WOOD GLUING

A Gluing Presentation by Bob Behnke

On January 18th, 2024, the SFVW had the privilege of watching a presentation by Bob Behnke from Tightbond Glues, who provided us with a presentation on The Best Gluing Practices.

He agreed to send his PowerPoint Stack to us, but he warned us that what he showed was fragmented. That is, the stack was not continuous and jumped to other files.

He agreed to send us the other files, and I have combined them all into one PDF of the entire presentation. All of these supplemental pages have been placed at the end of the original stack.

As you go through this PDF, press the “Next Page” (or arrow) in your PDF viewer as normal. But, if you see a link in the text (blue color), you can click on that and be taken to the supplementing material. If there are extra pages of that section, press the “Go to Next Page ->” button (upper right), click on that, and go to the next page of the supplementing material. At the end of each supplemental page(s), you’ll see a “Return to Page (#)” button (upper right). Please note there are several links in this collection that take you to the same supplemental pages. Because of that, you might see several orange “Return to Page (#)” on the same page. Each of these can take you back to the respective page where you clicked the link, so remember the page that started from.

Lastly, some of these links go to the internet and are colored with a red link. [Note that there are three that are identified as video links.] To return to this PDF will require you to return back to your PDF application.

Please note that there was a variety of page sizes; I have tried to normalize them as best I could.

Please enjoy this content,

On behalf of the San Fernando Valley Woodworkers, Gary Coyne

Wood

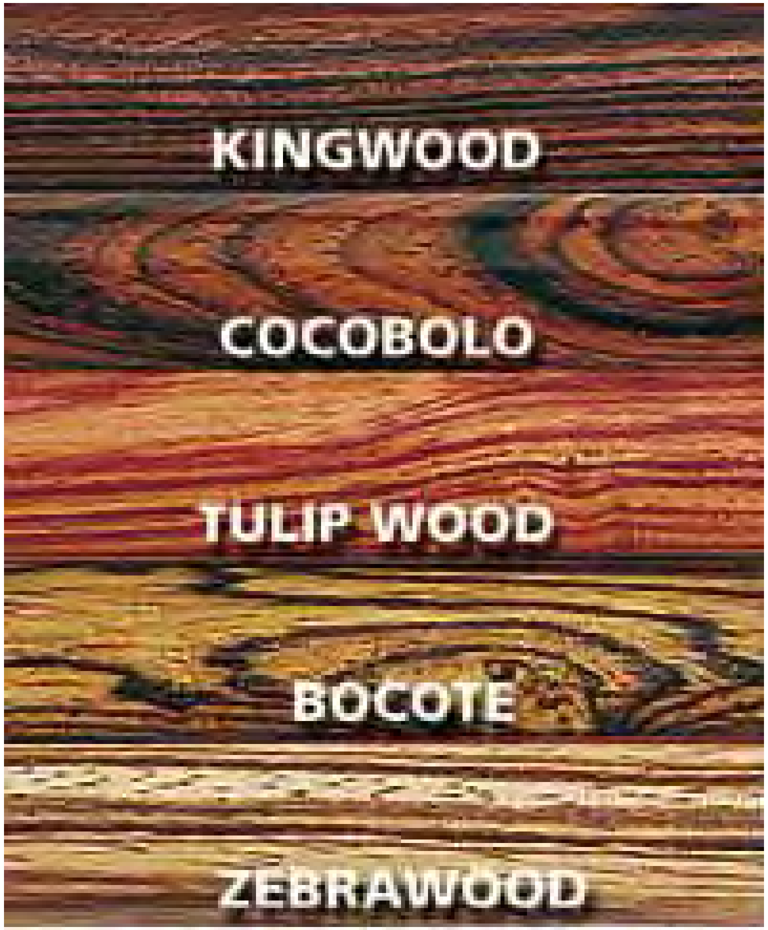
- Comes in a variety of sizes
- Light and Strong
- Easily Worked
- Hard and Elastic
- Permanence of Shape
- Retains stiffness until burned through
- Beauty
- Low Cost
- Sustainable
- **<u>EASILY JOINED TOGETHER</u>**

Hickory will stand more pull than a wrought iron bar of equal length and weight.

For applications where an article must withstand constant blows, no substitute has been found for hickory wood

Go to: Wood University

The objective of the bonding process is to develop a glued joint as strong as the wood itself



Various properties of wood affect its gluing characteristics

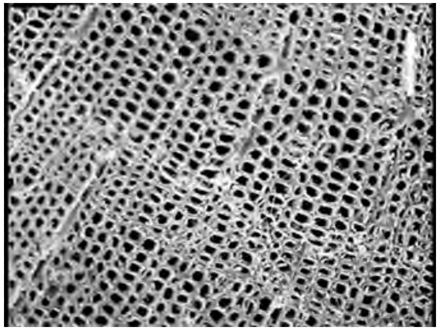
1. Wood density
2. Moisture content
3. Dimensional changes associated with changes in moisture content
4. Pitch content
5. Oiliness
6. Surface contaminants
7. Presence of extractives

Go to: Wood University

Wood Density

- Woods with lower density, hardness and strength tend to be easier to glue

- Developing bond strength equal to the strength of wood is easier to achieve with weaker woods



The cellular structure of red oak is so open that you can blow smoke through it from end-grain to end-grain (flat sawn).

White oak, on the other hand, has such a tight cell structure that water can't pass. That's why white oak works so well for whiskey barrels and outdoor furniture.

Go to: Wood University

Moisture Content

- Wood may be glued with moisture content ranging from 6 to 17 percent

- Proper moisture content depends upon where the wood is to be used
  - In heated and air conditioned buildings
    - 7-8 percent
  - For exposure to the outdoors
    - 12-15 percent

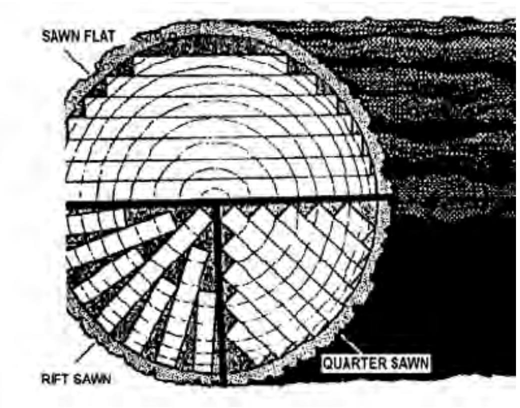
- Glued joints will perform best when %moisture equals the average moisture content the product will attain in service

