Vacuum Bagging Basics for Drying Lumber Firewood and Slab Wood by Global Energy

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Vacuum bagging basics.

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Vacuum Bagging for Wood Products

Vacuum bagging is a method of clamping, which has traditionally been used in the composites industry, but can also be used for vacuum drying materials, including wood products.

The basics of vacuum bagging for kiln drying include evacuating the moisture laden air, while simultaneously heating wood products (via use of a heated pad or heating blanket), which encourages the movement of water from the cells to outside the wood. Depending on the temperature, you may also be able to heat treat at the same time.
The extreme pressure of atmosphere clamping, prevents the wood products being dried from warping and other distortions from the drying process.
Vacuum bagging for wood products can be applied to any wood products including dimensional lumber, slabs, whole logs, pallet boards, firewood, timbers, and more.
Vacuum bagging can also be used to bond complex curves and veneer to substrate.

How Vacuum Bagging Works

Vacuum bagging uses atmospheric pressure as a clamp to hold laminate plies together. The laminate is sealed within an airtight envelope. The envelope may be an airtight mold on one side and an airtight bag on the other. When the bag is sealed, pressure on the outside and inside of this envelope is equal to atmospheric pressure: approximately 29 inches of mercury (Hg), or 14.7 psi. As a vacuum pump evacuates air from this envelope, the air pressure inside is reduced while air pressure outside of the envelope remains at 14.7 psi. Atmospheric pressure forces together the sides of the envelope and everything within the envelope, putting equal and even pressure over the surface of the envelope. The pressure differential between the inside and outside of the envelope determines the amount of clamping force on the laminate. Theoretically, the maximum possible pressure that can be exerted on the laminate, if it were possible to achieve a perfect vacuum and remove all of the air from the envelope, is one atmosphere, or 14.7 psi. A realistic pressure differential (clamping pressure) will be 12–25 inches of mercury (6–12.5 psi).

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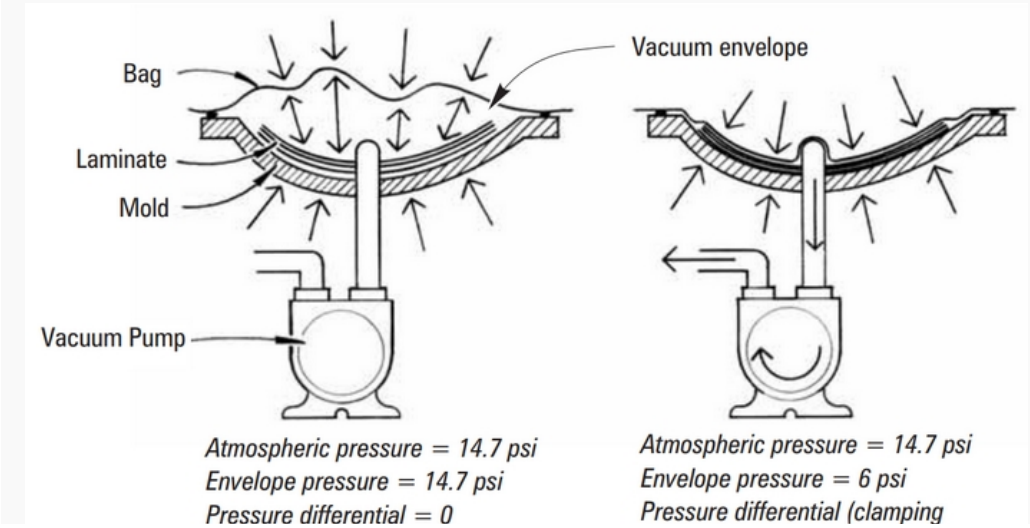


