

Thanks to these fluid power
manufacturers & associations for product support
in the **2002 Robotics Competition:**

- SMC Pneumatics, Inc.
- Bimba Manufacturing Co.
- Parker Hannifin Corporation
- Clippard Instrument Laboratory, Inc.
- Festo Corporation
- Norgren
- Monnier, Inc.
- Dresser Instrument (Ashcroft)
- Thomas Industries
- Hobbs Corporation
- Fluid Power Educational Foundation
- National Fluid Power Association
- Fluid Power Society
- Fluid Power Distributors Association



FIRST™

**The Pneumatic
Manual for**

First 2002 Competition



The Advantages of Using Pneumatics in 2002

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 motor. 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 additional valve and cylinder combinations, 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 13, 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 are rated 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 60 psi, you can get 180 pounds of force. As you can see, your options are wide open.

Custom Cylinders

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 2002 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. Dean likes to refer to the boxes of parts that you get as 140 pounds of junk. This year, none of the pneumatic components are junk. Many of the major components have been manufactured exclusively for this year's competition.

COMPRESSOR

We have the same compressor provided by **Thomas Industries** that we had last year. The compressor will put out approximately 120psi before the **Norgren** relief valve opens. Because the compressor can produce a significant amount of vibration, we have included vibration isolation mounts donated by the **Lord Corporation**. These are in the pneumatic parts kit. They can be screwed directly into the feet of the compressor. 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 center line of these feet to the rear foot is 5.19". A spike relay should be used to control the power to the compressor. Ensure that the relay is programmed to provide "forward" power only to the compressor. Do not reverse the compressor!



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

PRESSURE SWITCH

We have pressure switches manufactured by **Hobbs Corporation**. This switches come preset from the factory at 110 and 115psi. The setting is marked on the side of the switch. The pressure setting of the switch may be changed, if desired, by removing the rubber plug at the end of the switch and adjusting it with a hex head wrench. To wire the switch, just loosen the screws and attach your wires. The switch is normally closed. That means that current will flow until it reaches its set pressure and then the switch will open.

We have included two switches. The logic is that if the compressor is running, both switches would need to open to turn the compressor off. If the compressor is off, then both switches would have to close before the compressor would turn on again.



**Warning: The switch is not capable of handling the current of the compressor.
Always wire it as an input to the controller.**

TANKS

We have some great tanks from **Clippard Instruments**. They are small and may be mounted almost anywhere on your robot. The kit comes with two tanks. They should be mounted right after the compressor, before the Norgren main relief valve.



REGULATORS

Norgren has donated the primary 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. The 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 use reduced pressure if you have a use for it. This regulator must be placed after the Norgren regulator. Also, look at the top of the regulator. 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. Make sure that you use the teflon tape so that it doesn't leak.

ELECTRIC VALVES

There are two types of electric valves in your kit from **SMC Pneumatics**. The first one is called a single solenoid valve. (It has only one set of wires and is white in color.) There is only one of this valve in the kit. The only 1/8" NPT port on this valve is the pressure port. The valve already has fittings in the ports to the cylinders. The ports are marked on the face of the valve near the port. Find the "P" port on the bottom of the valve. This is where you connect the pressure line to the valve. The ports on each side are exhaust ports and do not require any fittings. Find the "B" port on the opposite side of the valve. If you do not energize the valve with 12 volts, the air will come out this port. Plumb this port to the rod end of the cylinder if you want the cylinder retracted when the valve is de-energized. Find the "A" port of the valve and plumb it to the opposite end of the cylinder. If there is pressure in the system press the orange button on the valve, which is called the manual override, and the cylinder should extend. Let up on it and the cylinder will retract. Apply 12vdc to the valve and the cylinder should extend just like it did when you pushed the manual override.



Tip: Always use at least 20psi or valve operation could be erratic.

