

How Strong Is



Your Glue?



We take six types to the breaking point, shattering some common wisdom in the process

BY MARK SCHOFIELD

Unless they confine their woodworking to knockdown furniture, all woodworkers rely on glue. As a result, there are dozens of types of glue and masses of competing brands all proclaiming their superiority.

To help make sense of it all, *Fine Woodworking* ran a test with three main objectives. The first was to compare six common types of woodworking glue; the second was to see if the type of wood might affect the bonding strength of the different glues; the third was to determine how tolerant the glues are to poorly cut joints.

The results were revealing. Some older glues performed superbly, while a newer glue was less than impressive. The wood type does make a difference, but don't believe the stories that say all dense tropical woods are hard to glue. And, while glue starvation seems to be a myth, so does the gap-filling ability of certain glues.

Selecting glues, woods, and gaps

To see whether an open-grained wood bonds differently from a tight-grained one, we chose white oak and hard maple. Dense tropical woods have a reputation as being difficult to glue. We intended to use teak, but the lumberyard owner suggested ipé, as he had heard many complaints about glue failure with this wood.

We chose a traditional interior polyvinyl acetate (PVA) yellow glue represented by Elmer's carpenter's glue; a newer PVA glue with a Type I waterproof rating in the form of Titebond III; two types of hide glue, a room-temperature version by Old Brown Glue and traditional granules that must be mixed with water and heated; a two-part, slow-set epoxy from System Three; and Gorilla Glue's polyurethane.

If a joint is sloppy, will the glue fill the gaps? Conversely, if the joint is so tight it has to be hammered home, will it be starved of glue? Does a perfectly fitting joint produce the strongest glue bond? To answer these questions, we tested bridle joints with three types of fit: tight, snug, and loose.

Bridle joints: First make 'em, then break 'em

We settled on a bridle joint, also known as an open mortise-and-tenon joint, because it has no mechanical strength and instead relies entirely on the glue bond. It also was easy to adjust the width of the tenon to change the fit of the joint to test each glue's gap-filling ability.

Precise milling—To lessen the impact of a rogue result, John White, *Fine Woodworking's* shop manager, made three samples of each joint for a total of 162 samples.

To keep wood variables to a minimum, he cut



THE TYPES WE TESTED

We picked six brands to represent the spectrum of common woodworking glues, including two types of PVA glue, a polyurethane glue, an epoxy, and two types of hide glue.



MAKING THE JOINTS

All 162 joints for the test were cut on a table-saw using a tenoning jig. To maintain even spacing on either side of the tenon in the loose joints, White machined each joint carefully and clamped both pieces to a piece of dead-flat glass while the glue dried.



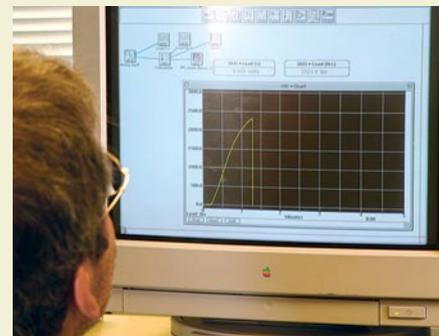
BREAKING THE JOINTS



Under pressure. Under the direction of David Matthiesen (left), Chris Tuma placed each joint in the machine at Case Western and applied force gradually.



Breaking point. Eventually, the force became great enough for the joint to break within the wood or, as in this case, along the glue line.



Monitoring the test. The computer displays the force applied and the amount the joint was compressed. The line's peak marks the point where the joint failed.

the joints from a single, straight-grained board of each species.

The joints were cut using a Freud box-joint blade set in the 1/4-in.-wide configuration, as these blades give a very clean cut with a flat bottom. White cut all the tight joints first, spacing them so that they needed a light tap to bring them together. Using a dial indicator to adjust the tenoning jig, he cut the snug-fitting joints so that they required only hand pressure to bring them together and would represent a perfect fit to most woodworkers. Last, he cut the loose joints with a 1/64-in. gap, split evenly on each side of the tenon. We chose this spacing because there was no wood contact on the tenon, but the joint was still tight enough that most woodworkers would take a chance and hope that glue would fill the gap.

Applying the glue—Each glue was prepared and applied according to the manufacturer's instructions. We used ample

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Watch a video to see how we prepared the joints for testing, and to see the Instron machine in action.

glue because squeeze-out was not a consideration.

The final step was to make a 45° cut at the end of each arm to prepare the joints for the joint-breaking machine. To give the glues time to develop maximum strength,

we allowed the joints to rest for three weeks.

Off to the lab—We shipped the joints to the Department of Materials Science and Engineering at Case Western Reserve University in Cleveland, Ohio. Under the direction of associate professor David Matthiesen, the samples were placed in an Instron testing machine. The force it took to break each joint was recorded on a computer, and then the values for the three joints were averaged and a standard deviation calculated. See what we learned, p. 40.

Mark Schofield is the managing editor.

WHICH GLUE IS THE STRONGEST?

The chart shows the glues ranked by the average force it took to break their joints. To give a guide to each glue's relative performance, its average joint strength is shown as a percentage of that of the strongest glue. We rated Type I PVA as the best overall, with interior yellow glue (PVA) as the best value.

