Vacuum Veneering
Vacuum Press Plans for Woodworkers, Cabinet-Makers and Instrument Builders
UPDATED!

Selecting A Vacuum Pump

Speed and Maximum Pressure:

Vacuum pumps are often rated on the flow capacity which is stated as CFM (cubic feet per minute). It references the speed at which the pump is capable of moving *or removing* air and is most often measured at zero pressure. A pump rated at 1 CFM will be fine for flat panel work on vacuum bags up to 4' x 4'. For bags up to 4' x 8' a 3 CFM or greater pump is needed.

If your vacuum press will be pulling down curved veneer forms or bent laminations, the general rule of thumb is that the pump must be three times faster. This means that a 3 CFM or greater pump is best for vacuum bags up to 4' x 4' for this type of use. Why? Because there is, on average, 3 times more free air inside of a bag containing a bent lamination than there is inside a bag containing a flat panel.

Vacuum pumps are also rated by their maximum achievable vacuum pressure at sea level which is often expressed as inches of mercury or "Hg". For vacuum veneering, the minimum acceptable level of vacuum is 18". The ideal vacuum pressure though is 21" of Hg. At the high end, the maximum level of vacuum pressure for veneer work is 25.5" of Hg. Anything over this amount is not only overkill, it's also harder on the pump and once in a while, extreme vacuum levels can cause the veneer to develop small pustules of glue on the veneer face.

Type of Vacuum Pumps:

The next consideration when building a pump based vacuum press system is the pump style. Here are the some of the options:

- Diaphragm based pumps are very quiet and durable. This type of pump is oil-less and usually has a small footprint. They are ideal pumps for a vacuum system. Typical CFM rating is 1 to 3.

- Piston based pumps are not as quiet as diaphragm pumps but are just as durable. They are almost always oil-less and also work well for a vacuum press. Typical range of CFM is 2 to 4.

- Oil bath pumps are a bit louder and have a tendency to emit a light plume of oil into the air. For some users, this can be a problem. This type of pump requires occasional oil changes and can draw a large amount of amperage. Usually, these pumps range from 3 to 6 CFM.

- Rotary vane pumps are available in oil-less and lubricated styles. They are generally maintenance free but they get very hot during use. This can create a serious issue if the thermal protection circuit kicks on while your press is in use. It's a good idea to have a standby unit on hand in the event that the rotary vane pump overheats. Typical CFM range for this style of pump is from 5 to

- Refrigerant compressors can also be used for limited runs of vacuum press work. They are quiet but slow to pull a full vacuum. Typical CFM is less than 1.

Vacuum Pump Manufacturers

The most common names in vacuum pump apparatus are Gast Manufacturing and Rietschle Thomas (pronounced 'rich-ley thomas'). Gast is now owned by the Idex corporation. Their pumps are refined, expensive, and are available in a wide range of models. Rietschle Thomas pumps are less refined looking but they're built a bit heavier and are less expensive. The corporate offices of RT have excellent customer service representatives but their local distributors can be hard to work with. My suggestion... buy a pump from me. I guarantee you will be satisfied.

Other manufacturers include Alcatel, Edwards, Sargent, Welch, Busch and Leybold. These are all manufacturers of high end, industrial, or scientific-use vacuum pumps.

Restart Pressure

The next consideration is for a pump based vacuum source is "restart" pressure. Many smaller pumps have a zero pressure restart rating. This means that if you turn off the vacuum pump and turn it on again, the back pressure will prevent the motor from turning and the pump will not start. Most heavy duty vacuum pumps and refrigerant compressors can restart regardless of the pressure in the system. The good news is that there is a simple fix that will allow any vacuum pump to work in a cycling mode. There's more about that on the next page.

