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Get Serious About Clamping

Most woodworkers are underclamping their joints

BY ROMAN RABIEJ

A common saying among woodworkers is, "You can never have too many clamps." Turns out, it might be more accurate to say that you can never apply too much force. Most woodworkers have only the vaguest idea of how much clamping force to apply when gluing boards. Even those perfectionists who rely on dial calipers and feeler gauges when cutting and planing wood often judge clamping pressure simply by the amount of glue that squeezes out. The results are occasional joint failures and embarrassing gaps between boards on the ends of tabletops.

During my career in wood technology I've done scientific studies of glue joints using different types of glue, different clamping pressures, different species of wood, and even different grain orientations.

Rather than blind you with science and make your next glue-up even more nerve-wracking, I'll assume you're using yellow (polyvinyl acetate—PVA) glue and I'll try to answer the following questions: What is the optimum force when clamping soft and hard woods? How many

KEYS TO SUCCESS:

1. MATCH THE CLAMPING PRESSURE TO THE WOOD

2. MAKE SURE YOU HAVE ENOUGH CLAMPS

3. DISTRIBUTE THE PRESSURE EFFECTIVELY

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1 Different woods require different clamping pressure

Both the wood species and the grain orientation affect the clamping pressure required for a strong glue joint.

WOOD TYPE

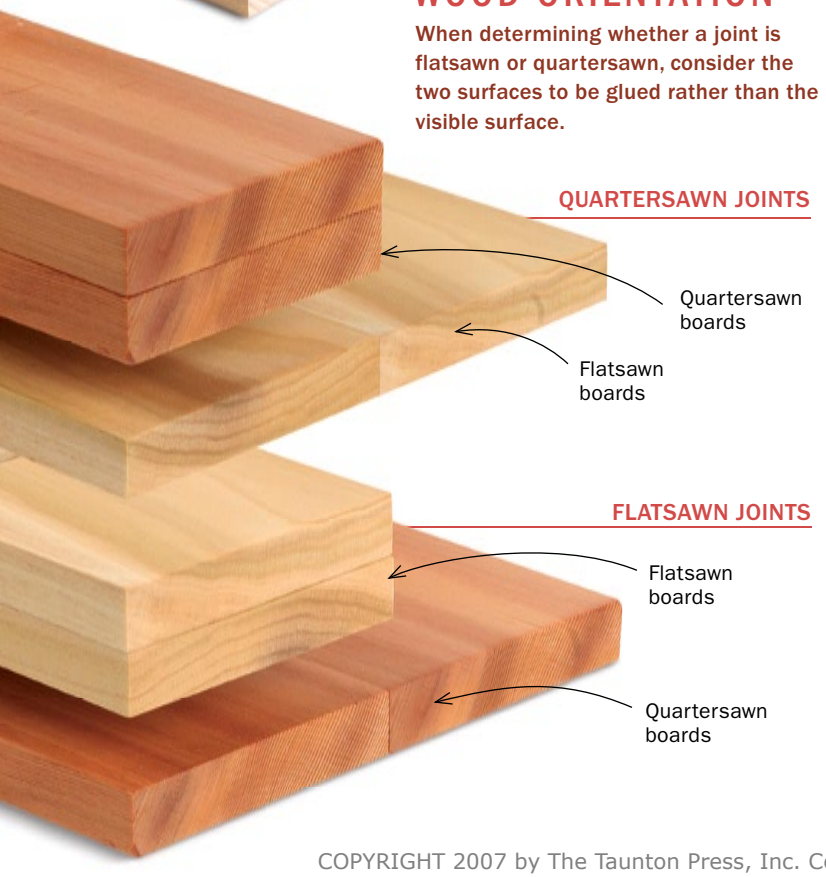
In general, dense and tight-grained woods require the application of greater force. On hardwoods, glue joints between radial or quartersawn faces require half the pressure of tangential or flatsawn face joints. This is because on hardwoods, the quartersawn face has half the compression strength of the flatsawn face, so the fibers are more easily crushed. On softwoods, the reverse is true, with the quartersawn-face gluelines requiring twice the pressure of the flatsawn-face gluelines.