The second **SMC** valve is called a double solenoid valve. There are two of these in the kit. 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 would maintain its position until you turned on the opposite solenoid. One last thing--Always avoid turning on both solenoids at the same time. While this won't hurt the valve, you can not be sure which way the spool will shift.



FESTO Corporation has also supplied a single solenoid valve. You will have to assemble this valve package. ***The fittings are special and will only work with this valve! Do not attempt to thread them into any other component!*** There is an instruction sheet in the valve package that will tell you how to put the valve together. As this valve is bigger you may want to use it if the cylinder you are moving needs to move at a higher speed than the others.



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 by just opening it.



PRESSURE GAUGE

SMC donated the extra pressure gauge. It will allow you to measure the system pressure upstream from the regulators.



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.



TUBING

SMC Pneumatics has donated the tubing.

KIT CYLINDERS

We have included a cylinder from **Bimba 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.



CUSTOM CYLINDERS

You will be able to order custom cylinders for your robot again this year. You have a choice of 3/4" bore (diameter), 1-1/2" bore and 2" bore. You can also order the amount of stroke. (See ordering sheet) This will significantly increase your ability to design a great robot. All of the bore and stroke models are in stock and the manufacturers are ready to ship directly to your team.

***Please use great care in filling out the form when ordering. The cylinders will be shipped to the address on the order form. If the address is wrong--no cylinders will arrive at your team.**

Quantities of custom cylinders will be limited to approximately 4 per team to insure that custom cylinders will be available late in the 6 week period.

How to calculate the retracted and extended length of a cylinder

Look at the drawing of the 1-1/2" bore cylinder (page 8). 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:

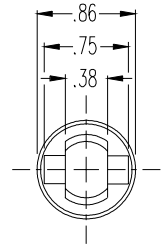
Base dimension	= 4.38"
Stroke	= 8.00"
Locking nut width	= 0.25"
<u>Clevis dimension</u>	<u>= 1.31"</u>
Pin to Pin Retraction	= 13.94"

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

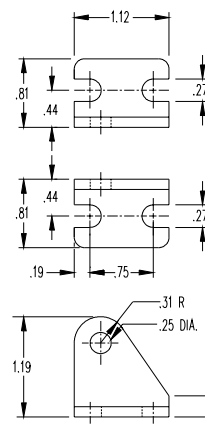
Pin to Pin retracted	= 13.94"
<u>Stroke</u>	<u>= 8.00"</u>
Pin to Pin Extended	= 21.94"