Tips and Tricks

Testing Your Vacuum Pump's Restart Pressure

1. Plug up the air intake on the pump (I use my finger)
2. Turn the pump on for a few seconds to let it build up full pressure
3. Turn the pump off and then turn it on again

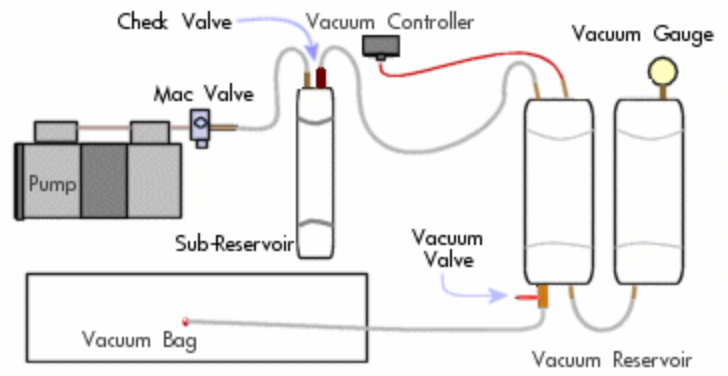
Did it restart without hesitation?
If it did, you won't need to unload the vacuum pressure using a sub-reservoir and Mac valve.

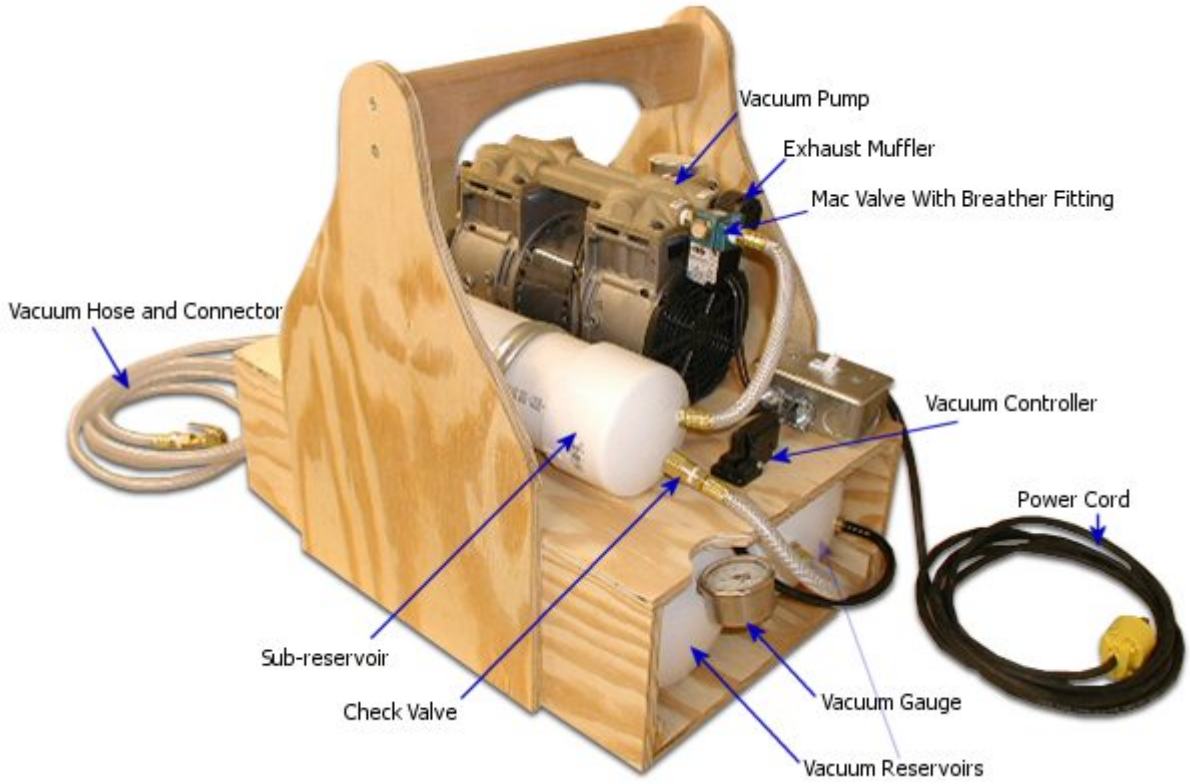
Pump Driven System - Concept
(Thanks to Jon Dake for assistance with this portion of the vacuum press)

Most standard duty vacuum pumps will require the vacuum pressure to be "unloaded" from the pump once it is shut off. To do this, you'll need a Mac valve with a normally open port, an 8 to 10" piece of 3" diameter PVC pipe and two ends caps. The combined PVC and end caps will be called a *sub-reservoir*. Once the vacuum system reaches the cut-off point and the vacuum controller turns the pump off, it will also disengage the Mac valve allowing the pressure in the sub-reservoir to be released. Inside of the sub-reservoir is an adequate volume of zero pressure air to allow the pump to attain full rpm before reaching a strong vacuum (where high back pressure exists).