RECOMMENDED CLAMPING PRESSURE (pounds per square inch)

Wood type	Quartersawn glue face	Flatsawn glue face
SUGAR MAPLE	600	1,200
RED OAK	450	900
BLACK WALNUT	300	600
BLACK CHERRY	250	500
PONDEROSA PINE	300	150

WOOD ORIENTATION

When determining whether a joint is flatsawn or quartersawn, consider the two surfaces to be glued rather than the visible surface.



clamps should you use and how should you arrange them? And last, how can you test a sample joint to see if you are getting good results?

Use this information to approach your next glue-up with newfound confidence, and the only thing under pressure will be the wood.

Why correct clamping pressure matters

Optimum clamping pressure creates strong glueline joints in several ways. First, it overcomes the viscous resistance of the glue and forces it into a thin, continuous film in contact with the wood, which is necessary for a strong joint. Second, as the glue releases moisture, causing the wood to swell, clamping overcomes this pressure and prevents the joint from opening up. Third, it overcomes minor surface imperfections between mating surfaces. And fourth, clamping holds parts in position until the glue cures.

Too little pressure will fail to achieve any of these benefits. Conversely, extreme pressure can produce weaker joints, although as I'll explain later, this is unlikely with common woodworking clamps. Because modern glues are stronger than the wood fibers, a good glue joint should break in the wood, a process known as wood failure, rather than along the glueline. So rather confusingly, the higher the percentage of wood failure, the better the joint. The

Photos, except where noted: Mark Schofield; wood and clamp photos: John Tetreault

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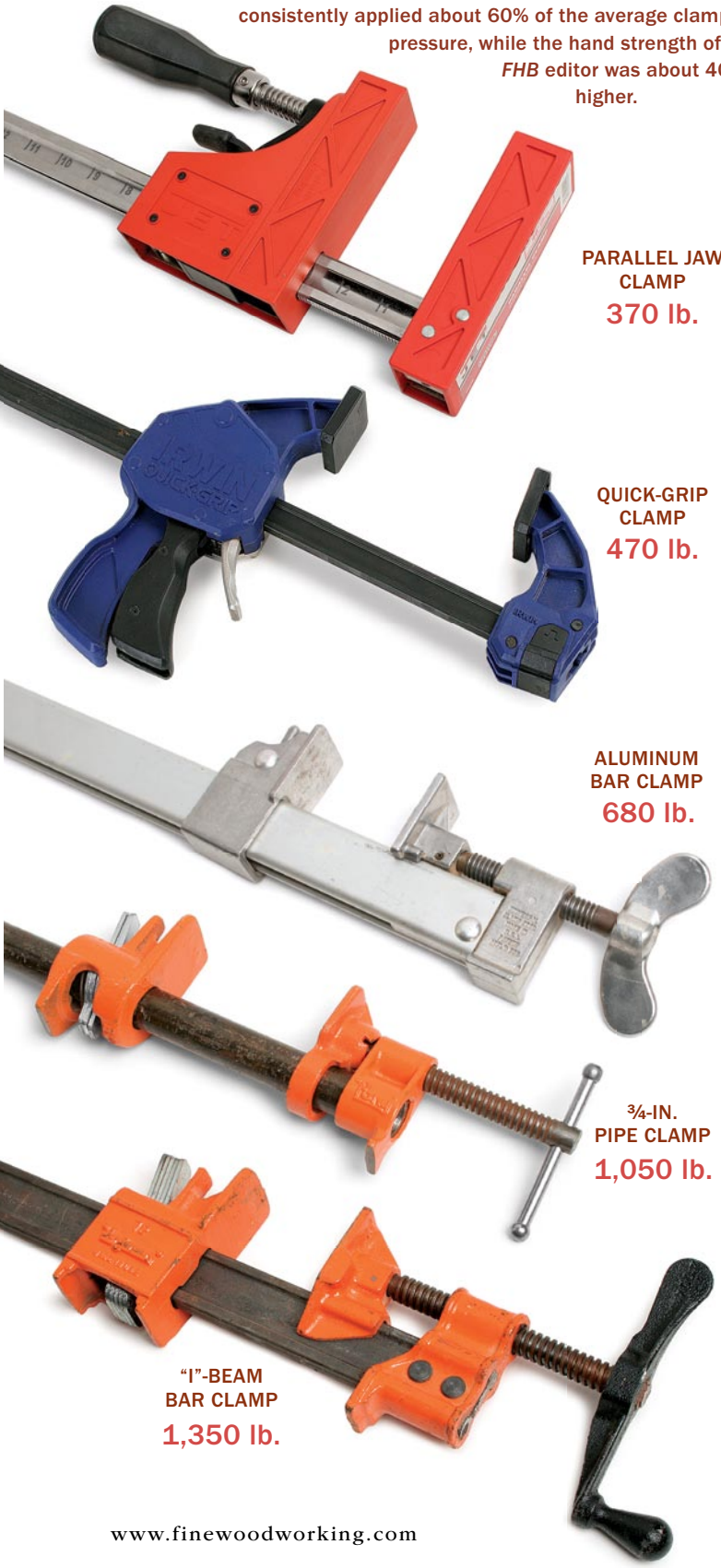
2 Not all clamps are created equal