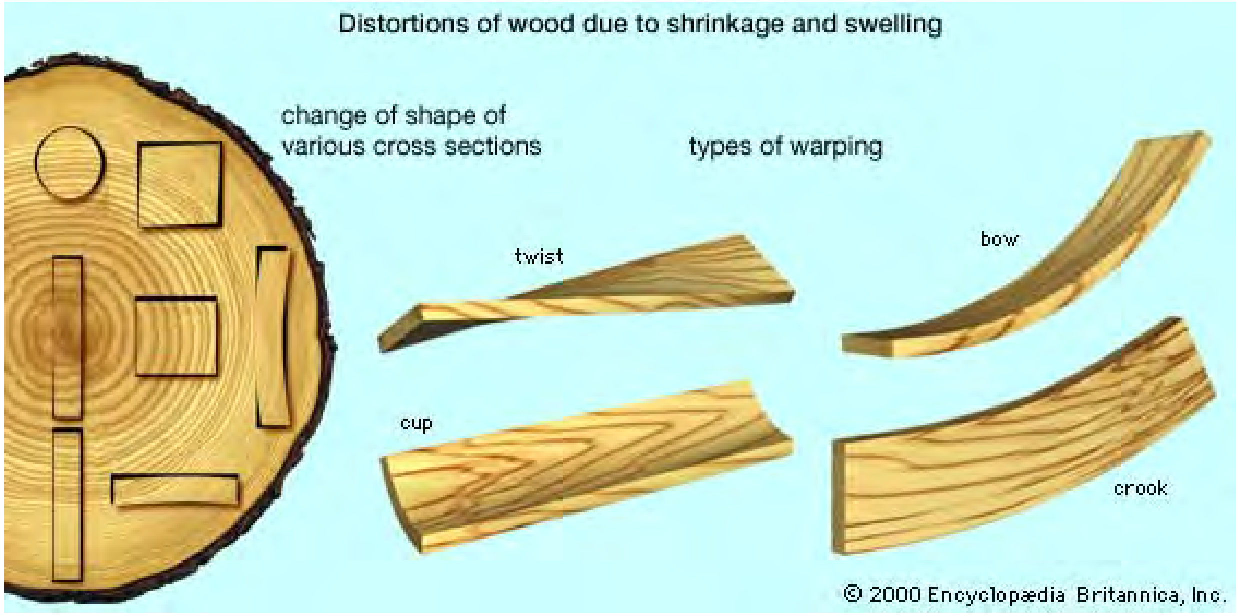
- Longer clamp time needed for higher moisture content

Titebond Wood Glue Chart

Dimensional changes associated with changes in moisture content

- Wood must be at similar moisture content to avoid stepped joints
- Wood grain direction can add to or minimize assembly movement
- Allow time for moisture to equilibrate before machining to avoid sunken glue joints
- Allow wood to attain use moisture content before machining wood
- Dissimilar woods will have different moisture dimensional changes
- Quarter/rift sawn wood is most stable





Pitch content, Oiliness, Surface Contaminants, Presence of Extractives

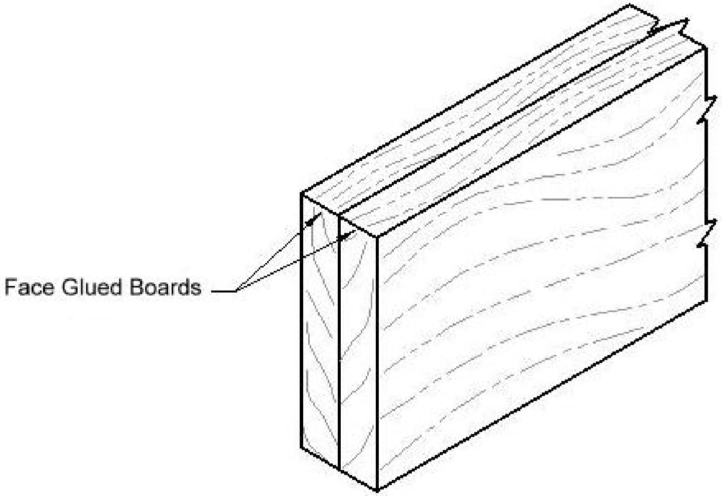
- Contaminants must be removed from gluing surfaces to allow tight fit
- Wipe joints with acetone on a white rag until the rag comes back clean
- Oily wood will keep water based adhesives from penetrating and wetting out the surface of the wood.
- Wood Glues bond to cellulose and anything that masks the cellulose will decrease potential bond strength
- Metal salt extractives in some woods can turn glue lines different colors
- Chain of adhesion states that the weakest link will dictate bond strength

Wood Glue Applications

- Edge and Face Gluing
- Assembly Gluing
- Cold Press Laminating
- Hot Press Gluing

Edge and Face Gluing

- Edge gluing used to create large panels
- Face gluing used to create thicker stock
- Usually only glue, no other fasteners are used
- Joints need to fit tightly
  - Square
  - Free of defects like saw marks, knife marks, glazing or burnishing
- Clamping required to hold stock together during drying of adhesive
- Grain patterns should be assembled to minimize warping and cupping
  - glued up panels should be quarter sawn if possible
  - place the cups in the boards opposite to each other



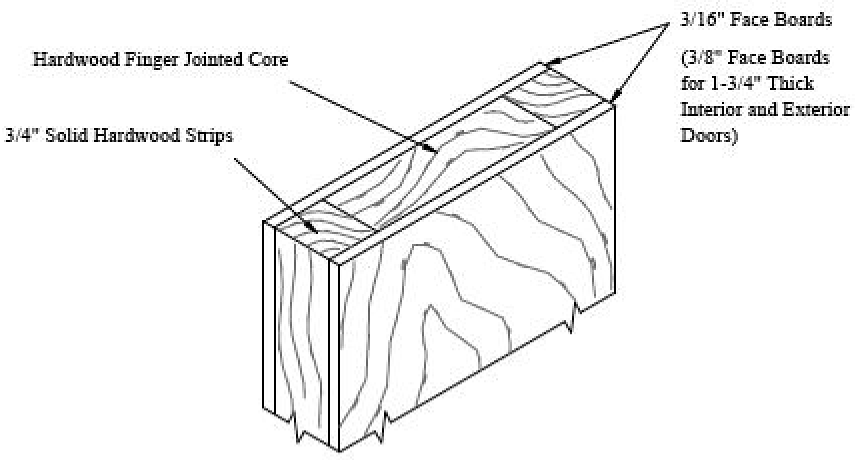
Assembly Gluing

- Joint Gluing
    - Mortise and Tenon
    - Dovetail
    - Tongue and Groove
    - Corner Blocks
    - Dowels
    - Biscuits
    - Miters