To prevent the air in the main reservoir from unloading, a check valve will be used between the two reservoirs. This way, only the air in the sub-reservoir will unload.

The concept - When the vacuum pressure in the main reservoir has dropped, the vacuum controller will turn the motor on and, at the same time, close the normally open port of the Mac valve. The pump will pull the air from the sub-reservoir until it exceeds the vacuum pressure in the main reservoir. At that point, the check valve will open and the vacuum will be pulled through the main reservoir (and the vacuum bag as well). When full vacuum is achieved, the vacuum controller will shut off the motor and disengage the Mac valve and unload the vacuum pressure from the sub-reservoir.



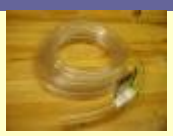


Vacuum Pumps on eBay

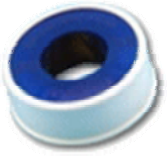
There are two very good reasons to be cautious about vacuum pumps sold on eBay:

- Most pumps have rubber gaskets, seals, and diaphragms that can dry-rot. Though a pump may look brand new, the rubber components could be rotten. The photo on the right shows a rotten diaphragm from a pump on eBay that was listed as "new".
- Vacuum pumps can be used in a variety of dangerous conditions ranging from chemical contamination to biohazardous waste and experimentation. Be sure your pump comes from a clean source with no history of chemical or biohazardous use. All of the major pump manufacturers have addressed this concern quite seriously and will not accept a pump for repair if there is any indication of such usage.

Pump Driven System - Parts:
The following parts should be available at your local hardware store:

Quantity	Item Description	Approximate Cost	Picture
12'	¼" Inside diameter vinyl tubing (clear and soft, not opaque and hard) *Note - standard duty 3/8" ID tubing will collapse under vacuum pressure, so stick with the 1/4"ID tubing.	$2.00	
1	Spool of electrical solder	$1.99	
1	Can of acetone or xylene	$2.99	
1	Sheet of ¾" MDF (4' X 2' is plenty) (to build the stand for the press)	$5.00	
10"	3" Diameter Schedule 40 or 80 solid core PVC pipe Local plumbing supplier might have a small piece for free	Free?	
15"	4" Diameter Schedule 40 PVC pipe You'll need two of these if you opt to build a double reservoir system. Your local plumbing supplier might have a few small pieces for free	Free?	
2	3" PVC schedule 40 pipe cap	$2.00	
2	4" PVC schedule 40 pipe cap	$6.00	
1	Small jar of PVC cement	$2.99	
1	½" Diameter dowel rod - 36" long	$.79	

Miscellaneous Items
You can help to support this article and save time and money by purchasing the following parts through VeneerSupplies.com.

Quantity	Item Description	Retail Price	Veneer Supplies.com Price	Picture
1	Heavy Duty Check valve	$19.95		
1	Roll of thread sealing tape	$1.00		
1	1/8" NPT(female) to 1/4" hose barb This is used to "remotely" mount the vacuum controller.	$2.50		
1	Brass pipe union - 1/4" NPT	$2.00		
1	Pack of "Universal Clamp-in" valve stems Available at your local automotive store. Camel #30-445-7 (used for veneer press vacuum bags)	$12.99 for 4 stems		
1	Wika industrial grade vacuum gauge with heavy-duty sensing elements and a stainless steel case. This industrial gauge offers greater accuracy than general purpose gauges and is typically used in more demanding applications. Case: **Stainless Steel** Window: Polycarbonate Dial: White ABS plastic Dial Size: 2"	Varies		
1	Vacuum pump Must be capable of pulling at least 21" of Hg The two big names in vacuum pumps are Gast and Thomas.	Varies		

1	Vacuum pressure controller The most critical piece for the vacuum system. Adjustable from 1.5" to 28" of Hg. Contact Rating: 15 amps.	$26.00- $115.00	
?	30 Gauge clear vinyl Available at your local canvas awning supplier or upholstery store	$14.00 to $18.50 per yard	
1	HH-66 Vinyl cement part # 7506 Imperial Inc. : 1-800-558-2808	$14.00	
1	Mac valve This is the mechanical piece of the press that unloads the back pressure between the pump and the check valve.	Retail: $29.00	
8	Brass fittings - ¼" hose barb to ¼" male thread	$1.10 ea	