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

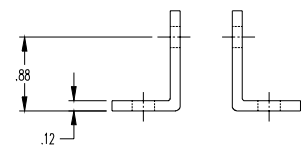
3/4" Bore



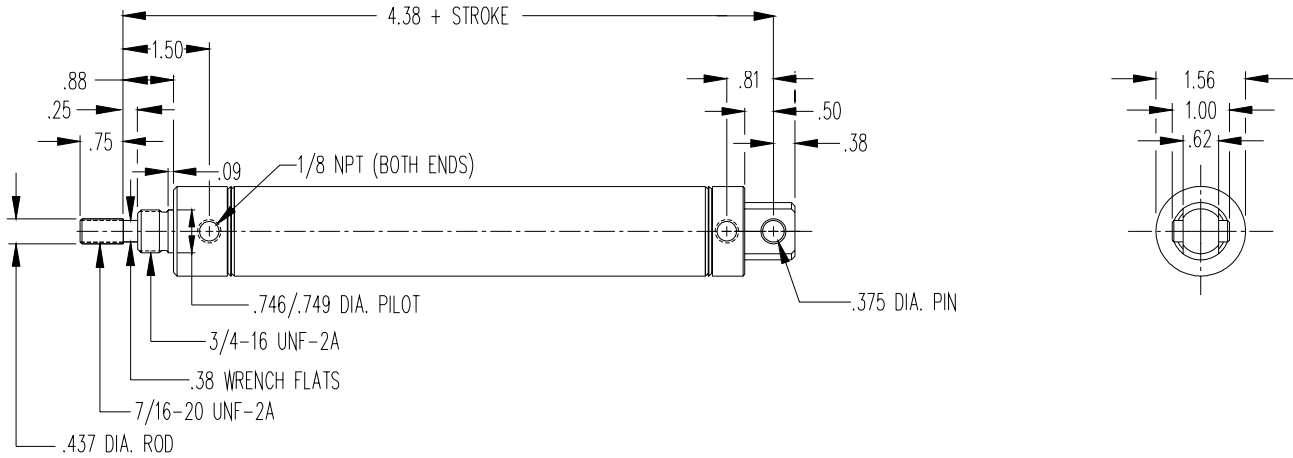
Rod Clevis



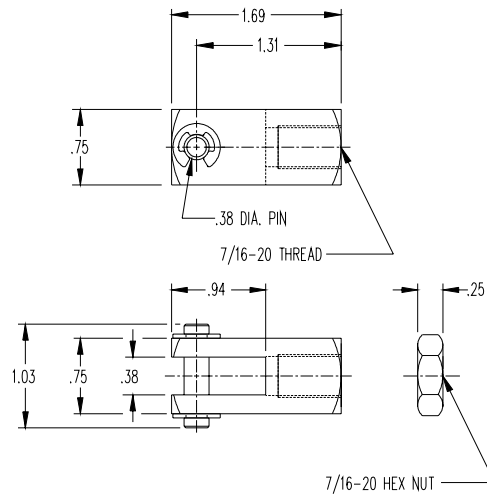
Pivot Brackets