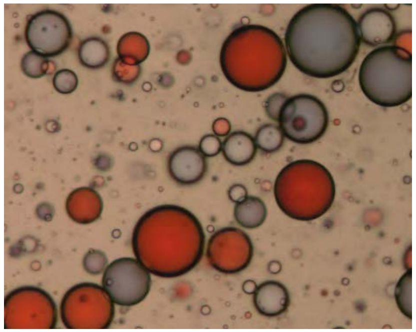
- Side to side grain gluing
- Side to End grain gluing
- Tight fitting

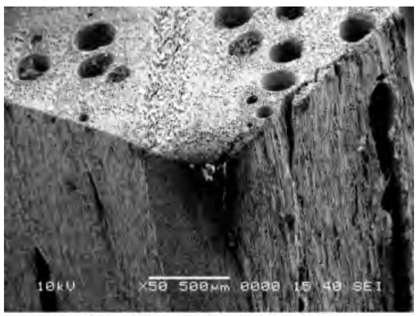
Cold and Hot Press Laminating

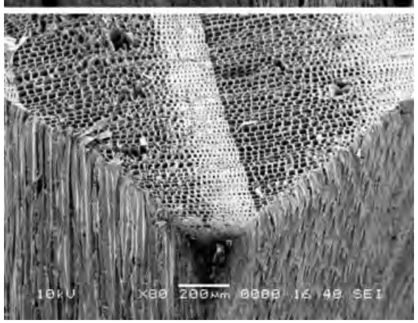
- Usually used for large number of like sized materials
- High Pressure laminates and veneers to plywood, particle board, MDF
- Environmental alternative to solvent based contact cements
- Need close tolerances for bond lines
- Use proper adhesive to minimize bleed through on veneers
- Uniform pressure critical
- Variable Press time
  - ambient conditions (temperature and humidity)
  - Glue spread
  - Core materials
  - Type of equipment with heat capabilities



A Word on End Grain Gluing







Synthetic wood glues are based on an emulsion polymer **composed of polyvinyl acetate (PVA) stabilized with polyvinyl alcohol (PVOH)**. In general these water based wood glues are just, microscopic balls of plastic suspended in water. Each company adds chemicals or reduces the amount of water, to add water resistance, fast grab, color, thickness (viscosity), and ability to stick to plastic substrates such as melamine counter tops. To the left is a microscopic picture of a water based emulsion (this picture was taken from the internet):

What allows these polymers to stick to wood so well is that the PVOH has an affinity for cellulose. This attraction coupled with the strength of the PVA polymer makes for a strong bond. To the left are microscopic pictures of wood (taken from the internet), the top picture shows a large pore structure and the bottom a finer pore structure. **In edge and face grain gluing, there is a large surface area of cellulose that is available for bonding**, therefore the bonding per square inch is maximized and the cellulose is held together strongly to the point where the adhesive forms a bond stronger than the inherent weakness in the wood structure itself. This weakness is observed as wood failure during stress testing.

End grain gluing, as can be seen from the picture at left, has much less cellulose available for bonding. Most of the structure is air, similar to gluing the ends of a drinking straw together versus the sides of a straw. **This is why end grain gluing is so weak**. The cellulose bonding per square inch is much reduced, to the point where the force to break the bond is much less than the strength of the wood and no wood failure is observed. Therefore joints using end grain gluing must be designed to limit stresses versus stresses placed on side or face glued wood and therefore should not be used where high stress joinery is required. In all cases, these bonds should perform as designed for the duration of the wood structure itself.

There are **other issues with end grain gluing that causes weak bonds** also. In some cases, the **viscosity and particle size** of the polymer is so low that most of the adhesive is transported, through capillary action, through the ends of the pores, causing a **starved wood glue joint**. In other cases, water is "sucked" from the adhesive so quickly that the **glue dries too fast** before the parts can be assembled.

A Word on End Grain Gluing cont.

Because of the reduced amount of cellulose, water based wood **glued end grain joints will always be weaker than face or side grain gluing**. To **maximize the bond, high viscosity glue** should be used to keep adhesive from disappearing down the end grain. Franklin makes a product specifically for end grain and mitered joints. **Titebond No Run, No Drip is 36,000 cps versus 4,000 cps** for most wood glues and sets with minimal clamping. Otherwise, lower viscosity wood glues can be used by first priming the end grain with a 50/50 mixture of glue and water and allowing it to dry. This will plug the pores of the wood without covering up the cellulose for subsequent gluing. The end grain can then be glued normally without issues of premature drying or starved glue joints.

It is important to understand that the bond is dependent on the availability of cellulose. In using some species of tropical hardwoods or fragrant soft woods, oil from the wood can contaminate the cellulose and must be removed to create a strong bond. Side and face grain gluing can be accomplished by wiping the wood with acetone until a white rag returns clean. Immediate gluing after cleaning will result in acceptable bond strength. **With end grain gluing however, ability to remove oils from the ends of the "straws" can be difficult and bond strength should be tested before including this type of joint in your design**.

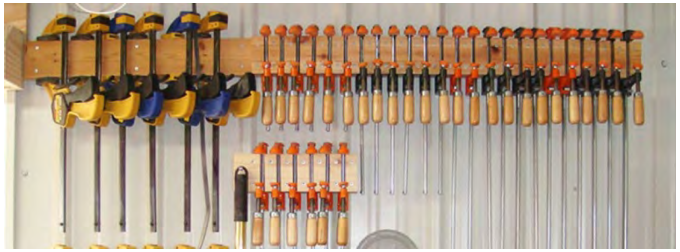
Additionally, wood glues need to dry to build strength. If using a dense, tropical hardwood with high oil content, water will have a difficult time finding a path out of the glue line, therefore more time should be given to clamping/drying. In some cases, a full week should be given for full strength build. Wood with high moisture content can also inhibit drying of the adhesive. Normal dry times given in company literature are based on wood that has a moisture content of 6-8%. Moisture content above this value will increase the need for clamping/drying time. Moisture content above 15 to 17% may not allow the wood glue to dry at all. Lower moisture content can cause the glue to dry quickly and reduce the amount of time to assemble a project, so it is important to have a good handle on what moisture content your wood has during assembly.
Titebond II and Titebond III are designed to be used for wood working projects that need water resistance. Titebond III has the additional capability to withstand boiling water so is a good choice for cutting boards that may see a dishwasher cycle.