Pump Driven System - Construction

The Reservoir Tank

A reservoir tank is used to hold spare vacuum pressure. It prevents the vacuum source from having to cycle on and off too frequently. The reservoir tank that is used with this system is 4" diameter schedule 40 or 80 PVC. Be sure that you purchase only this type of PVC. It can be found at your local plumbing shop. In fact, it is best to buy it at a plumbing shop because if you were to find it at a hardware store, you would have to buy a 10' length of it. Your local plumber may even give it to you for free if you are lucky.

Be 100% sure that it is schedule 40 or 80 PVC. You will need a 15" length of it for a single reservoir system. The more reservoir space that is available, the less the unit has to turn on and off. This minimizes the wear and tear on the Mac valve or motor components. If you decide to make a larger vacuum reservoir it is best to "piggy back" two similar sized tanks next to each other. To do this, simply plumb the two reservoirs together with 2 brass barbed fittings and a piece of tubing.

Be sure to check the PVC for cracks or pits. Any abnormalities in the PVC could allow leaks or, even worse, an implosion. This is serious business. You don't want 1 billion pieces of plastic shrapnel flying at you!

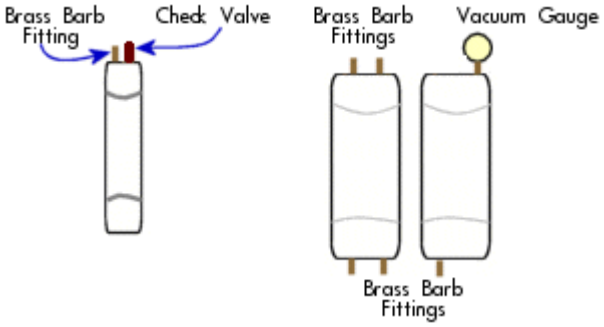
Tap the Caps

Schedule 40 or 80 PVC end caps are used to make the reservoir's ends.

The end caps on the vacuum press will need holes drilled in them for the brass fittings and the vacuum gauge. I recommend using a drill press for this part. When drilling the holes use light pressure to prevent cracking the PVC cap.

For a double reservoir system, here is the list for the holes in each cap:

- (2) 4" PVC caps - 2 holes
- (2) 4" PVC caps - 1 hole
- (1) 3" PVC cap - 2 holes
- (1) 3" PVC cap - no hole



Method #1

For the ¼" pipe thread of the fittings, a 31/64" drill bit will create a hole that is just snug enough. Remember, you will be threading the fittings into unthreaded plastic so you need a good fit.

After each hole is drilled, use a wrench to insert one of the barbed fittings into a hole. Remember to screw them in straight. A deep-reach socket and ratchet will make inserting the fittings much easier. The first time you screw the fitting in, you may wish to use a light lubricant to aid in the threading process.

A safe way to drill the caps.

Now remove the brass fitting and you'll see that you have created light thread marks in the PVC cap. Use the same fitting to "thread" the other holes.

Method #2 UPDATE

The easiest and most reliable way to create the threads is with a dedicated 1/4" NPT tap. Most hardware stores carry them for about $9.00. To use the tap, simply drill a 7/16" hole in the cap and carefully screw in the tap using about 3/4 of the tap length. Then test the threads with a brass fitting. If it is too snug, re-tap the hole and screw it in a bit further. This will widen the hole just a bit.

After you have threaded each of the holes, apply Teflon tape to the fittings and gauge and reinsert them into the cap. When attaching the gauge, be sure to turn it with a wrench at the bottom of the gauge and not body the gauge's body.

At this point, you can use regular PVC cement and apply it generously to both sides of the mating areas. Twist (1/4 turn) and slide the PVC cap and body parts together. Allow the PVC cement to cure before continuing. And for goodness sake, do this in a well ventilated area.

