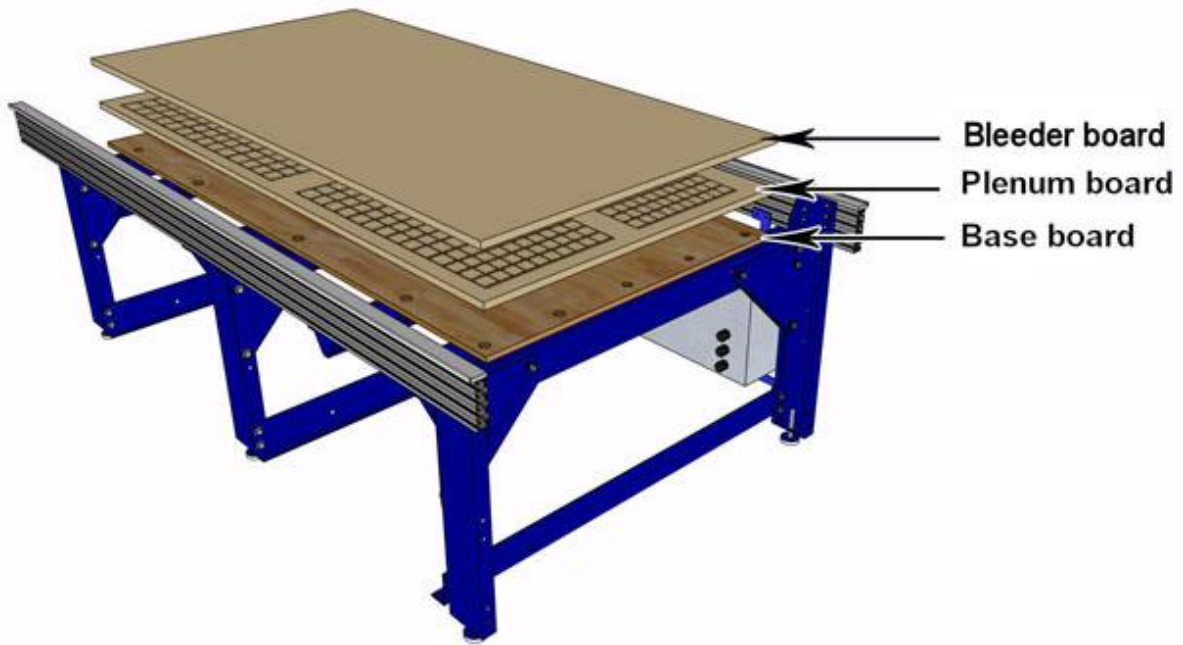


ShopBot Vacuum Hold Down System



Vacuum Pump (installed under the table)



Vacuum Zone Control Manifolds

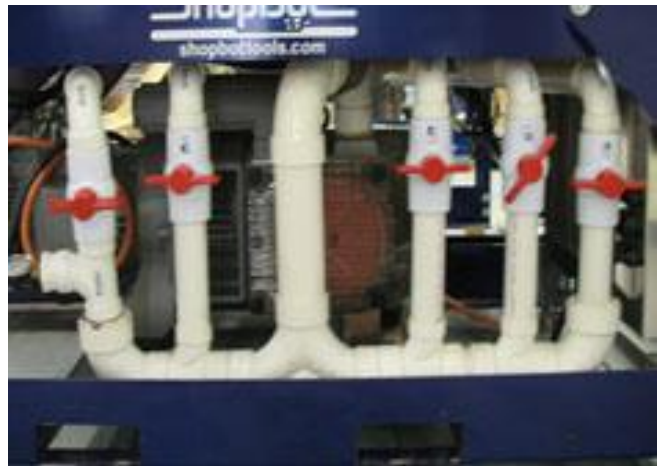


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Overview

Vacuum System Information

The vacuum hold down system consists of the blower and associated plumbing. Depending on the type of vacuum system, the setup may include:

- Vacuum plenum and a bleeder/spoil board
- Fixtures and templates
- Vacuum motor(s)

Types of Vacuum Systems

There are two general strategies for the use of vacuum in holding parts down for cutting or machining with a CNC router. While there are certainly more strategies than this, the two systems covered here are:

- Conventional
- Universal

Note: On ShopBot machines, the bleeder board is also a replaceable spoil board. For the purpose of this document, this top board will be referred to as a bleeder.