Gluing Application Guidelines for Titebond Wood Glues

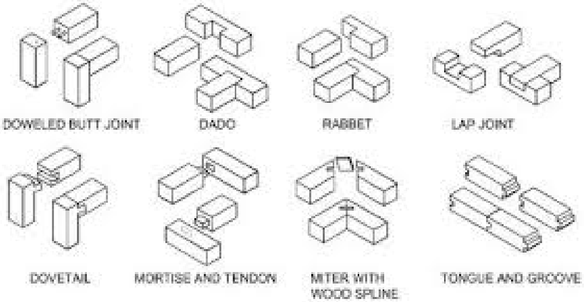
- Temperature
  - Keep from freezing
    - Most freeze thaw stable
    - Designed for 5-10 freeze thaw cycles
    - Thaw and mix before using
    - Eventual irreversible thickening
  - Assembly time
    - Cold moist conditions will extend set and final strength attainment time
    - Hot dry conditions will greatly shorten open time
    - Chalk Temperature
- Humidity and Moisture Content
  - High humidity will extend set, clamp and final strength attainment time
  - Excess or uneven moisture can cause distortion, warpage, delamination
  - Moisture in glue line can cause sunken wood joints
  - Best moisture content is between 6-8%
  - Allow assemblies to equalize moisture content before final machining
- Clamp Time
  - Vary with species of wood
  - Vary with temperature, and moisture content
  - Stable woods such as maple require short clamp times
  - Ring porous woods such as oak and walnut require slightly longer clamp times
  - Composites such as MDF and particle board tend to require even longer clamp times

Gluing Application Guidelines for Titebond Wood Glues (cont.)

- Clamp Pressure
  - 30-80 psi for High Pressure Laminates and veneers
  - 100-15 psi for soft woods
  - 125-175 psi for medium density woods
  - 175-250 psi for hardwoods
  - Avoid excessively bowed or distorted wood
  - Use uniform clamping pressure



- Joint Preparation
  - Surfaces must be free of saw marks, knife marks, glazing, burnishing
  - Clean off any foreign materials that seals wood pores
  - Be sure joints are tight fitting a square
  - Joint that are too tight can scrape glue off of surfaces during assembly
- Joint Design
  - Design joints to handle usage stress
  - Minimize amount of end grain to end grain gluing
  - Maximize amount of edge to edge gluing
  - Minimize gaps between joints



- Clean-Up
  - Allow glue to reach partial dry state before removing
  - Minimize amount of rubbing of wet glue onto wood surfaces
  - A straw cut on an angle can help remove wet glue squeeze out in corners
  - Scrape off excess dry glue with a sharp chisel
  - Sand remaining glue to get a clean surface
  - Keep clothing contaminated with glue wet as dry films are very difficult to remove.

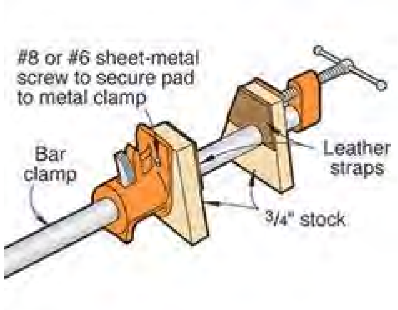
5 Steps for Successful Gluing

- Do a Dry Fit
- Prepare the Glue and Accessories
- Prepare Clean Up Items
- Glue up
- Allow to Dry/Cure

5 Steps for Successful Gluing

Do a Dry Fit

- Clamp pieces without glue to make sure the **joints come together tightly**
- Mark pieces for **proper alignment** (and to keep them from being glued in backwards)
- Test for **choice of clamps and blocks**
- Make blocks, strips or pads to **protect the wood from clamping pressure**
- Use double sided tape to **keep blocks, strips and pads in place**
- **Fix joints** which are too tight or too loose
- Water based wood glues don't fill gaps so **loose joints may require an epoxy adhesive**
- For easy clean up, put **masking tape on all joints** then cut apart to disassemble
- Bridge edge to edge joints with a clamp to **keep seams from creeping**
- Check moisture content of all wood to be sure **all parts are within 1% moisture content**
- **Clean** away any residual saw dust or contamination that may keep joints from fitting tightly



5 Steps for Successful Gluing

Prepare the Glue and Accessories

- **Determine the correct glue** for the project requirements
- Be sure **glue is in good condition** by mixing with a small stick
- If glue has settled **stir** in settled material before proceeding
- If unsure of glue, **test on scrap piece of wood**, clamp 24 hours then break with hammer
- Clean glue bottle **applicator tip**
- **Clean glue brushes** and remove any loose bristles
- Coat or **mask any iron pipes** to avoid **black stains**
- **Arrange and orient clamps** from the dry fit for easy access

5 Steps for Successful Gluing

Prepare clean up items

- For water-based wood glues have a bucket of **<u>water handy for spills</u>**
- For **<u>other types of adhesives, use acetone or mineral spirits</u>** for cleanup
- Spread plastic sheeting over work surface to **<u>protect against drips</u>**

5 Steps for Successful Gluing

Glue up

- Be sure the **shop and substrate temperatures are above the chalk point** of the adhesive
- **Consider gluing in stages** to reduce open and total assembly time
- A threaded rod or hand trowel (1/16" x 1/32" x 5/64" U-notch) works well as a **tool to spread the correct amount of glue**
- **Wipe joints with acetone** before gluing especially for oily tropical woods
- Apply approximately 6 mil wet film or **250 ft2 per gallon**
- Peel off any masking tape **when glue is slightly rubbery**
- Use wax paper under clamps if in contact with any glue squeeze out
- Allow squeeze out to dry for 10-20 minutes then remove with a putty knife
- After gluing **remove cap from bottle and clean out glue**, replace with clean cap

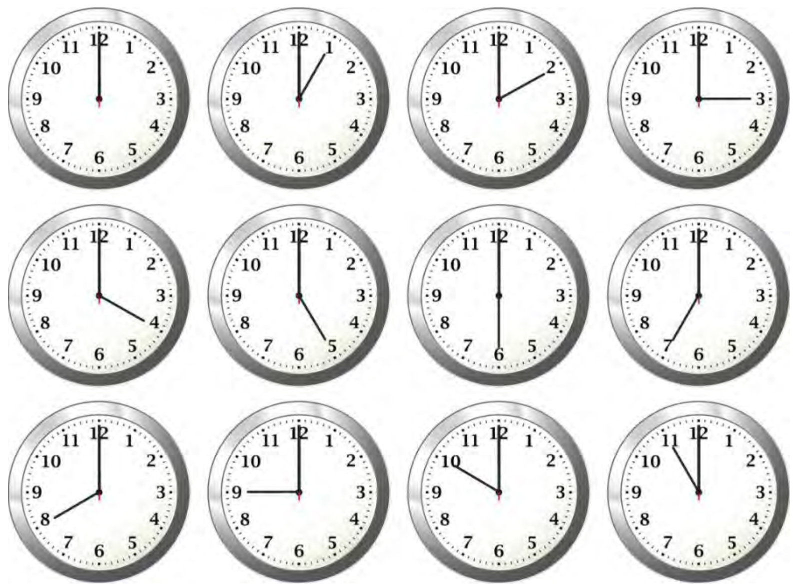
5 Steps for Successful Gluing

Drying

- Allow joints to dry for at least 2-3 hours before unclamping, **<u>best to leave for 24 hours</u>**