The force applied by each type of clamp varies greatly depending on the strength of the operator. We conducted a test using four different staff members; two *Fine Woodworking* editors, our female copy editor, and a brawny *Fine Homebuilding* editor. The numbers below are the average of the *FWW* editors. The copy editor in our test consistently applied about 60% of the average clamp pressure, while the hand strength of the *FHB* editor was about 40% higher.



PARALLEL JAW CLAMP
370 lb.

QUICK-GRIP CLAMP
470 lb.

ALUMINUM BAR CLAMP
680 lb.

¾-IN. PIPE CLAMP
1,050 lb.

"I"-BEAM BAR CLAMP
1,350 lb.

CALCULATING CLAMP REQUIREMENTS

$$\frac{\text{Glue surface (sq. in.) x Required clamping pressure (psi)}}{\text{Force applied by each clamp (lb./in.)}} = \text{Number of clamps}$$

EXAMPLE 1

Less pressure for pine. *These two pine boards have a glue surface area of 16½ sq. in. Because the glue faces are nearly flatsawn (see inset), the recommended pressure is 150 psi, requiring a total force of 2,475 lb. This can easily be met by using three ¾-in. pipe clamps.*

EXAMPLE 2

More pressure on maple. *The effective glueline area is the same as for the pine (even though there are three boards to glue instead of two). The glue faces are quartersawn (see inset), so the recommended pressure is 600 psi. This total force of 9,900 lb. requires nine pipe clamps.*

wood-failure percentage starts to diminish as clamping pressure is increased beyond a certain point, because excessive pressure begins to starve the joint of glue and also to compress the wood and reduce its ability to absorb the glue.

The chart simplifies the science

The chart on the facing page shows the recommended glueline pressure for selected furniture woods. The optimal pressure is roughly twice as high. This peak pressure is the point just before the glueline is starved or the wood fibers are crushed. For most hardwoods, however, normal woodworking clamps can't get close to these levels of force. But joints clamped at the recommended levels will be quite strong enough, with the glueline being

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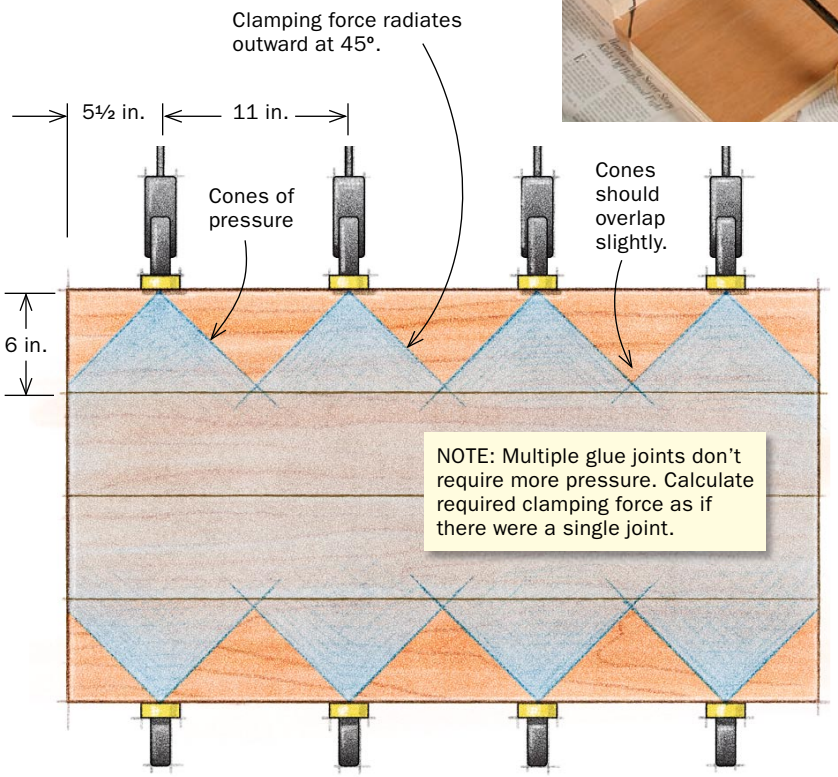
3 Put the pressure where you need it