Pump Driven System - Set Up the Vacuum

When building this type of system, an important factor is the pump's "restart" pressure. Most vacuum pumps have a zero pressure restart ability. This means that if you turn off the vacuum pump and turn it on again while under pressure, the pump will not start. Most vacuum pumps will require the vacuum pressure to be "unloaded" from the pump once its is shut off by the vacuum controller.

The pressure will be unloaded using two assemblies. The first is the 3" PVC sub-reservoir and check valve. The second is the Mac valve assembly.

The Mac valve assembly consists of the following items:

- ¼" NPT brass pipe union
- ¼" NPT breather fitting
- ¼" brass barbed fitting
- Mac valve

Port numbers highlighted in yellow

The breather fitting creates a clean, muffled exhaust from the Mac valve and gives the overall assembly a professional look.

The Mac valve shown in this picture has three ports. When the power to the valve is removed, air flow is only allowed from port #2 to port #3. When power is applied to the valve, the center port is closed and air can only flow from port #2 to the port #1. The orientation of the Mac valve is critical!

Attach the components to the vacuum pump as shown in the picture above using thread sealing tape at each junction.

UPDATE

If you'll also be using your press for vacuum clamping and templating, it's a good idea to add a decent filter at the Mac valve as shown. You'll also need a 1/4" NPT pipe union fitting to connect the filter.

Please note: Be sure to use the vacuum or "intake" side of the pump. Using the output side will immediately ruin the diaphragm inside the vacuum controller when the system is first turned on.

Set up the Vacuum Controller

Vacuum controller with fitting attached

The vacuum controller is what regulates when the vacuum device turns on. These are adjustable up to 28" of Hg (Hg in the scientific symbol for mercury). The updated construction method no longer involves mounting the vacuum controller directly to the PVC reservoir. Instead, it is now mounted remotely to the system stand/carrier and connected via vacuum tube.

Wrap the threads of the vacuum controller with thread sealing tape and attach a 1/8" NPT barbed fitting onto the unit. Do not over-tighten the fitting. The maximum torque for the plastic body of the vacuum controller is 4 lbs.

The vacuum controller will be mounted and connected in the following pages.

Vacuum Dampener

If your vacuum pump pulls more than 4 CFM, you'll want to add this dampener to the vacuum controller. I've also heard that rotary vane pumps (regardless of size) work best with the dampener. This will prevent the vacuum controller from sputtering on and off at the end of a charge cycle by dampening the airflow to the controller. It is attached between the vacuum controller and the brass fitting.

Pump Driven System - Build the Stand

There are countless methods of building the stand/carrier for the vacuum press. It's a good idea to take a look at some of the other presses that were built around this system before building your own. You can find pictures and brief descriptions of these systems at this address: http://www.joewoodworker.com/veneering/visitorspress.htm

Pictures of my vacuum press are shown below. The stand is made from 1/2" plywood that has been glued and nailed together. Each of the reservoir cradles were cut from a piece of plywood which had two 4.5" holes drilled in it. It was then sawn in half (creating a top and bottom piece for the cradle).

Image 1

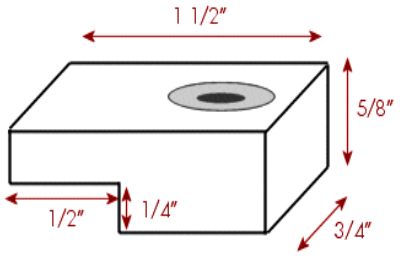
This image shows the cradles for the main reservoirs. The tubing connections around the reservoirs are also visible.

Image 2

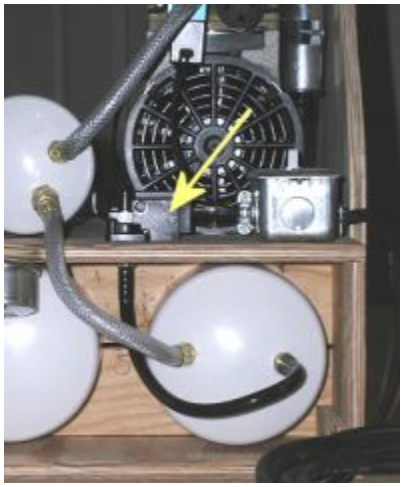
This image shows the placement of the sub-reservoir, electrical box, vacuum pump, and the vacuum controller.