This photo is an example of a custom conventional vacuum plate used for a single production part run. The black material is gasketing used to seal the area to be secured by vacuum hold down. These will only work for shapes that are larger than the gasketed area

Conventional

The conventional vacuum solution is typically the more affordable, but often less practical, option. It makes use of a high vacuum (20-29”Hg) low flow volume motor. This works well for machining parts that do not use through-cuts. A limitation of conventional systems is that a small leak will cause a large drop in vacuum power, making the holding force inadequate and potentially interrupting operations, thus a good vacuum seal is imperative to hold parts securely.

For mass production, these vacuum templates are quite useful, simply requiring the plate to be swapped out for a new part. Having a number of these plates does however increase setup time and a need for plate storage. When using conventional techniques, there are many different options for devices to produce the vacuum. A few of the most common are listed on the next page.

- Shop vacuums
- Compressed air venturi vacuum pump
- Small squirrel cage blower
- Rotary vane blower

Conventional vacuum solutions tend to be specific to the application or production process they are being made for and are usually custom designed by each shop. The plenum system described below is used in conjunction with vacuum templates in a conventional system, even though it is designed for creating universal vacuum with a bleeder board.



This is ShopBot's in-house vacuum setup. Notice that the bleeder board has been damaged by the cutter. This board is thick enough to allow resurfacing and will eventually be replaced when the surfacing has made it too thin.

Universal

In contrast to conventional vacuum systems, universal systems have the advantage that specific sealed vacuum fixtures or templates are not necessary. This allows for a piece of material to be set on the table and the vacuum to be applied with enough holding force to allow cuts.

Both the surface area of material, and square footage of vacuum suction, affect holding force. This relationship is adjustable on multi-zone set-ups by reducing the number of zones used. If zones are located directly under parts it eliminates extra vacuum bleed-off from unused zones. This system works well as long as the required airflow does not exceed the specifications of the particular blower.

The universal system does not require a vacuum template. Quick part changeovers are possible because material is placed directly on the bleeder board. The universal solution depends on relatively powerful and expensive industrial blowers/pumps to achieve the required airflow. These large industrial blowers have the drawback of typically requiring 3-phase power. The installation instructions in this document are for a universal system using either a positive displacement or regenerative blower.