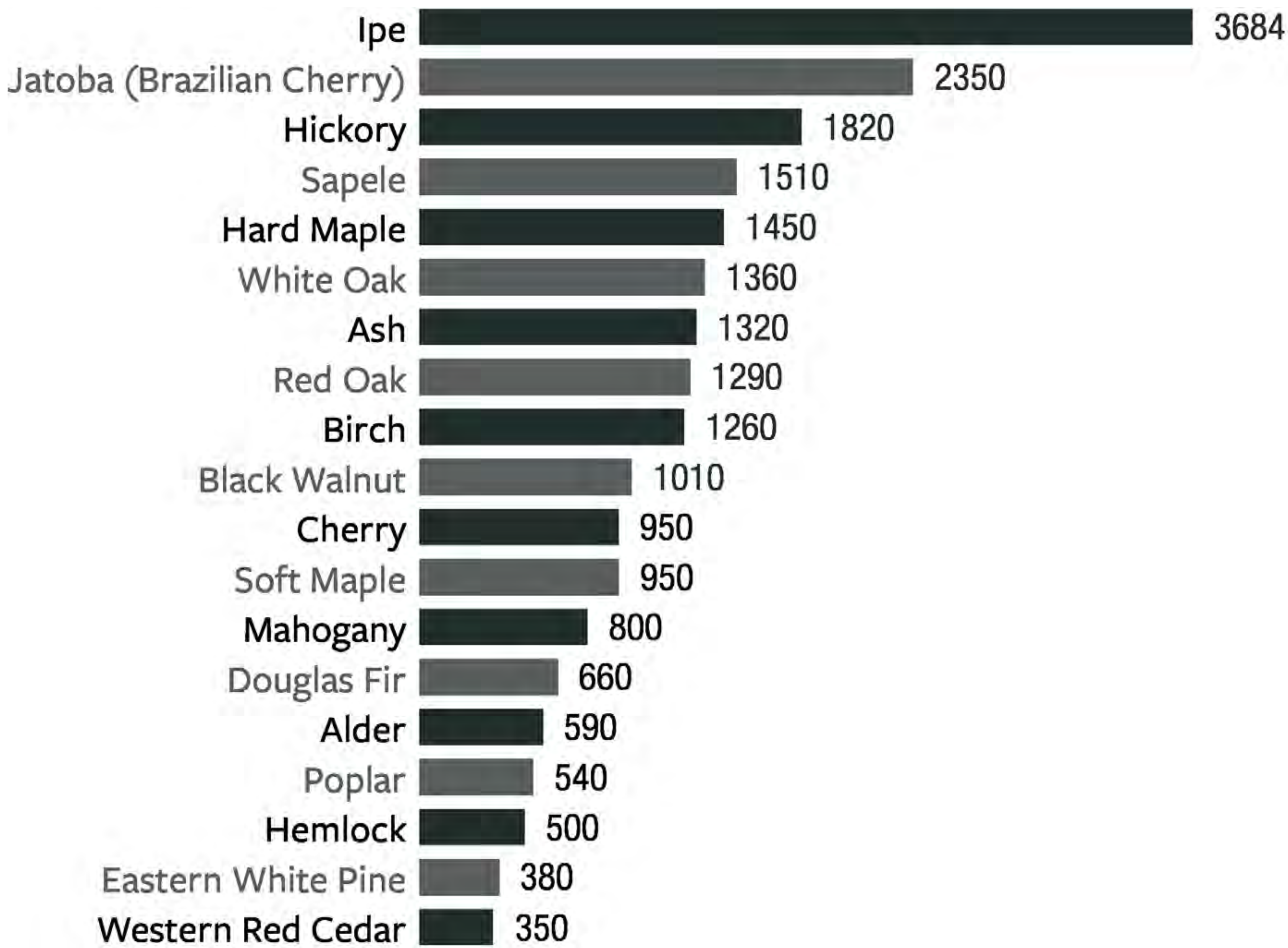
- Allow edge to edge joints to **<u>dry for several days</u>** before sanding or planing smooth to reduce the chances of <u>sunken glue joints</u>





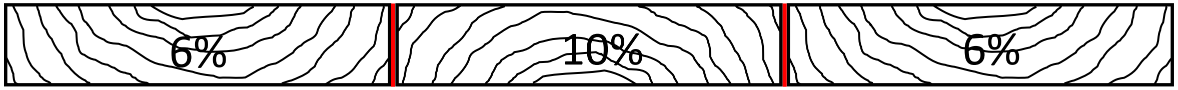
Janke Hardness testing results

Return to page 6



The Sequence Creating Stepped Joints in Edged Glued Panels

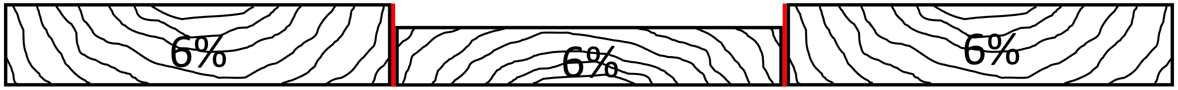
Return to page 8



Return to page 19

1) Moisture content of wood pieces are not equal
2) Glue is applied and pieces are joined.
3) Moisture in wood pieces equalizes over time to 6%.
   a) Pieces at 6% stay the same dimension.
   b) Pieces at 10% shrink as moisture goes to 6%.
4) Glued panel has one board that is now thinner than other panels