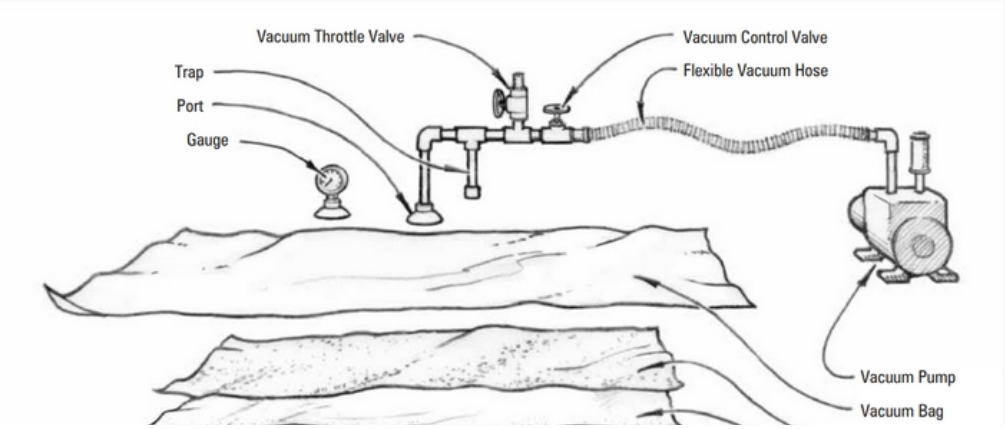
pressure) = 8.7 psi

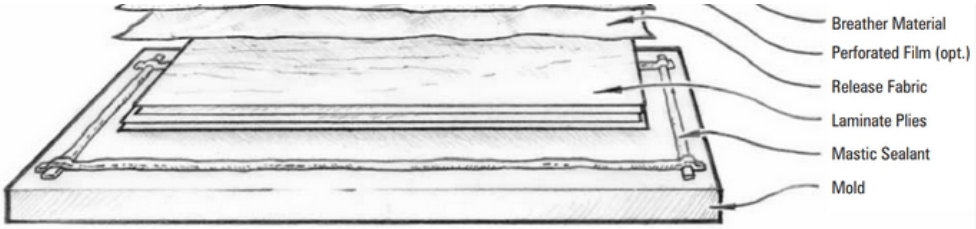
Advantages of Vacuum Bagging

As with other laminating methods, you can incorporate different materials into the laminate.
You select materials to match the component's structural requirements and your choices aren't limited by the clamping method.
Provides firm, evenly distributed clamping pressure over the entire surface regardless of the material you're laminating. This allows a wider range and combination of materials as well as a superior bond between the materials. It's superior to mechanical clamping or stapling, which applies pressure only to concentrated areas, can damage fragile core materials, may not provide enough pressure to bond in some areas, and may require additional adhesive to bridge gaps.
Results in thinner, more consistent glue lines and fewer voids thanks to uniform clamping pressure across the laminate. Because atmospheric pressure is continuous, it evenly presses on the joint as the adhesive spreads evenly within.
Lets you control epoxy content and removes excess adhesive from the laminate, resulting in higher fiber-to-epoxy ratios. This translates into higher strength-to-weight ratios and cost savings.
Allows for using a greater variety in molds and creating custom shapes. With vacuum bagging, the atmosphere pushes down on the top of the envelope and pushes up equally on the bottom of the envelope or mold. Since atmospheric pressure provides equal and even clamping pressure to the back of the mold, the mold only has to be strong enough to hold the laminate in its desired shape until the epoxy has cured. This means vacuum bag molds can be relatively lightweight and easy to build.
All of the materials in the laminate are wet out and laid up at the same time, which means vacuum bagging lets you complete the laminating process in one efficient operation. Learn more about laminating in Applying Fiberglass.

Vacuum Bagging Equipment

The vacuum bagging system consists of the airtight clamping envelope and a method for removing air from the envelope until the epoxy cures.





Vacuum Pumps

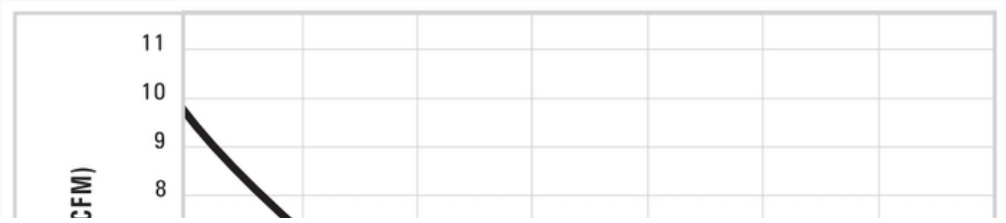
The heart of a vacuum system is the vacuum pump. Powered vacuum pumps are mechanically similar to air compressors, but work in reverse so that air is drawn from the closed system and exhausted to the atmosphere. Vacuum pumps are designated by their vacuum pressure potential or Hg maximum (Hg is the symbol for inches of Mercury), their displacement in cubic feet per minute (CFM), and the horsepower (HP) required to drive the pump.

