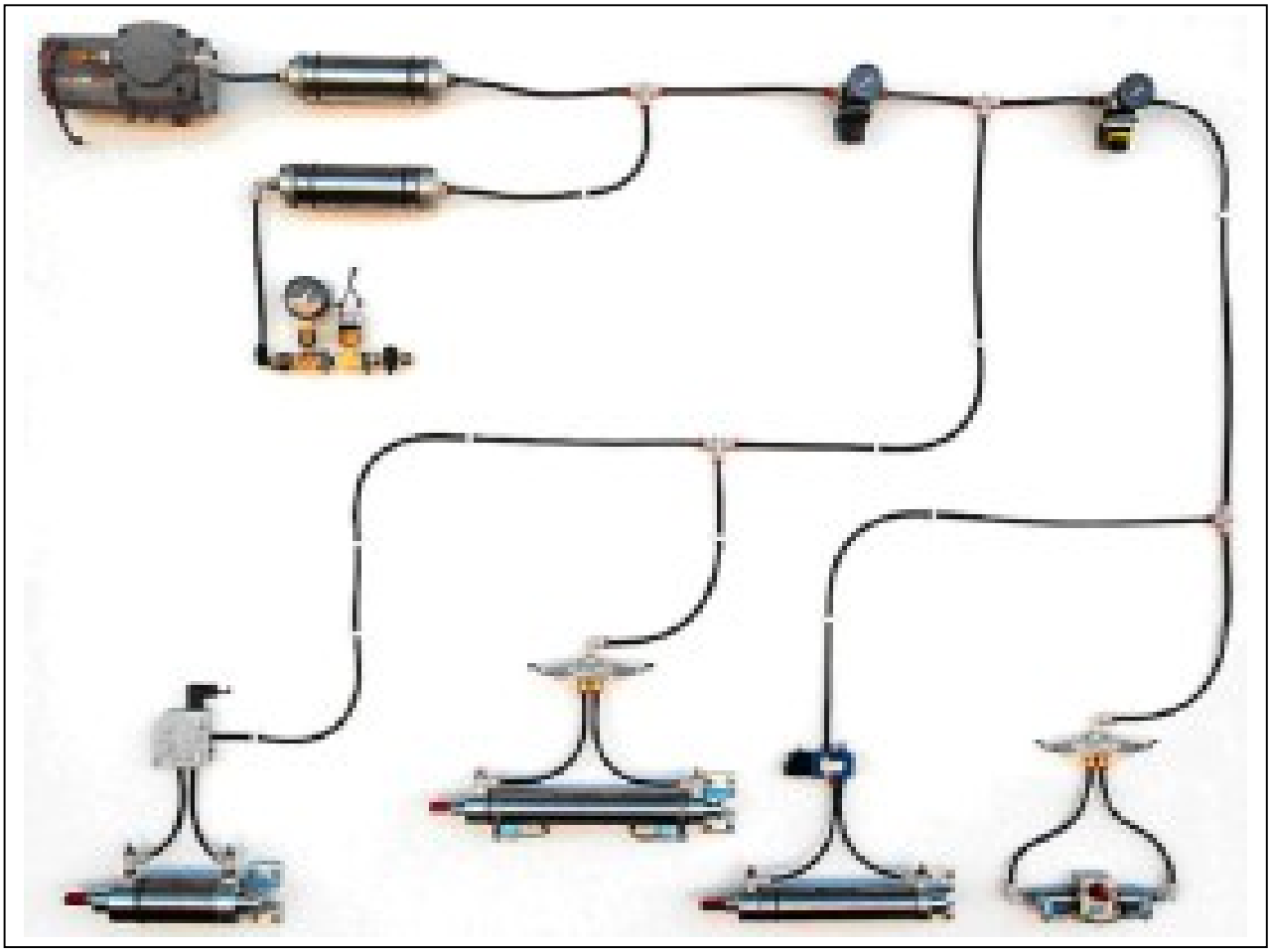
Vacuum Equipment

PIAB Vacuum Products has donated a suction cup and a P2010 vacuum pump to the kit for the 2007 competition. **PIAB Vacuum Products** included the specification sheets for the cup and the vacuum pump in the kit, but they can also be found at the following sites:

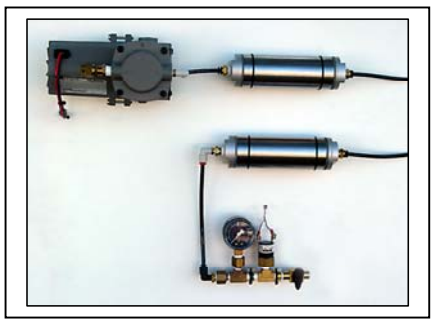
- http://www.piab.com/Templates/WebBase/Datasheet.aspx?id=10135 for the cup
- http://www.piab.com/Templates/WebBase/Datasheet.aspx?id=10209 for the pump

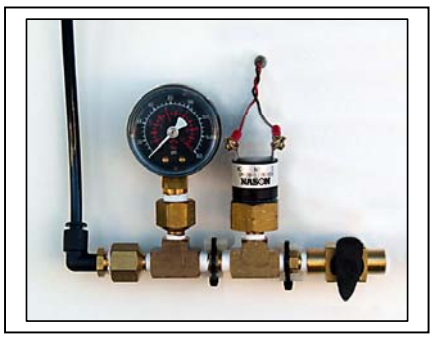
Vacuum technology allows parts to be picked up be generating a pressure that is lower than surrounding air pressure. The vacuum cup will pick up items with slightly domed or flat surfaces. The rubber material in the cup gives a high friction coefficient to hold parts firmly in place. The 2.95” diameter pad has a maximum vertical lifting force of 50.6 pounds at 27 inches of mercury and a parallel lifting force of 57.3 pounds at 27 inches of mercury. The operation of the vacuum pump consumes air since it is a venture device. **Legris** has provided the fittings and **Freelin-Wade** has provided tubing that completes the vacuum kit.

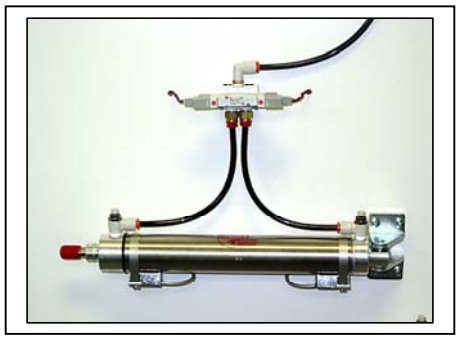

Typical Pneumatic Circuit
Monnier Regulator
Note minimum pilot pressure requirements of valves
Norgren Regulator
60 psi maximum
System pressure should be limited by Nason Pressure Switch to 115 psi
Clippard
Air Receivers
Nason
Pressure Switch
Parker System
Pressure Vent Valve
(3) Pressure Gauges
Norgren
Relief Valve
125 psi
Thomas
Compressor
Compressor Package
Optional Reduced Secondary Pressure
SMC
SY3240 Valve
P
EA
EB
A
B
20 psi min
Rotary Actuator
Working pressure of 60 psi maximum
(6) SMC
Flow Controls
Cylinder
Note: Valves may be interchanged with any actuator. All valves and actuators may be used with 60 psi.
FESTO
P R
2
4
30 psi min

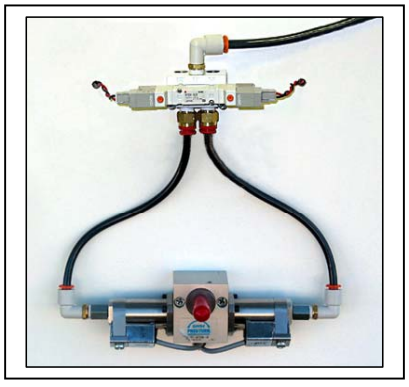


Details of the previous photo are below.