I've found that the easiest way to mount the vacuum pump is with 4 hardwood "clips" as shown below. Drill a hole in each clip for a small wood screw. Be sure that the placement of the clips will not allow the screw to contact the reservoirs underneath.

Please note: These dimensions are for the new (not rebuilt) Thomas Pump available at VeneerSupplies.com. Other pumps may require a slight adjustment in the measurements shown.



The stand should have a 5/8" hole drilled in it for the brass fitting on the vacuum controller. Then connect a piece of tube from the fitting on the main reservoir to the vacuum controller (through the hole). The image on the right shows a piece of black tubing from the vacuum controller to the main reservoir.



The vacuum controller can then be fastened to the stand with two small screws.

Pump Driven System - Connections

The heavy duty check valve is available through the VeneerSupplies.com webstore. I purchased several hundred of them to get a good price. You can click on the picture if you would like to order one.

Heavy Duty
Check Valve

Attach a piece of vacuum tube from the fitting on the Mac valve to the first brass barb fitting on the sub-reservoir. Air flow should be viewed as flowing backward from the vacuum bag toward the pump/Mac valve.

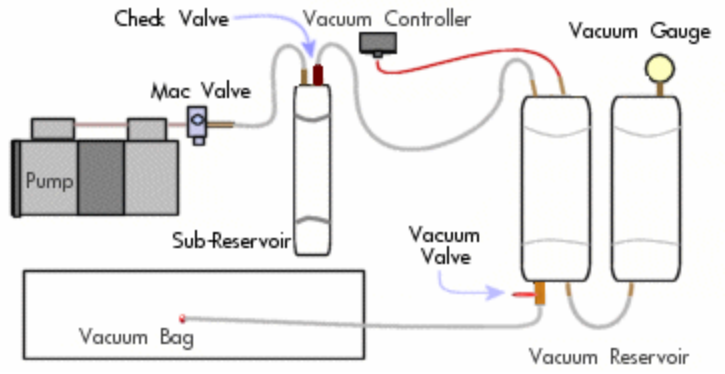
Attach the check valve to the subreservoir. Then connect a 1/4" brass barbed fitting to the check valve. Now attach another piece of tubing from the check valve to the main reservoir. After you have constructed a stand for the vacuum press, you can remove the tubing and cut it to lengths that are as short as possible between all components to minimize any air flow restrictions.

UPDATE

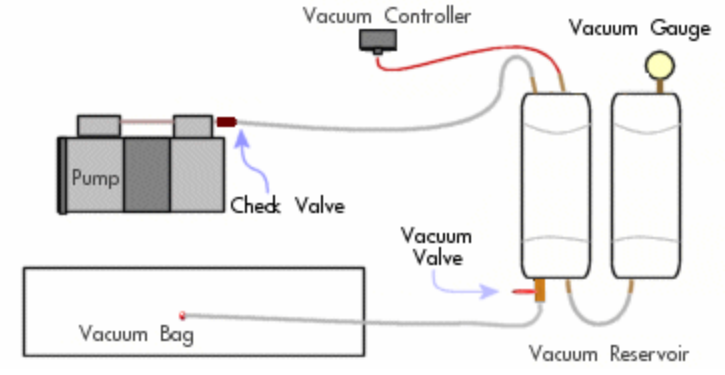
System Pre-Charging

By placing a ball valve between the reservoir and the vacuum tube (the tubing that goes to the vacuum bag), you can pre-charge the reservoirs with pressure. This will give you a slightly faster pull-down of the bag.

Vacuum Valve



Vacuum Tube Connections With Sub-Reservoir



Vacuum Tube Connections Without Sub-Reservoir

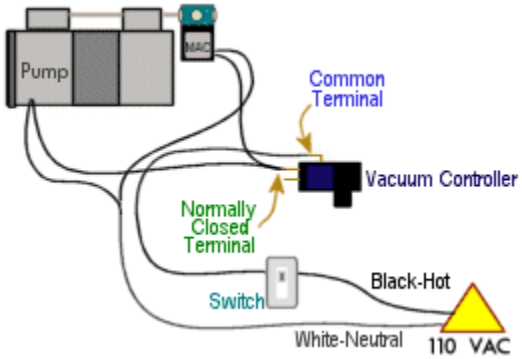
Pump Driven System - Electrical Connections

Don't Forget!