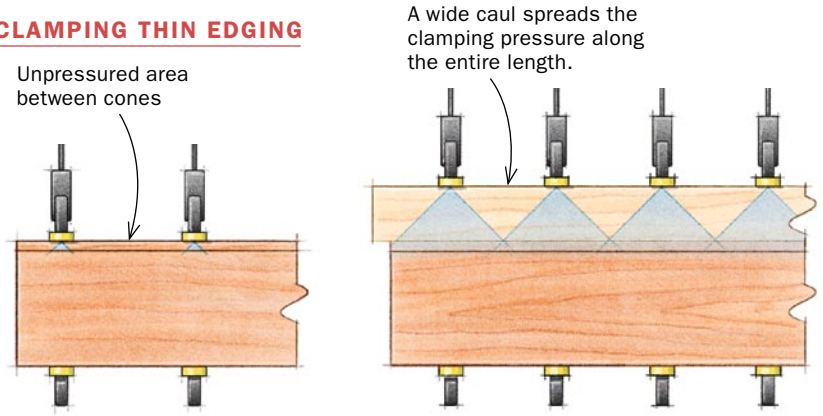
The force from a clamp spreads out in a 45° cone from each head. For the cones to overlap and the glueline to receive even pressure, the clamps need to be spaced correctly. The 45° angle makes the cones of pressure easy to measure. The force will radiate sideways in both directions the same distance as the clamp is from the glueline. So, in the example below, the 6-in.-wide board creates 12-in.-wide cones of pressure at the joint.

Cauls spread the force. *When clamping a narrow strip, the clamps have to be close together in order to have the pressure cones overlap (at right in photo). A solution is to employ a wide caul that spreads out the force before it meets the glueline (at left).*

CLAMPING WIDE BOARDS



CLAMPING THIN EDGING



Where the glueline is close to the clamp head, place the clamps very close together or use a wide caul. Otherwise, some parts of the glueline will not receive sufficient pressure.

stronger than the wood itself. You'll achieve a glueline thickness well under the recommended maximum, which is about 0.004 in. To give a point of reference, the cover of this magazine is 0.005 in. thick.

The next step is to find out how much pressure you are applying with each type of clamp.

We tested the common bar clamps

In his book, *Understanding Wood* (The Taunton Press, 2000), R. Bruce Hoadley illustrated that the amount of force applied by different types of woodworking clamp varies widely. He also found that the force of an individual clamp can differ by a factor of two depending on the strength of the operator.

To compare traditional bar and pipe clamps with newer designs and to see how the force they apply varies by user, *Fine Woodworking* rigged up a jig linked to a set of bathroom scales. The magazine's female copy editor represented one end of the strength scale, a brawny former builder at *Fine Homebuilding* represented the other, and a couple of *Fine Woodworking* editors fell in between (see p. 39). Generally, clamps with T-handles exert more pressure than those with round handles.