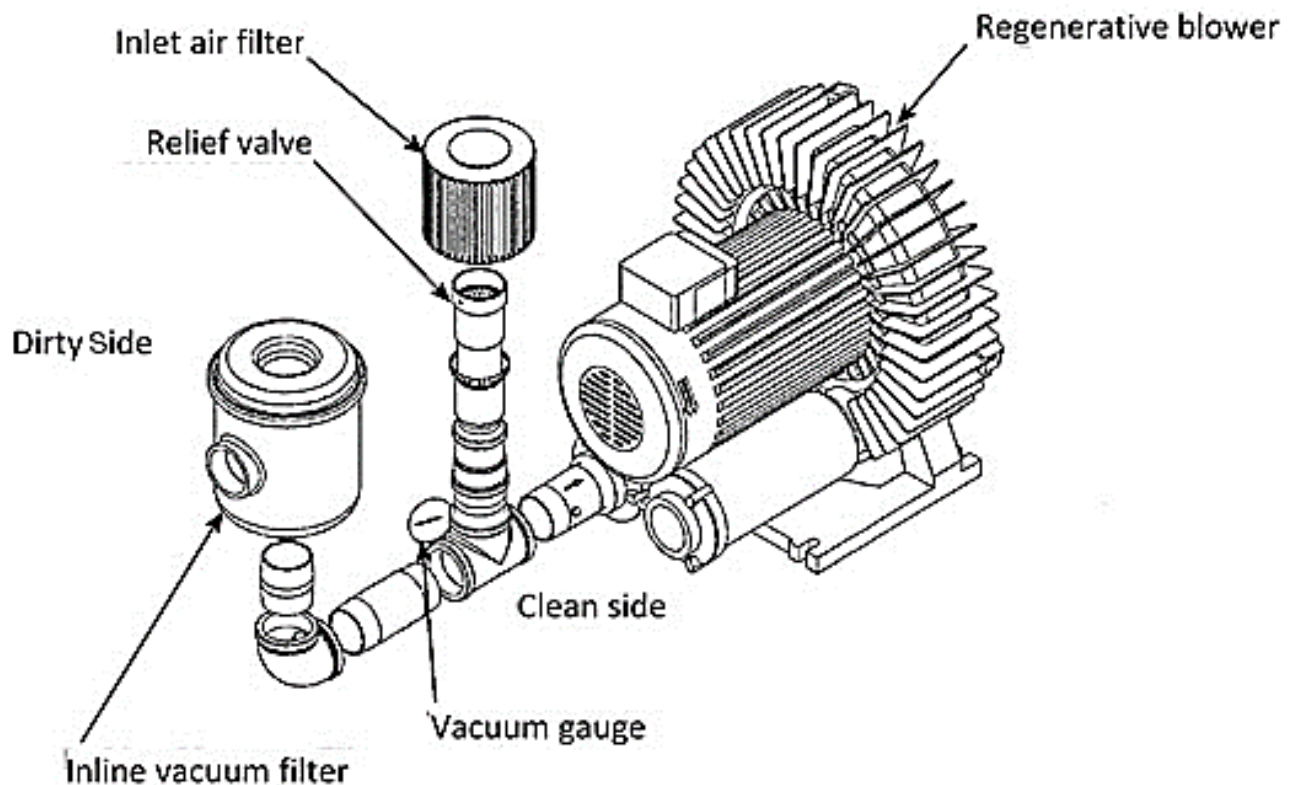
Understanding the Input Plumbing

It is helpful to understand the purpose of the various input plumbing components on the blower. Knowing how they work can help prolong the life of the blower. It is also important to understand that the system has a dirty side and a clean side that is separated by the inline filter. The plumbing from the inline filter to the blower must remain clean and must contain a relief valve just in case the inline filter becomes clogged.

There is a relief valve connected to the input plumbing. Its purpose is to protect the blower from exceeding its maximum vacuum. The valve should be installed between the inline filter and the blower as close to the intake as possible.

There is an inlet filter on this relief valve to prevent debris from entering the blower when the valve opens. If debris enters the blower it can cause premature failure. The arrow on the valve (indicating the direction of airflow) should point toward the pipe that leads to the blower input. If the valve is mounted too far from the blower inlet or if the pipe is smaller than specified, then the valve may not open at the vacuum level that it was calibrated for, possibly resulting in a catastrophic blower failure. The valve is calibrated for the ShopBot vacuum table and no adjustment should be necessary. There is a vacuum gauge near the blower inlet to monitor the system's performance.

There is also an inline filter positioned between the blower and manifold, this filter is a critical part. This filter prevents any debris from entering the blower through the plenum. It needs to be checked regularly and kept clean to allow the blower to work at full efficiency.

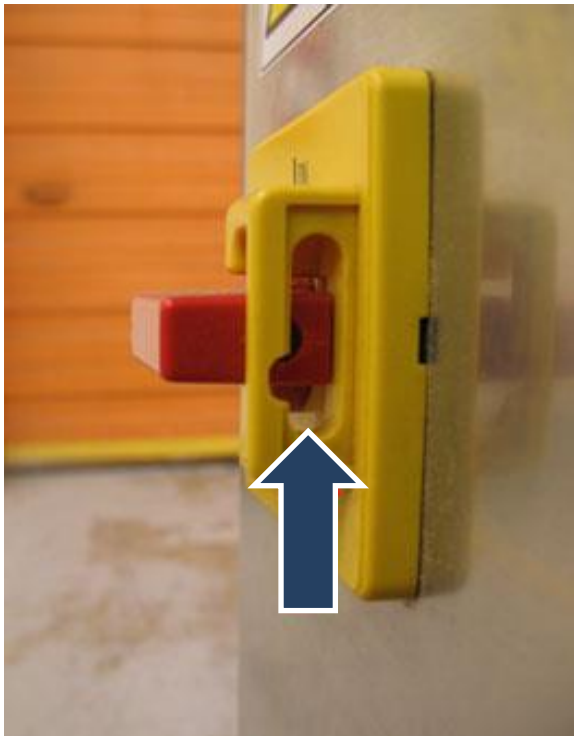


Safety

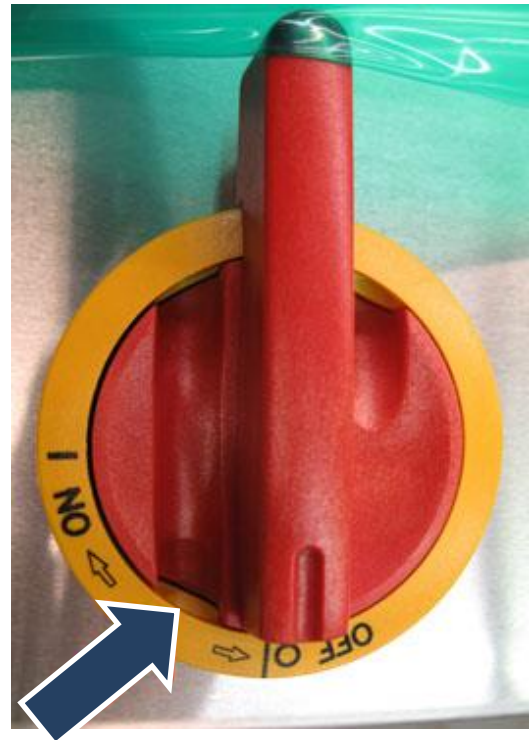
During Installation

STOP! here and be sure the lock out/tag out processes are well understood before proceeding. More information and training is available from OSHA. See <https://www.osha.gov/SLTC/controlhazardousenergy/program.html>.