When soldering, be careful not to damage the vacuum controller by over-heating the tabs. Allow the soldering iron to reach full heat before you begin. Then apply some solder to the common and normally closed tabs. Next apply solder to the wire ends. Lastly, reheat the wire ends onto the tabs. This last step should not require any additional solder.

There are several possible wiring options based on the type of vacuum pump you are using.

Situation #1 (The most common method)
If your 110v pump will not restart under pressure, use the diagram below.



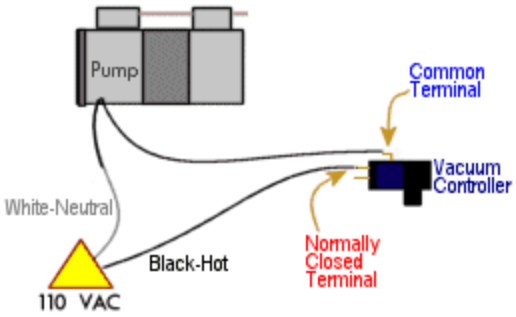
The Mac Valve:
There are two leads from the Mac valve. One is wired to the NC terminal on the vacuum controller. The other is connected to the white A/C power wire. It doesn't matter which wire from the Mac valve is used to either connection (there is no polarity).

The Vacuum Pump:
The vacuum pump also has two wires. One is wired to the NC terminal on the vacuum controller. The other is wired to the A/C power wire. The vacuum pump wires also have no polarity (either wire can be used).

The Vacuum Controller:
The vacuum controller's C terminal is then wired to the switch. From the switch, a final wire is connected to the black A/C power wire.

Please Note:
If you've purchased a rebuilt RT vacuum pump from VeneerSupplies.com, please note that the red wires from the pump are connected to the capacitor. The other two wires (which should be black) are connected to the system as shown on the wiring diagram above.

Situation #2
If your pump will restart at full vacuum and does not draw more than 10 amps at 110v you may connect it directly to the vacuum controller as shown below. Note... the Mac valve pressure release is not used.



The Vacuum Pump:
The vacuum pump has two wires. One is wired to the common terminal on the vacuum controller. The other is wired to the white A/C power wire. The vacuum pump wires also have no polarity.

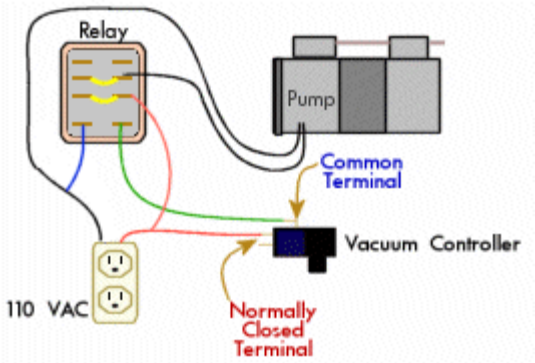
The Vacuum Controller:
The vacuum normally closed terminal is then wired to the black A/C power wire.

Situation #3

If your vacuum pump will restart at full vacuum and draws more than 20 amps at start up, you will need a DPDT relay with a 110v coil and contacts rated for 20 amps @ 110v.. The connection is shown below.

Please note: The red wire on the diagram above is the "hot" side.

Use the normally closed tab of the vacuum controller and the normally open tabs on the relay (tabs 4 & 6). The theory is that when insufficient pressure is inside the reservoir tank, the vacuum controller is closed. Thus powering the coil in the relay which closes the contacts inside, allowing power to be transmitted from the 110VAC (at tabs 7 & 9) to the vacuum pump. When adequate pressure is achieved, the vacuum controller opens the contact and removes power from the coil. The coil resets to the open position and power to the vacuum pump is turned off.

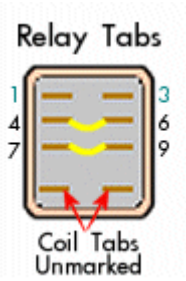


UPDATE

<u>If your pump will not restart under pressure</u> and you are using a Mac valve to unload the pressure, just connect the Mac valve to the relay's coil tabs. One of the black wires from the Mac valve is connected to either one of the unmarked tabs on the relay. The other black wire from the Mac valve will go to the other unmarked tab on the relay (see tab diagram below). There is no polarity to the wires on the Mac valve.