Time = Weeks



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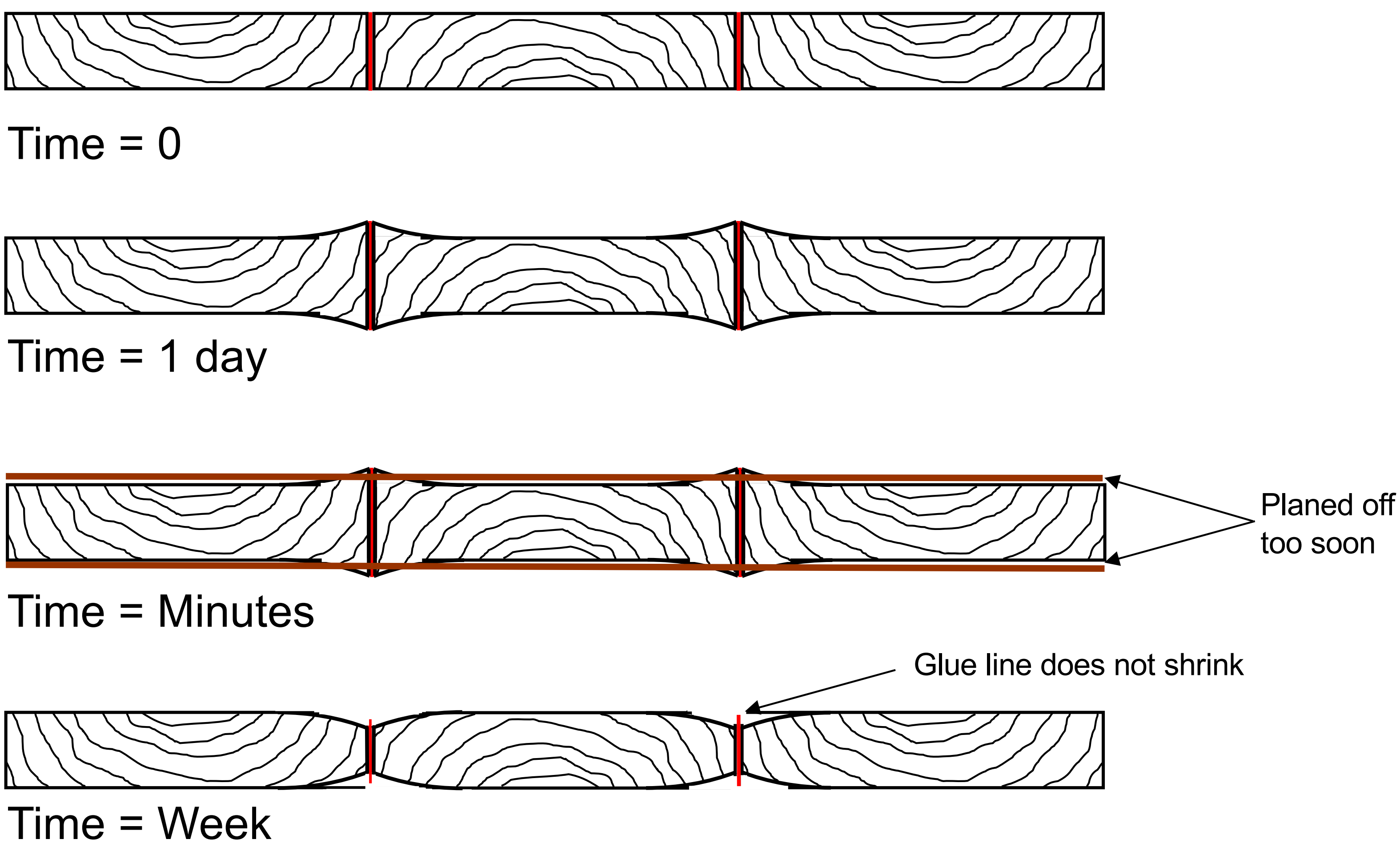
The Sequence Creating Sunken Joints in Edged Glued Panels



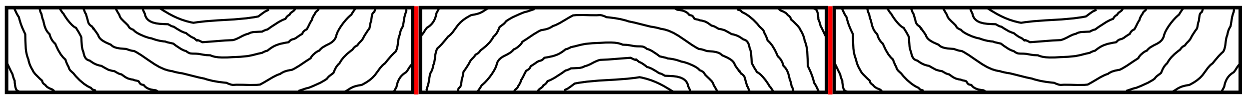
1) Glue is applied and pieces are joined.
2) Moisture in glue causes localized swelling.
3) Panels are planed smooth before swelling goes down.
4) Swelling goes down, after planing, leaving a depression.

The Sequence Creating Ridges of Glue on Panels

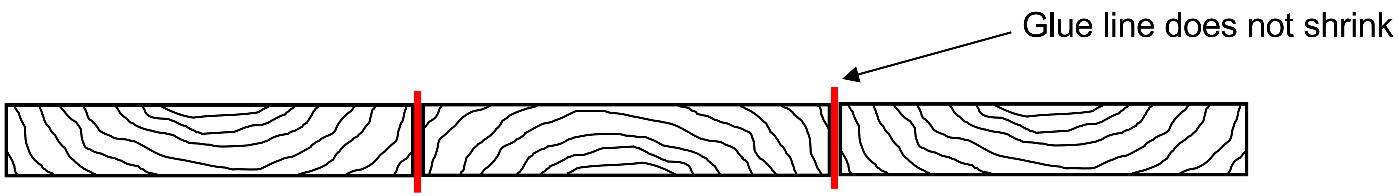
Return to page 9

Return to page 16

Return to page 23



Time = 0 Wood Moisture Content 10%



Time = Week or longer Wood Moisture Content 6%

1) Glue is applied and pieces are joined.
2) Panels are planed smooth.
3) As the wood moisture decreases, it leaves a ridge of glue.

Note: Glue cannot extrude from glue line without extreme heat and pressure as it is a solid plastic.
Use a straight edge to determine which of these mechanisms are causing the ridge. Light under the straight edge means the wood was sanded/planed too early. If the straight edge rocks, then the moisture content of the wood was too high initially.

Go to next page ->

Gluing Oily Tropical Hardwoods

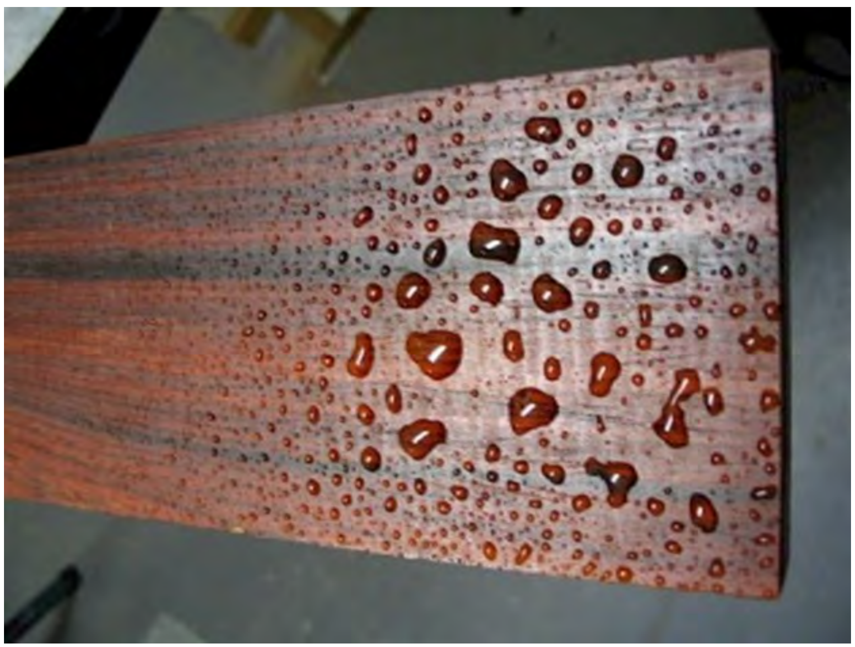
by Eric Meier

Conventional wood glues like Titebond are water-based, and they rely on penetrating into the grain of the wood, and then (once the water has evaporated) hardening, leaving a bond that is in many instances stronger than the wood itself.