Turn off the electrical power before making electrical connections to the blower by using a lock out/tag out system. This should be done at both the control box locations (shown below) and at the breaker box. A licensed electrician should make all electrical connections.



Old style switch lockout location



New switch lockout location

During Operation

- Stay clear of blower inlets and outlets. The exhaust gets extremely hot. Contact with the hot exhaust pipe can cause burns.
- Do not use PVC components on the outlet of the blower as they might melt and cause a fire.
- If exhaust must be routed to another location, use metal pipe and locate the pipe in an area that people will not contact and burn themselves on it.

Wear adequate hearing protection when the blower is in operation.

Step 1 – Gather Parts and Supplies

Table Materials

Provided with machine:

- 3/8" by 1 1/2" carriage bolts, washers, lock washers, and nuts.

Customer supplied:

- Deck – 3/4" plywood
- Plenum – 3/4" MDF
- Bleeder board – 3/4" Trupan or other porous material

Piping and Valves

If the vacuum and piping system is ordered as a complete unit, it will come with all necessary parts except for very long pipe sections. If these long pipe sections are needed it is much more cost effective to source them locally and cut to length, as the location of the vacuum blower varies.

The kit comes with:

- Manifold (pre-assembled or kit)
- Table piping
- Flanges

If the machine is used with a different vacuum source or different table configuration, additional parts may need to be purchased. Always dry fit the sections and mock-up the setup before installing to reduce trips to the store. Always double-check lengths before cutting.

Vacuum Blower

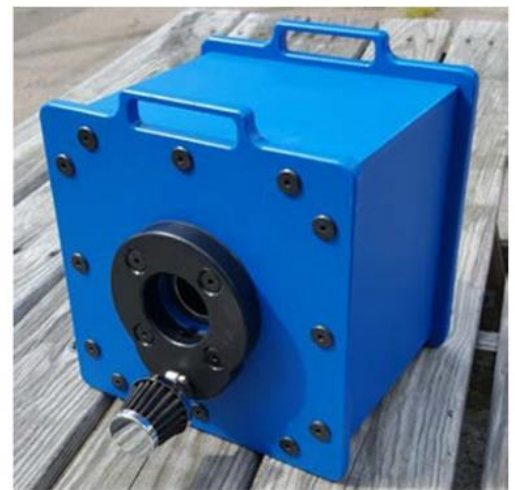
There are many different options for vacuum systems, some commonly used systems are listed below:

1. Regenerative vacuum blower
2. Rotary vane vacuum pump
3. ShopBot Vacuube™ System (shown in the photo)

Safety Notice



In order for the Vacuube to function safely and properly, this system requires unrestricted airflow in an open space. In the event of improper ventilation or overheating, the motor is designed for automatic shut-off. If this occurs, allow the unit sufficient time to cool and then remove any enclosures or obstructions to the side or top ventilation slots. Once unit is obstruction-free, resume operation. If repeated shut off occurs, contact ShopBot Tools Technical Support for assistance. DO NOT open enclosure or modify the unit in any way.



Step 2 – Install Deck and Plenum Board

Install Deck Board

The deck is the center support board(s) for the work area. It is recommended to have about 1” of material overhang past the end support at each end. The Y-axis measurement for all table sizes is 6.75” in from the inside face of the front table side.

First, clamp the deck layer into position, then, from under the table, drill a 1/8” pilot hole through the deck boards. Use the holes in the upper end cross supports, and alternating holes in the center cross supports, as a template.

Counter bore the holes on the top of the deck with a 1” spade bit, bore deep enough for the head of a carriage bolt to be just below the surface. Then drill through the 1/8” pilot holes with a 3/8” bit.

Insert 3/8” x 1 1/2” carriage bolts down through the deck board, upper end cross supports, or center cross support, and attach with flat washers, lock washers, and nuts. This will provide a good base for the vacuum table setup.

Install Plenum Board

Note: For this document, it is assumed that a sheet of MDF will be used for the vacuum plenum board. The following steps need to be done together to ensure assembly before wood glue dries, it is recommended to have another person or two to help during these steps.

Seal the 3/4” MDF plenum board to maintain the integrity of the vacuum system. It is recommended that, at a minimum, the bottom and sides of the MDF plenum board are sealed with a high-quality wood glue. Titebond 3 is recommended. The best way to apply this glue is using a paint roller or other fast applicator. This allows for approximately 15 minutes of work time before the glue dries. A typical application uses about 1/3 of a gallon of wood glue.