The first step when gluing boards is calculating the square inches of glue surface. For example, if you are gluing two boards ¾ in. thick and 36 in. long, a single glue surface equals 27 sq. in. Even if you are edge-gluing several boards, you still need to measure only one glue surface because the clamping pressure is transmitted across the width of the boards. If you are edge-gluing flatsawn red oak boards and wish

Photos, opening page and facing page (top right): Kelly J. Dunton; drawings: John Hartman

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Wet both surfaces. *To ensure the uniform wetting of the wood that aids glue penetration, apply glue to both surfaces.*

to apply about 450 lb. psi, then 27 multiplied by 450 equals a force of 12,150 lb. that must be applied. Using the average of the editors' clamping forces, this could be supplied by around nine heavy-duty bar clamps, a dozen ¾-in. pipe clamps, or 26 quick-grip clamps. Obviously it would be hard to fit 26 clamps along a 36-in. board, so add some more powerful clamps if you have them. It's fine to mix and match types of clamp.

Just as important as the overall force is how it is distributed. You want even pressure along the whole glueline. This can be done in two ways. The force applied by a clamp radiates outward at 45° on either side, so you'll need to space the clamps so that the force from them just overlaps along the glueline.

When edge-gluing wide boards, such as for a tabletop, you can employ powerful clamps spaced widely, alternating the clamps above and below the workpiece to prevent the boards from bowing. If the glueline is close to the face of the clamp, such as when applying solid-wood edging to plywood, to avoid having a clamp placed every inch or two, you can use wide cauls that will spread the clamp pressure as well as protect the edge of the workpiece from the clamps. □

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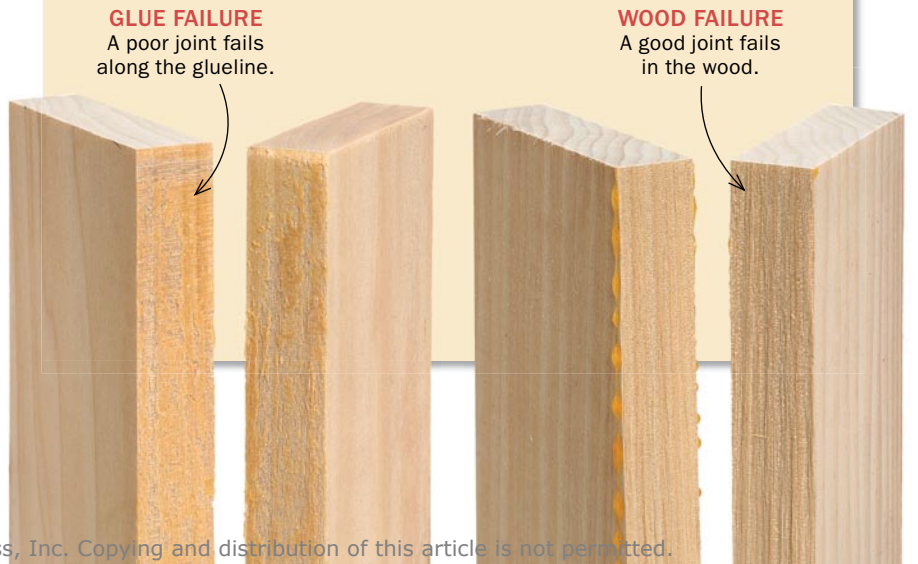
Tips on gluing

It is important to get even, continuous glue coverage on the surfaces to be bonded, so apply yellow glue to both surfaces when you can. This provides instant wetting of both surfaces without relying on pressure and surface flatness to transfer the glue from one surface to the other. You will, however, have to work fast as the open time for yellow glue can be around five minutes at a temperature of 70° F (21° C) and relative air humidity of 50%.

How long should the joint be subjected to clamp pressure? The time varies from species to species, with woods that have an even density across the growth rings, such as maple, requiring less time. But in general, the glueline reaches around 80% of its ultimate strength after 60 minutes of clamping. After this, joints can be released from the clamps, but the full glue strength won't develop for about 24 hours.

HOW STRONG IS YOUR GLUELINE?

Even if you have used the correct pressure, it is still reassuring to make sure that you are achieving well-glued joints. A simple test is to place a sharp chisel exactly on the glueline, and strike it with a mallet. A weak joint will split in the glueline, either because the glue was too thick or the glue didn't penetrate the wood correctly. The percentage of wood failure will be very low or nonexistent. A good joint will split mostly in the wood adjacent to the glueline.



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