FIRST
Pneumatic Component
Bill of Material

Vendor	Quantity Per Kit	Part Number	Product Weight	Description
SMC				
SMC	2	SY3240-6HZ-X70	3.0 oz.	Double solenoid valve-12vdc complete
SMC	1	SY3240-	3.0 oz.	Single solenoid valve- 12vdc, complete
SMC	3	SY3000-27-1T	2.0 oz.	Sub plate for double solenoid valve
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	0.5 oz.	Male, 90 degree Elbow 5/32" tube 1/8"NPT
SMC	1	KQ2H03-34S	0.5 oz.	Male Conn., 5/32" tube- 1/8"NPT
Freelin-Wade				
Freelin-Wade	1	1J-151-046	1.5 oz.	1/4" OD tubing – 100’
Freelin-Wade	1	XX-156-XX	0.3 oz.	4mm tubing, 15’
Parker Brass Div.				
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"
Norgren Kit				
Norgren	1	16-004-011	5.1 oz.	120 psi relief valve
Norgren	1	R07-100-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
Festo Valve	1	VPLE18-M5H-4/2-1/4	3.3 oz.	Single solenoid valve
Clippard	2	AVT-32-16	14 oz.	Volume Tank 2" bore by 6" length
Nason	1	SM-2B-115R	2.1 oz.	Pressure switch
Monnier				
Monnier	1	101-3002-1	3.2 oz.	Secondary pneumatic regulator
Monnier	1	13536	1.2 oz.	Regulator mounting bracket and nut
Wika	1	9690242	4.0 oz.	Pressure Gauges
Lord Corporation	3	SMB003-0100-2	0.3 oz.	Vibration isolators for compressor
HPE Automation	1	HPE	0.2 oz.	1/4" by 100" Teflon Tape
Thomas	1	405ADC38-12	4.75 lbs.	Compressor
PIAB Vacuum				
PIAB Vacuum	1	FC75P.4E.07UF	1.59 oz.	Suction cup
PIAB Vacuum	1	01.07.996	0.54 oz.	Vacuum pump
Legris	2	3011 04 10	0.25 oz.	4mm male fitting
Bimba	3	Special order Cylinders		Not included in the kit

Thank you to the following companies who provided parts for the 2007 Kit of Parts:

Bimba Manufacturing
Clippard Instrument Laboratory, Inc.
Festo
Freelin-Wade
HPE Automation
Legris
Lord Corporation
Monnier, Inc.
Nason Corporation
Norgren
Parker Hannifin, Inc.
PIAB Vacuum Products
SMC Pneumatics, Inc.
Thomas Industries, Inc.
Wika Instrument

Web Sites for Product Suppliers and Kit of Parts Supporters are as follows:

Bimba Manufacturing	- http://www.bimba.com
Clippard Instrument Laboratory, Inc.	- http://www.clippard.com
Festo	- http://www.festo.com
Freelin-Wade	- http://www.freelin-wade.com
HPE Automation	- http://www.hpeco.com
Lord Corporation	- http://www.lordmpd.com
Legris	- http://www.legris.com/
Monnier, Inc.	- http://www.monnier.com
Nason Company	- http://www.nasonptc.com
Norgren	- http://www.norgren.com
Parker Hannifin, Inc.	- http://www.parker.com
PIAB Vacuum Products	- http://www.piab.com/
SMC Pneumatics, Inc.	- http://www.smcusa.com
Thomas Industries	- http://www.thomasind.com
Wika Instruments	- http://www.wika.com
FPEF	- http://www.fpef.org

PLEASE NOTE: Information in this guide is intended to provide assistance and advice.
It does not supersede any rules or statements made in the 2007 Robotics Competition Manual.

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 = ¾” 17 = 1 ½” 31 = 2”	0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12, 24	DP for ¾” DP for 1 ½” 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 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 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