Note: After the MDF vacuum table program is run, the cut surface of this board can also be sealed with the wood glue to minimize the vacuum leaks between zones for maximum efficiency. For normal installations, this is optional.

While the glue on the plenum is drying, apply a light layer of glue to the top of the baseboard and place the plenum on top. Hold the plenum down with weights, evenly across the surface, for about 30-40 minutes while the glue cures. The goal is to create an impervious surface to maintain the integrity of the vacuum system. This will help ensure there are no leaks and that the system works efficiently.

Note: If no weights are available, screws can be used, but they will have to be removed after curing. There is a 2” perimeter around the outside of the board if using the ShopBot plenum cut files. Space them 16” apart in this 2” width and fasten securely.

Bit recommendation: The choice of bits is partly dependent on the depth of cut. The plenum files included with the control software are designed to use a 1/2” diameter X 1” depth of cut, two flute, carbide tipped straight bit. This is Onsrud tool# 48-072 from the Starter Bit Kit.

- Once the cutter is centered over the desired hole location, hit the “Esc” key to exit keypad mode. Press the OK button to mill the hole. Once the hole is milled, a prompt will ask if the hole cut all the way through. If the material is thicker than expected, or the tool was improperly zeroed, simply type in ‘N’ and a second cut will be made 0.25” deeper. This can be continued until the tool cuts all the way through the bottom of the baseboard.

NOTE: A straight bit is required to make the vacuum holes.

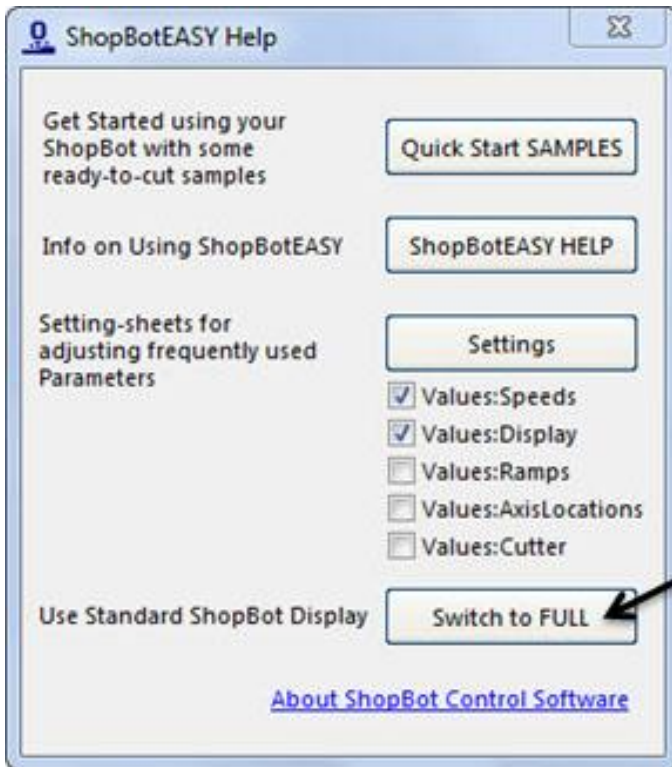


Standard Plenum Hole Placement

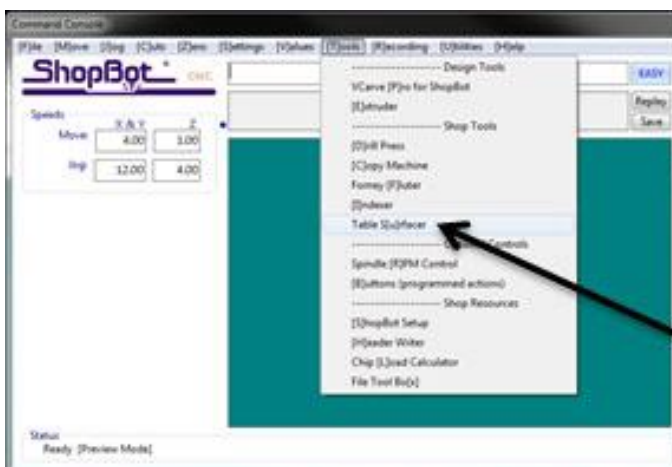
Step 3 – Install Bleeder Board

Surfacing the Bleeder Board

Both sides of the bleeder board will be surfaced during the following routine. Knowing how to create and run the surfacing file is important. First, start the ShopBot 3 control software.