The Problem:

Many tropical hardwoods are so oily or resinous that they're practically waterproof. It would then stand to reason that if conventional wood glues need to penetrate into the wood in order to obtain a strong bond, then these oily woods would present a challenge in gluing.

Water beads up on the surface of Cocobolo.



Untreated, raw Cocobolo, which was misted with a spray bottle full of regular water (along with a handful of other tropical species), appear to be nearly waterproof.

Go to next page ->

They're technically not waterproof: since **ALL** wood, (even the Cocobolo pictured above), contains some degree of moisture that changes depending upon the relative humidity of the surrounding air. But for most intents and purposes, in the short amount of time that is elapsed in the gluing process, so little of the glue sinks down into the wood grain that it is essentially waterproof, or perhaps more accurately, **glue-proof**.

Between different types of wood, and even within the same species of wood, **there can be a lot of variability in oil/resin content**, and gluing success/difficulty. Sometimes an oily wood can be glued with regular yellow glue with no problems, and in the next instance, the glue joint will almost fall apart on its own.

So what can be done about this unpredictable nature of wood?

Go to next page ->

Some Solutions:

Please note that these are **some solutions that can help give consistent results in gluing troublesome woods**; but it is by no means a cure-all that is guaranteed to work every time, with all wood species and with all types of wood joints. On the whole, **employing these tips should result in generally stronger, longer-lasting glue joints in oily woods**.

1.) Wipe the wood surface with a solvent prior to gluing.

Since the **primary problem that tropical woods present in gluing is their oiliness**, (with density probably being the second biggest problem), any of these natural oils and resins that you can remove from the wood surface will help the glue adhere that much better. While it's not a cure-all, wiping the wood with a solvent first goes a long way. But you have to be sure of two things: first, you should try to **glue the pieces of wood to be joined as soon as possible after the solvent has evaporated from the wood surface**. This is because the wood's oils will tend to migrate back to the surface of the wood where you removed some of the oils. Secondly, you have to **be sure that the solvent you're using is actually dissolving and removing the wood's oils**. A good way to gauge this is by checking the towel that you're using to wipe the solvent to see if it's changed to the wood's color.

Go to next page ->

2.) Sand the wood to help open up the grain.

You'll notice that sometimes on particularly dense woods, just after they're out of the planer, that they almost have a shine to them. This is because the **blades of a jointer/planer can actually burnish the wood** as it passes through the machine. Sanding helps to break up this flattened/polished surface so more glue can penetrate into the wood. It's tempting to take the wood straight from the planer or jointer and glue it immediately, but for stronger joints, especially in dense woods, it helps to sand the wood with medium-grit sandpaper before it's glued. (use 220-320 grit sandpaper)

3.) Use synthetic, non-water-based glues.

Since water is repelled by the wood's oils, using water-based glues like Titebond® can pose problems—though **Titebond® II or III are usually better at gluing oily woods** than Titebond® Original. Instead, use glues that aren't water based, and/or glues that can bond a wider variety of materials like plastics and other non-porous surfaces (since that's practically what we're doing with these exotic woods anyways).

NOTE: Testing has shown that removing the oils is essential for getting a strong bond even for non-water based wood glues.

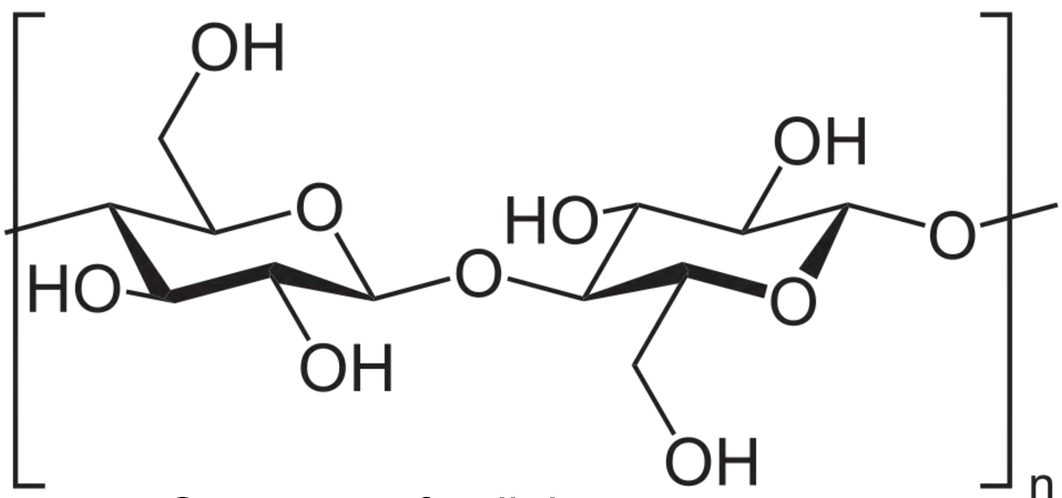
Return to Page 8

Return to Page 22

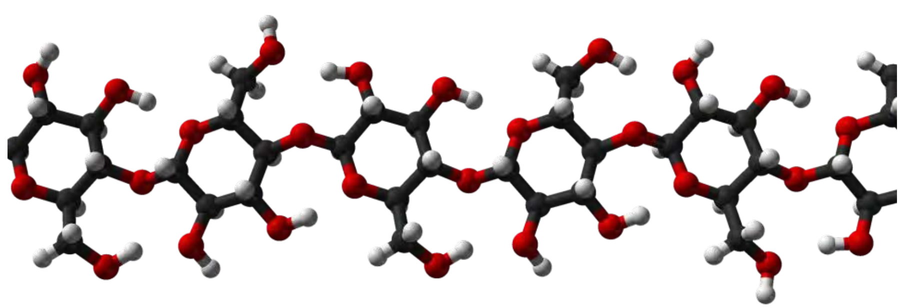
Wood	Gluing Notes
Bubinga	High density, closed pores, and natural oils can cause problems with glue penetration.
Bulletwood	High density and moderately oily.
Cocobolo	Very high oil content and high density.
Cumaru	High oil content and high density.
East Indian Rosewood	High oil content and medium/high density.
Ebonies	Some oil present, along with very high densities.
Ekki	High density and moderately oily.
Goncalo Alves	High density and natural oils prevent water absorption.
Greenheart	High density and natural oils.
Honduran Rosewood	High oil content and high density.
Ipe	Reportedly very difficult to glue in exterior applications, especially for the long term.
Katalox	Very high density, along with natural oils.
Kingwood	Very high oil content and high density.
Lignum Vitae	Extremely high oil content and density can pose gluing challenges.
Osage Orange	Oils present can give gluing problems.
Purpleheart	High oil content and high density.
Rosewoods	Typically very oily and very dense.
Santos Mahogany	High density and moderately oily.
Teak	Oils/resins can present challenges in outdoor applications.
Verawood	Extremely high oil content and density can pose gluing challenges.