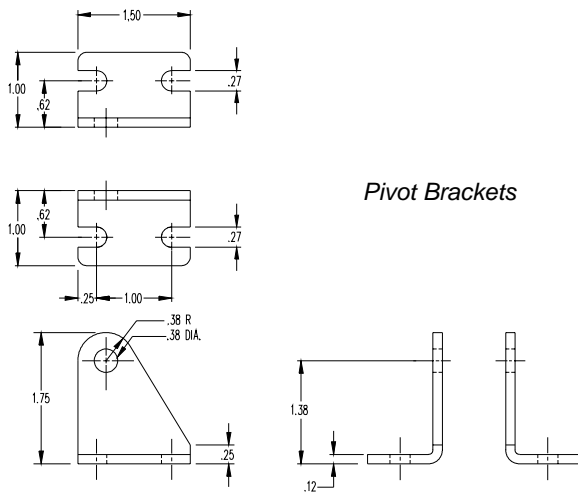
1-1/2" Bore



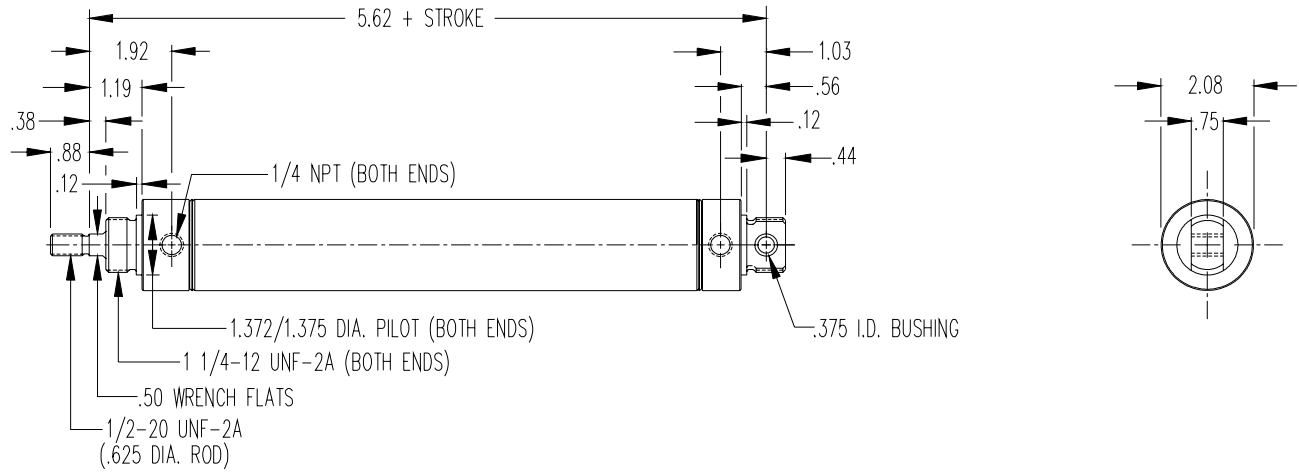
Rod Clevis



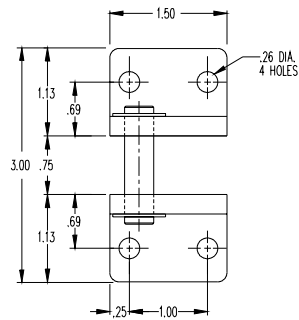
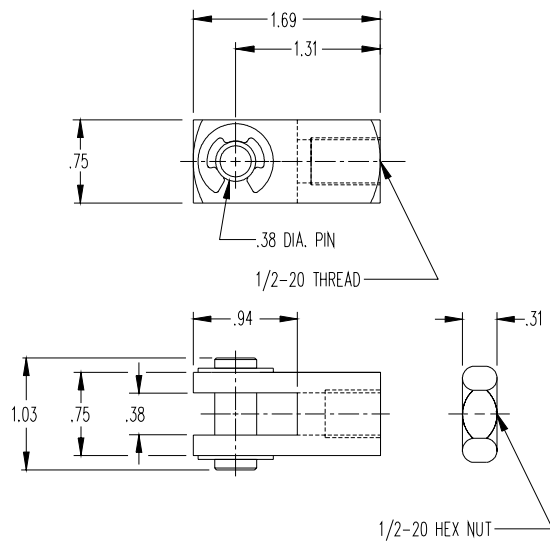
Pivot Brackets