If currently running in Easy Mode, go to the Full View by clicking the help button (the blue question mark) in Easy Mode, which pulls up the Help menu shown to the left. Now click “Switch to Full” to go to the standard ShopBot display.



From there, go to the tool menu and select the “Table Surfacer” as shown.

Fill in the values in the pop-up window and click to create the file. Once the file is saved, it can be run anytime that it is necessary to surface the table.

It is very important to properly prepare and evaluate the bleeder board. The lighter and more porous the bleeder board is, the more vacuum will pull through to hold down the part. Ultra light density fiberboard (ULDF) is one of the best materials to use, although MDF and even particle board can be used if needed.

Note: One of the best brands of lightweight MDF for this purpose is Trupan.

1. First, place the bleeder board on the plenum board and turn on the vacuum. It is a good idea to countersink a screw in each of the four corners of the board to prevent it from flexing or moving while it is being surfaced. Ensure the top of the screws are down deep enough to not be hit by the cutter during the surfacing toolpath. Surface the first side to remove the slick outer surface and reduce the thickness of the MDF. Remove the bleeder board from the table when finished. Make sure to clean up all debris and sawdust so that it does not get into the plenum and sucked into the system.
2. Next, seal between the bleeder board and the zones on the plenum with silicone caulk. Put the surfaced side of the bleeder board on the vacuum plenum being careful to position it precisely. Turn on the vacuum to pull the board down while the caulk dries. Once installed, seal the outside edges. If the edge is not sealed, there will be major air leaks, reducing the efficiency of the system.
3. Apply vacuum with all zones open and read the vacuum gauge. Subtract this number from the maximum vacuum and the result is the suction available to hold the part. A well-prepared bleeder board will use between 2"-4" Hg.

If parts are starting to move, more vacuum is required in the system. Another option is to take lighter cuts (reducing the force applied).

To increase the vacuum, either block off unused zones by shutting off the PVC valves to the unused zones, or physically block off an unused area with scrap material. Shower pan liner can be found at home improvement stores and is wonderful for blocking off areas when cutting oddly shaped/sized boards.

Valve labels are provided that are designed to help keep track of which zone each valve operates. Other methods, like numbering or color-coding, would work as well. Be aware these may need to be continuously refreshed as the bleeder board gets worn and is surfaced. Make sure not to do anything to impair the permeability of the bleeder board (such as applying paint).

Step 4 – Piping mock-up

The recommended placement of the vacuum blower is directly under the ShopBot table for easy pipe routing, though many ShopBot users place the blower in other locations near the ShopBot. For example, the blower can also be installed in another room to reduce noise.

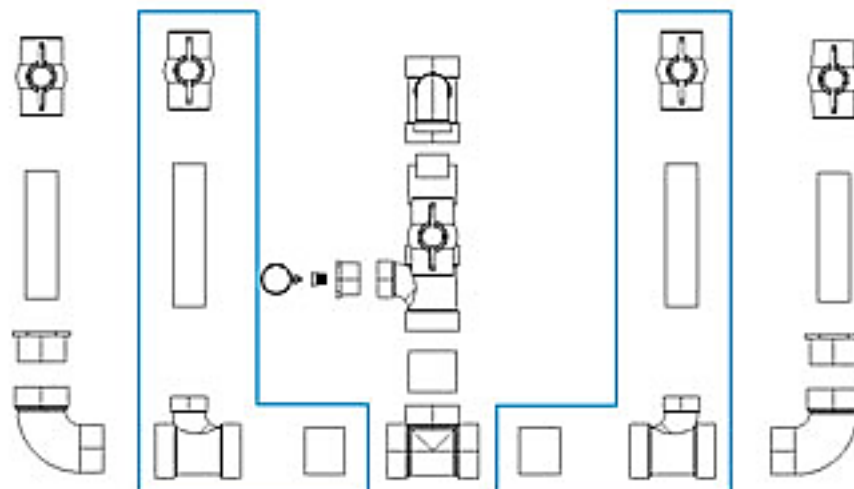
Once the blower installation location has been determined, mock-up the piping to the zones on the table. The blower piping pieces will have to be cut to size, so it is recommended that the PVC is dry fit first and not cut until ready to install. The dry fit step is important for proper placement of the holes for the pipe flanges. The holes will be cut in the next step. Do not assemble anything other than the parts shown in the manifold diagram. All other parts must be dry fit during final assembly before attachment.

On most tools, the manifold comes pre-assembled according to the number of zones ordered.

If the tool ordered uses a 12" Z or greater in height, the manifold will not be pre-assembled. While it should be pre-cut to the correct sizes, it is also important to dry fit this before gluing all together.