GLUE	JOINT FIT	MAPLE	OAK	IPÉ	AVG. JOINT STRENGTH (LB.)	JOINT STRENGTH AS % OF TYPE I PVA GLUE	COMMENTS
AUTHOR'S BEST OVERALL CHOICE Type I PVA glue (waterproof)	Tight	1842	1843	2554	2024	100%	This proved to be a good all-around glue with no weakness in any of the woods or joint fits. Combined with its ease of use and moderate cost, this glue wins the best overall label.
	Snug	1700	1822	2733			
	Loose	1593	1603	2525			
Slow-set epoxy	Tight	1690	1908	2425	1994	99%	The betting before the test was that this glue would be the strongest. It came in a close second, but given its high cost and longer preparation time, this was disappointing. In particular, it didn't prove to be the clear choice for gap-filling.
	Snug	1680	1832	2712			
	Loose	1635	1557	2503			
AUTHOR'S BEST VALUE CHOICE PVA glue	Tight	1737	1769	2696	1924	95%	Many woodworkers will be relieved to see that their first-choice glue performed so well. Amazingly, it produced the strongest bonds on tight and snug ipé joints. This glue is the best value.
	Snug	1543	1684	2842			
	Loose	1474	1537	2036			
Liquid hide glue	Tight	1468	1850	1716	1595	79%	Not as strong as epoxy or the PVAs, this glue still gave a very credible performance. It performed particularly well on oak, but was relatively less strong on ipé.
	Snug	1516	1699	1779			
	Loose	1436	1521	1374			
Hot hide glue	Tight	1488	1847	1769	1531	76%	Proponents of hide glue have never claimed that it is as strong as PVA, but instead promote its reversibility and compatibility with stains and finish. From this test, it appears that hot hide glue is only a little weaker than yellow glue and is stronger on oak.
	Snug	1412	1765	1459			
	Loose	1485	1618	936			
Polyurethane	Tight	1414	1491	1875	1164	58%	The surprise of the test was this glue's poor showing. The snug joints were poor, and the loose joints were unacceptable. Polyurethane may be a tough finish, but it isn't a tough glue.
	Snug	1336	1055	1455			
	Loose	564	571	716			

THE WEAKEST LINK

The joints failed in three different ways: With the strongest glues, particularly in maple and oak, the failure was usually 100% in the wood. With the weakest glues, particularly in the strongest wood, ipé, the failure was 100% along the glue line, with the wood fibers remaining intact. But the majority of the joints showed some combination of both types of failure.



GLUE FAILURE



WOOD FAILURE



COMBINATION

What we learned about glue

The first lesson is that most (but not all) of these joints are incredibly strong. As Matthiesen joked, “You could park a car on these joints!” Given that the majority of the joints showed either complete or partial wood failure (with the exception of hide-glued ipé and all three woods glued with polyurethane), we concluded that most woodworkers can rely on their glue. That said, there are significant variations between the different glues, between the three woods, and according to the fit of the joint. Many of the results directly contradict conventional wisdom.



Ordinary yellow glue is as strong as the expensive stuff

If you are confident in your joint-making ability, then stick with good old-fashioned interior yellow glue. It was only a little weaker than Type I PVA on tight and snug maple and oak joints, and it was stronger on ipé. If your joint-making skills still need a little help, go with the more expensive Type I PVA.



Liquid hide glue is as good as hot hide glue

Based on the average strength of all the joints, liquid hide glue beat out hot hide glue. However, if you look at specific joints and woods, hot hide glue was strongest in five of the nine categories. I had expected liquid hide glue to be weaker due to the addition of urea to keep it workable at room temperature, but in this test the two glue types were about equal. Where hot hide glue was comparatively weakest was on snug and loose ipé joints.



Open-pored wood produces stronger joints

In only two of 18 categories did maple produce a stronger joint than oak. Hide glues in particular seem to get a better bond on open-pored woods. This may explain why period furniture makers have great success using hide glue on mahogany, another relatively open-pored wood.

Epoxy isn't necessary on a dense tropical wood

The strongest joint in the whole test was yellow glue on ipé—a real surprise. Indeed, both yellow glue and Type I PVA were stronger than epoxy in tight and snug ipé joints. On loose ipé joints, epoxy showed no great advantage, so I would stick with either interior PVA or Type I PVA on this tropical wood. At all costs, don't hope that polyurethane will fill a loose ipé joint—it won't.



Tightness didn't starve these joints

With oak, all six glues created stronger bonds on tight joints than on snug ones, and the same was true with five out of six glues on maple. If oak and maple are representative of domestic woods, you don't need to worry about a tight fit causing glue starvation. Of course, these “tight” joints are far less tight than a clamped joint. On ipé, and perhaps other dense tropical woods, leaving a little extra room for the glue seems like a good idea. That said, both PVA glues and epoxy create incredibly strong joints whether the joints are tight or snug.



Polyurethane glue fails in loose joints

With the exception of hot hide glue on maple, all glues were slightly weaker on loose joints compared to tight and snug ones. All but polyurethane, however, were strong enough. If you want the best adhesive for a sloppy joint, use epoxy for maple, hot hide on oak, and Type I PVA on ipé. Polyurethane gluelines failed on loose joints in all three woods.