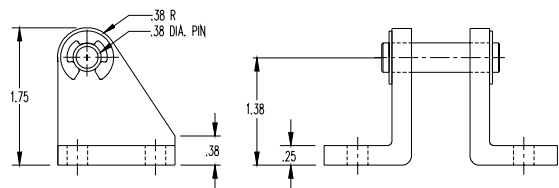
2" Bore



Rod Clevis

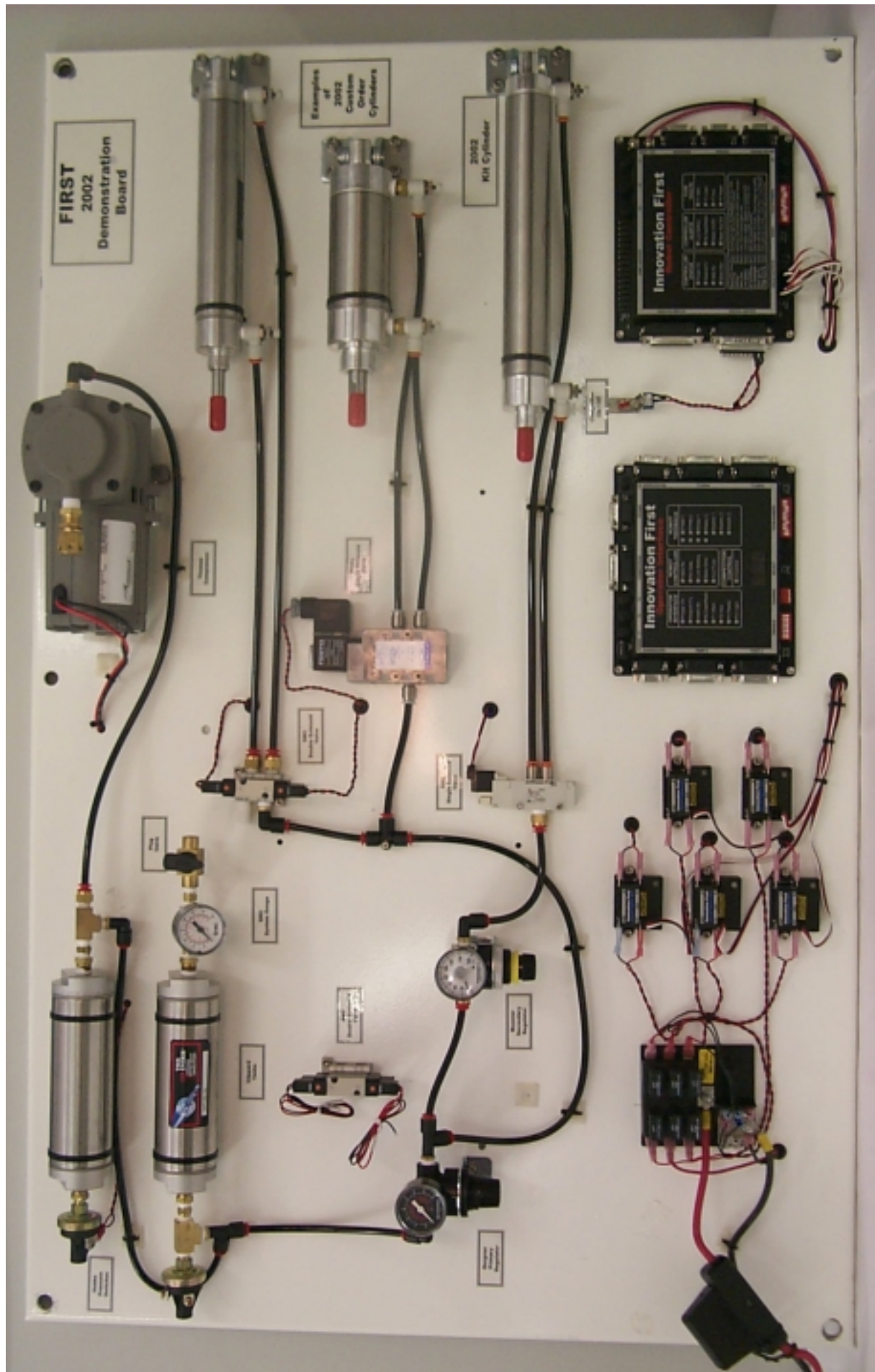


Pivot Brackets



Extend and retract forces of all three bore sizes

	3/4" Bore	3/4" Bore
Pressure	Force Extended	Force Retraced
(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 Retraced
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 Retraced
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 2002 Demonstration Board