Once the manifold is secured to the machine, dry fit the piping to find the optimal flange and blower placement. There is an additional diagram on manifold assembly and piping located in the Appendix at the end of this document.

Note: A four zone vacuum manifold is shown for reference. These drawings may differ from the manifold you receive (this is the most common layout). Two zone vacuum systems will not have the components marked as add-on zones. Vacuum systems with more than four zones will have additional add-on zones that can be inserted next to either of the add-on zones shown in the drawing below.



Optional zones are in blue. Up to 6 additional zones can be added in between the two outer zones

Vacuube™ Connection to Manifold

To connect a single phase Vacuube™ pump to a manifold, connect the included flexible hose to the manifold using the following PVC/adaptor arrangement. Use the flexible rubber coupling to secure the hose to the 2.5" PVC tube. More tubing may be needed depending on the location of the Vacuube™. This tube connects to the 2.5"-3" adapter in the manifold.

Safety Notice



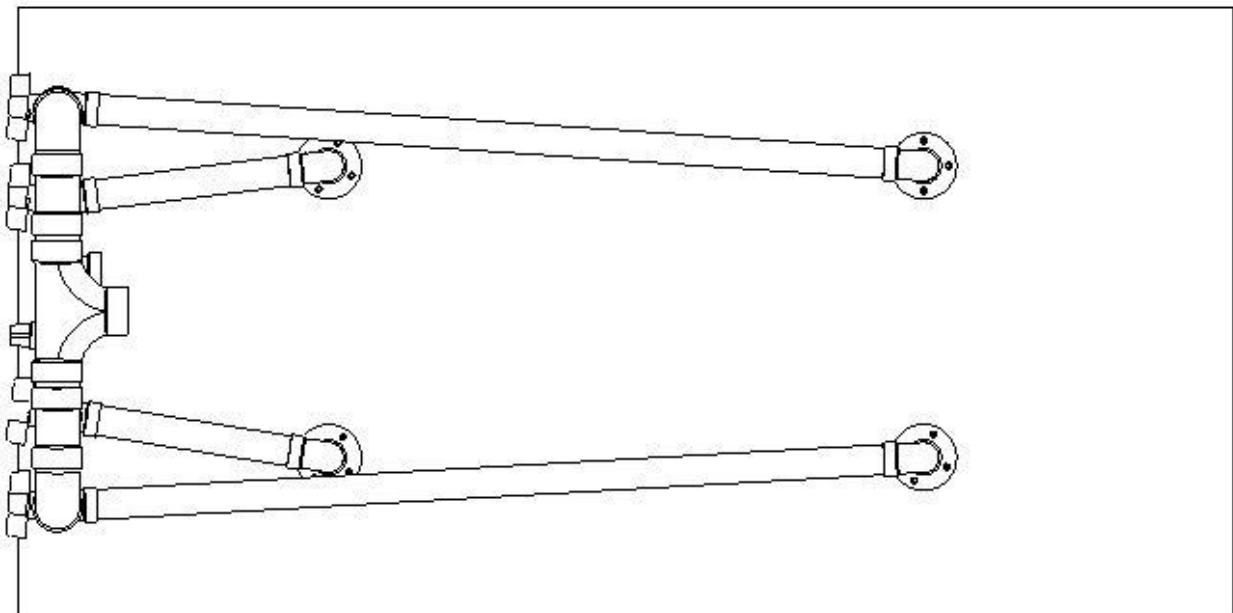
In order for the Vacuube to function safely and properly, this system requires unrestricted airflow in an open space. In the event of improper ventilation or overheating, the motor is designed for automatic shut-off. If this occurs, allow the unit sufficient time to cool and then remove any enclosures or obstructions to the side or top ventilation slots. Once unit is obstruction-free, resume operation. If repeated shut off occurs, contact ShopBot Tools Technical Support for assistance. DO NOT open enclosure or modify the unit in any way.