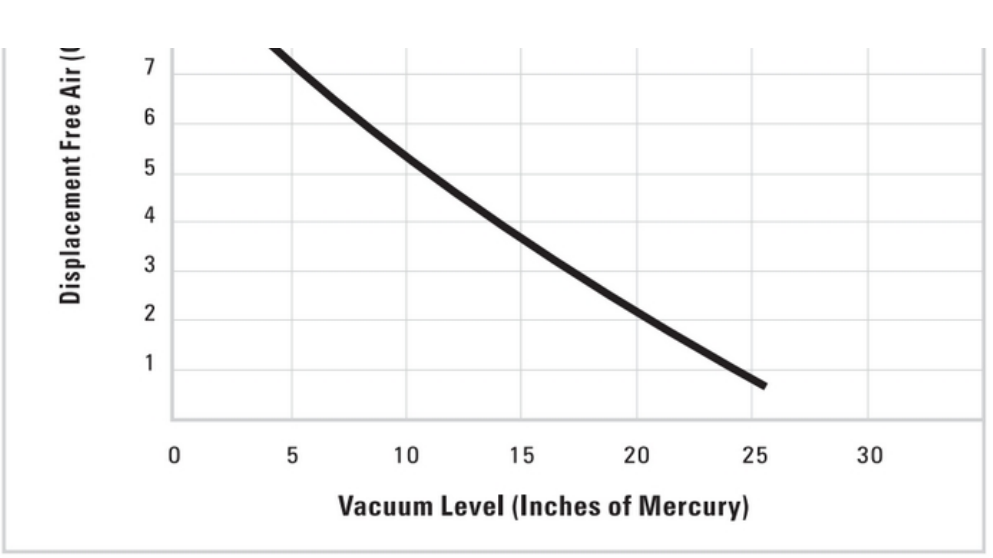
Vacuum Pressure

The inHg maximum level is the maximum vacuum level (measured in inches of mercury) recommended for the pump. This vacuum level translates to the maximum amount of clamping pressure that can be generated. Two inches of mercury (2 inHg) equals about one pound per square inch (1 psi) of air pressure. (Remember that 1 atmosphere = 29.92 inches Hg = 14.7 psi) If you are vacuum bagging a one-square-foot laminate, a 20 inHg vacuum will yield 10 psi clamping force or a total of 1440 pounds of clamping force over the entire laminate. If you are laminating a 4 ft × 8 ft panel, the same 20 inHg (10 psi) will yield over 46,000 pounds of clamping force spread evenly over the entire panel.

Displacement

The volume of air a pump can move (rated in cubic feet per minute or CFM) is also an important consideration in the selection of a pump. If the vacuum system (the mold, bag, plumbing and all seams and joints) were absolutely airtight, any size pump should be able to eventually pull its rated Hg maximum vacuum regardless of the size of the system. However, creating a perfectly airtight vacuum bagging system is nearly impossible, especially with systems that are larger or more complex. The greater the CFM rating, the closer the pump can come to reaching its Hg maximum and maintaining an adequate clamping force against the cumulative leaks in the system. A vacuum pump with a high CFM rating will also achieve an effective clamping force more quickly. This is an important consideration if the working life of the adhesive is limited or if the laminate will not hold its position until the clamping force is applied.





Performance and HP

The horsepower requirement of the pump helps indicate how efficient the pump is. It doesn't reveal how well a pump is suited to vacuum bagging. When selecting a pump, use the Hg maximum and CFM ratings as a guide rather than horsepower. Smaller pumps designed for specific applications may trade off either vacuum rating or air displacement to suit a particular job. Generally, to get both higher Hg maximum and CFM ratings, more horsepower is necessary.
For larger drying operations which require more air removal and surface area, larger CFM vacuum pumps are required.

Pump Selection

The size and shape of the mold and type and quantity of the material being laminated will determine the minimum pump requirements. If you are laminating flat panels consisting of a few layers of glass, flat veneers or a core material, 5 or 6 inHg (2.5–3 psi) vacuum pressure will provide enough clamping pressure for a good bond between all of the layers. If the area of the panel is limited to a few square feet, a 1 or 2 CFM pump will provide adequate clamping pressure. As the panel area increases, the CFM requirement increases proportionately. A displacement of 3.5 CFM may be adequate for up to a 14 ft panel. For larger jobs, a pump with a displacement of 10 CFM or more may be required.

Poor seals in the plumbing system or envelope, or materials that allow air leakage, will require a larger capacity pump to maintain satisfactory vacuum pressure. The more airtight the system, the smaller the pump you'll need. A higher Hg maximum rated pump will be required if you need more clamping pressure to force laminations to conform to a more complex mold shape. Curved or compounded mold shapes and or laminations of many layers of stiff veneers or core materials may require at least a 20–28 inHg vacuum to provide an adequate clamping force.

Again, if the panel size is limited to a few square feet, a 1 or 2 CFM pump with a high Hg rating will work, if the envelope is airtight. However, a very large panel may take a minimum of 10 CFM pump to reach and maintain enough clamping force to press all of the laminate layers to the mold shape and produce consistent glue lines throughout the laminate.

Generally, the best pump for a specific vacuum bagging operation will have the largest air moving capacity for the vacuum/clamping pressure required while operating at a reasonable horsepower.

Pump Types

Vacuum pump types include piston, rotary vane, turbine, diaphragm, and venturi. They may be either positive displacement or non-positive displacement.
We build our own vacuum pumps from parts sourced from McMaster.