FIRST

Pneumatic Component

Bill of Material

Manufacturer	Quantity	Part Number	Product Weight	Description
			Each	
Bimba	1	178-DP	7.3 oz.	Cylinder 1.5" bore x 8" stroke rear pivot mount
Bimba	1	D-231-1 Pivot bracket	1.6 oz.	Cylinder pivot bracket set
Bimba	1	D-229	1.0 oz.	Cylinder rod clevis
Clippard	2	AVT-32-12	14 oz.	Volume Tank 2" bore by 6" length
Festo valve kit	1	MFH-5-1/8	10.6oz.	Solenoid valve kit with fittings
Thomas Compressor	1	405ADC38-12	4 lbs.- 12oz.	Compressor
Norgren Relief	1	16-004-015	On Compressor	120 psi relief valve
SMC Pneumatic Kit				
SMC	1	K40-MP1.0-N01S	2.2 oz.	System gauge 0-160 psi
SMC	2	NVJ5243Y-6G-01T	3.0 oz.	Double Solenoid Base Ported Valve
SMC	1	VQZ2121-6L-N7T	3.9 oz.	Single Solenoid Body Ported Valve
SMC	6	NAS2201F-N01-07S	0.6 oz.	Flow Control
SMC	20	KQH07-34S	0.3 oz.	Fitting, Straight 1/4 Tube
SMC	20	KQL07-34S	0.4 oz.	Fitting, 90 Elbow 1/4 Tube
SMC	5	KQT-07-00-Y	0.2 oz.	Fitting, Tee Union 1/4" Tube
SMC	5	KQY07-34S	0.5 oz.	Fitting, Male Run T 1/8 NPT ~ 1/4 Tube
SMC	1	TIUB07B-20	1#	1/4" OD tubing - 20 meters
Parker Brass Kit				
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"
Additional Kit				
Lord Corporation	1	SMB003-0100-2	0.3 oz.	Vibration isolators for compressor
Hobbs	1	76065-110	2.1 oz.	Adjustable pressure switch set at 110 psi
Hobbs	1	76065-110	2.1 oz.	Adjustable pressure switch set at 115 psi
Norgren	1	R07-153-RNEA	4.7 oz.	Main regulator w/60psi max output
Norgren	1	18-013-212	1 oz.	0-160 psi gauge for Norgren regulator
Norgren	1	18-025-003	0.7 oz.	Regulator mounting bracket and nut
Monnier	1	101-3002-1	3.2 oz.	Secondary pneumatic regulator
Monnier	1	13536	1.2 oz.	Regulator mounting bracket and nut
Dresser/Ashcroft	1	0-160 psi	2.2 oz.	0-160 psi gauge for Monnier regulator
Teflon tape	1			1/2" by 100"
Approximate weight calculations for custom cylinders, not including the rod clevis or pivot brackets:				
3/4" Bore	0.21 lbs. + 0.03 lbs. per inch of stroke			
1/2" Bore	0.73 lbs. + 0.08 lbs. per inch of stroke			
2" Bore	1.62 lbs. + 0.15 lbs. per inch of stroke			

The following companies provided product for the 2000 Competition:

Bimba Manufacturing
Clippard Instrument Laboratory, Inc.
Dresser Instrument/Ashcroft
Festo
Hobbs Corporation
Lord Corporation
Monnier, Inc.
Norgren
Parker Hannifin, Inc.
SMC Pneumatics, Inc.
Thomas Industries, Inc.

Web Sites for Product Suppliers and Associations

Bimba Manufacturing	- www.bimba.com
Clippard Instrument Laboratory, Inc.	- www.clippard.com
Dresser Industries/Ashcroft	- www.dresserinstrument.com
Festo	- www.festo.com
Hobbs Corporation	- www.hobbs-corp.com
Lord Corporation	- www.lordmpd.com
Monnier, Inc.	- www.monnier.com
Norgren	- www.norgren.com
Parker Hannifin, Inc.	- parker.com
SMC Pneumatics, Inc.	- smcusa.com
FPDA	- www.fpda.org
FPEF	- www.fpef.org
FPS	- www.ifps.org
NFPA	- www.nfpa.org

FIRST Custom Cylinder Order Form

Team Number _____ Team Name _____

Person Ordering Cylinders _____

For Order Confirmation:

Phone Number: _____

Fax Number: _____

E-Mail Address: _____

Ship to Address: _____

City: _____

State: _____

Zip Code: _____

****Important****

Please be sure that all information is correct. Cylinders will be shipped to above address.

Is this address:

☐ Standard Shipping address ☐ For this order only ☐ To be used from now on

Instructions: Place the quantity needed in the square next to the bore size and below the stroke length that you require.

Stroke Length

Bore Size	1/2"	1"	1-1/2"	2"	2-1/2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"
3/4" Bore										N/A		N/A		N/A	N/A
1-1/2" Bore															
2" Bore														N/A	

*All cylinder orders include clevis, jam nut and pivot brackets.

FAX ORDER TO THIS NUMBER: 954-429-9515

Back up fax number: 954-429-0858

email address: fhord@hpeco.com

In case of emergency only--Phone: 954-429-9560