Step 5 – Assembling Piping



Side view of a typical setup with vacuum piping



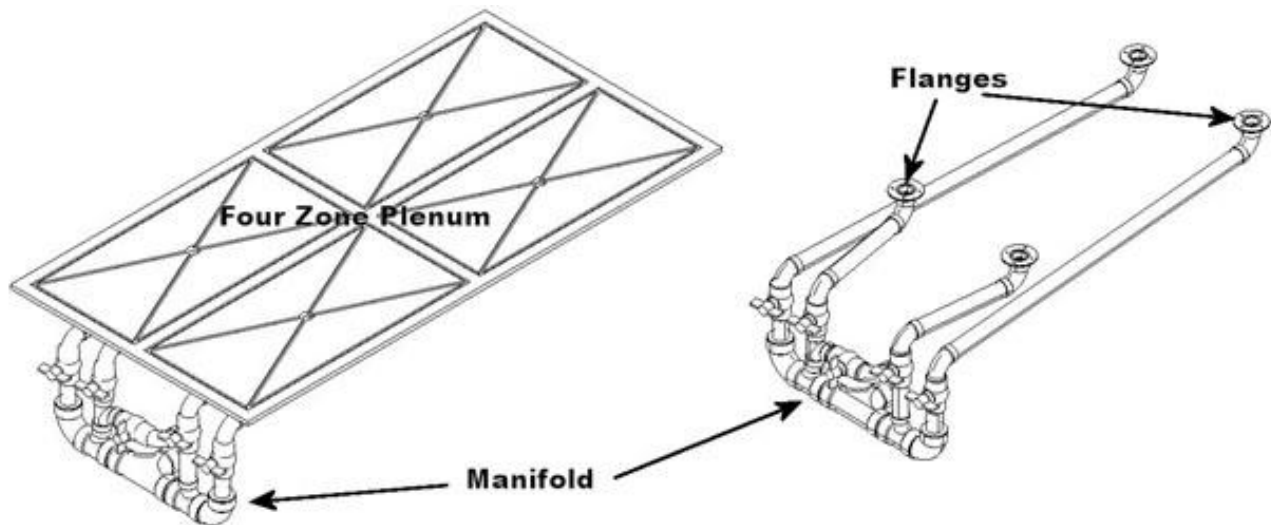
Bottom view of vacuum plenum plumbing

Attach the flanges to the holes that should have been drilled for each of the vacuum zones in the previous section. Make sure to use caulking to attach the flanges to the baseboard-- it will help prevent leaks.

The flanges are fastened to the underside of the support board, and PVC pipes are then connected to the flanges for each of the vacuum zones. The pipes from the zones will run to the vacuum manifold valves. These valves allow for airflow cutoff from zones that are not in use.

The large pipe from the manifold connects to the inlet filter. In addition to the zone valves there is an open air valve, which should be opened before starting the blower. Once the blower is up to speed, it will be closed to generate the vacuum.

Starting the blower under vacuum puts it under more stress and will cause premature failure.



Example of how four zone setup works. Each flange is at the center of a zone.

Operation Tips and Techniques

Connecting to Electrical Source

The blower and piping setup have been configured with safety in mind, but it is important to verify the following items before operating the blower.

- Check the electrical specifications on the plate of the blower and verify that the supplied voltage matches the blower voltage. This voltage must be within the specified range (e.g. 208-230 volts). If 460 volts is supplied to a blower that is specified for 230 volts the motor will burn up and the warranty voided. For both safety and warranty purposes, have a licensed electrician make the electrical connections to the blower.
- Make sure that the relief valve and filters are in place. If debris gets into the blower, it can cause the blower to seize up.
- Ensure that there is adequate airflow around the blower to allow for proper cooling. Taking a few minutes now can save costly downtime and expense from a burnt-out blower.
- Once the blower is wired, the electrician should check for proper rotation. If the rotation is not correct, switch any two of the three wires. A properly installed and maintained blower will provide years of trouble free service.
- ShopBot cannot be held liable for damages resulting from improper wiring or assembly. The blower manufacturer's warranty only covers defects in material or workmanship.

For Vacuum Efficiency

To test the vacuum, close the open-air valve and all PVC zone valves. The vacuum gauge on the clean air side of the filter should now read the rated vacuum of the blower. Check all joints for leakage.

If the vacuum reading is below the rated vacuum of the blower then there most likely is a leak somewhere in the table or piping system.

The relief valve should let air in to protect the blower. If the blower exceeds its rated vacuum, turn it off immediately and correct the blockage or other problem. Continued operation will result in catastrophic blower failure.

For Longer Life

The blower motor is under the greatest stress when first started. In order to prolong the life of your blower do not cycle the blower more than necessary. For instance, do not turn the blower off after cutting a file if another file will be cut immediately. Close the zone valves and open the open air valve in order to change out sheets of material. This allows the blower to keep running while removing suction from the table. If there is a lag time between cutting files, turn the blower off, but try and limit starts to no more than four per hour.

Warranty

Several different blowers for vacuum systems are used depending on the needs of the customer and the power available at the site. Blowers are only warrantied by the manufacturer. If there is a problem with the pump/blower, ShopBot will help resolve the issue, however, warranty replacement or repair is done through the manufacturer and is only valid with correct installation and use of the blower.

Appendix

Optional zones in blue. Up to 6 additional zones can be added in between the two outer zones.