If you are using a relay purchased at VeneerSupplies.com, the connections are as follows:

- The # 9 tab is connected to the 110v source (preferably the hot side)
- The # 7 tab is jumpered to the # 9 tab
- The two unmarked tabs are attached to the vacuum controller and the neutral side of the 110v source
- The # 6 tab goes to the vacuum pump
- The # 4 tab is jumpered to the #6 tab
- Note that tabs 1 & 3 are not used



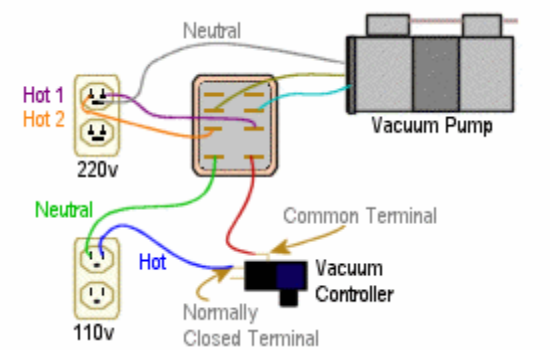
Note the yellow lines are jumpers!

Situation #4 (Updated 9/9/05)

If your vacuum pump operates on 220v the diagram below should help. Keep in mind that your relay must be rated for 220v at the contacts and must engage with 110v. For 3-wire vacuum pumps, the relay controls both "hot" lines independently (no jumper is used) and the neutral line is connected directly from the power source to the vacuum pump.

Please note that due to the complexity of wiring a 220v pump and the safety concerns associated with such high voltage, <u>I do not support this type of configuration</u>. Please consult your local electrician before building a 220v system. I realize that several surplus centers are carrying

inexpensive 220v pumps. But you have to ask yourself if it's worth saving $35 for the sake of having multiple electrical connections and the additional hazard of wiring a system with 220v.



Pump Driven System - Initial Testing

Place a small piece of duct tape over the last remaining open fitting on the top of the main vacuum reservoir. Be sure you are wearing safety glasses and then plug in the AC cord. When you apply the A/C voltage, the pump should turn on and air should begin moving through the system. You should see the vacuum gauge needle move towards the far end of the scale.

Notice that there is a small plastic cap on the vacuum controller just in front of the “common” tab. Under this cap is where the adjustment is made for setting the amount of vacuum inside the unit.

For the next stage of testing, you will want to carefully adjust the vacuum setting to 21"- 23". Turn on the system (do not touch the tabs or bare wire on the vacuum controller while the unit is plugged in). Using a small flat screwdriver, slowly turn the adjusting screw counter-clockwise until the unit creates 21"- 23" of vacuum and cycles off. Counterclockwise turns of the screw will increase the amount of vacuum required before the controller will turn off the air pressure at the Mac valve. I've found that most often, 21" of Hg is when there is about 1/8" of thread showing above the adjustment screw.

It will automatically cycle on again when the vacuum has decreased. The manufacturer of the vacuum controller claims that the unit will cycle back to the "on" mode within 4" of Hg decrease. This 4" amount of "differential" is not adjustable. In my opinion, this constant increase and decrease in vacuum pressure inside the press bag allows for an even greater bond of the veneer to the substrate.

During normal operation of a tightly sealed unit, it is common to have the unit cycle on every 10 minutes for 5 - 20 seconds. The length of time depends on the size of the vacuum bag, pump and the reservoir.

After the system has automatically turned off, watch the needle on the vacuum gauge to see if it shows signs of a leak. It shouldn't leak if the brass fittings were corrected installed into the reservoir with thread sealing tape. However, it’s not uncommon to have a small leak show up. The fix for this is simple.

Leave the system charged with vacuum pressure and apply a small amount of silicone to each of the brass fittings and gauge. If a pressure leak does exist, the vacuum pressure will pull the silicone into the void area causing the leak to seal itself.

After you have applied the silicone, turn the system off and let the air back into the PVC pipe by removing the duct tape. Allow the unit to sit overnight so the silicone can cure.

Attach a 10' piece of ¼" inside diameter vacuum tube to the open fitting on top of the PVC pipe. This piece of tubing will be what connects your veneer press to the vacuum bag.