Go to next page ->

Cellulose is the structural component of the primary cell wall of green plants, many forms of algae and the oomycetes. Cellulose is the most common organic compound on Earth. About 33% of all plant matter is cellulose (the cellulose content of cotton is 90% and that of wood is 40–50%).



Structure of cellulose



Cellulose from wood pulp has typical chain lengths between 300 and 1700 units; cotton and other plant fibers as well as bacterial celluloses have chain lengths ranging from 800 to 10,000 units.

Many properties of cellulose depend on its chain length or degree of polymerization, the number of glucose units that make up one polymer molecule

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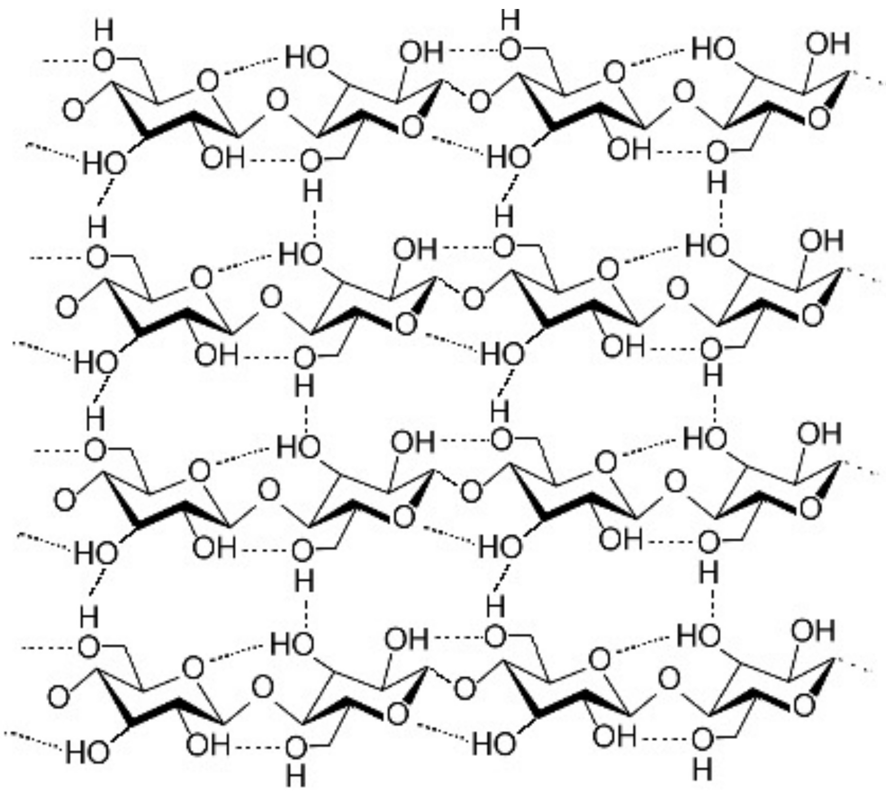
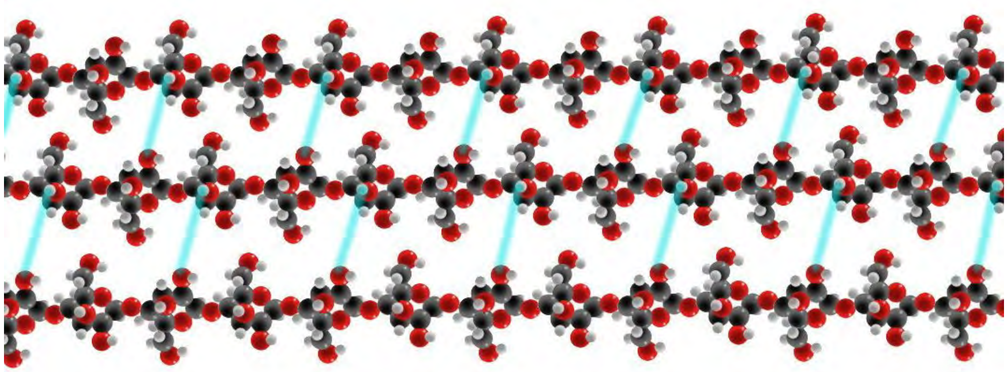


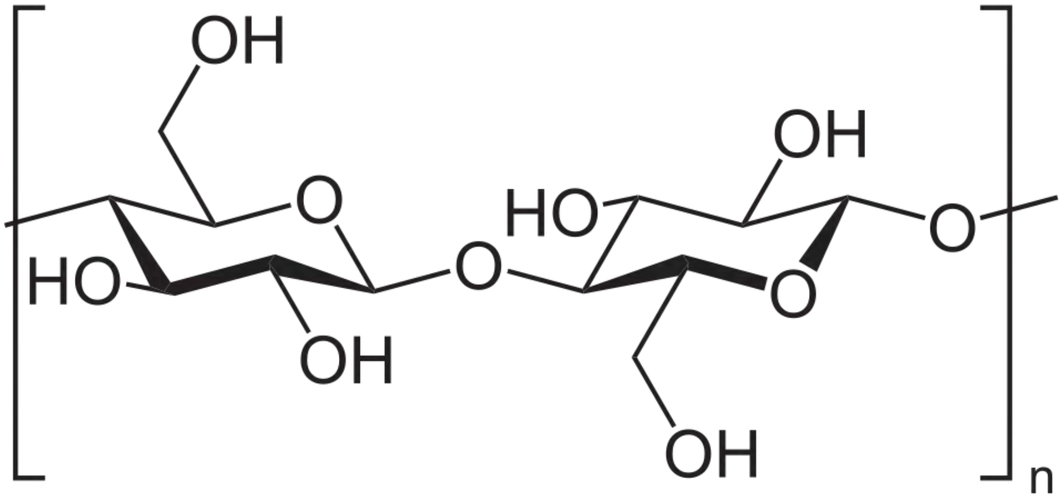


A strand of cellulose showing the hydrogen bonds (dashed) within and between cellulose molecules.

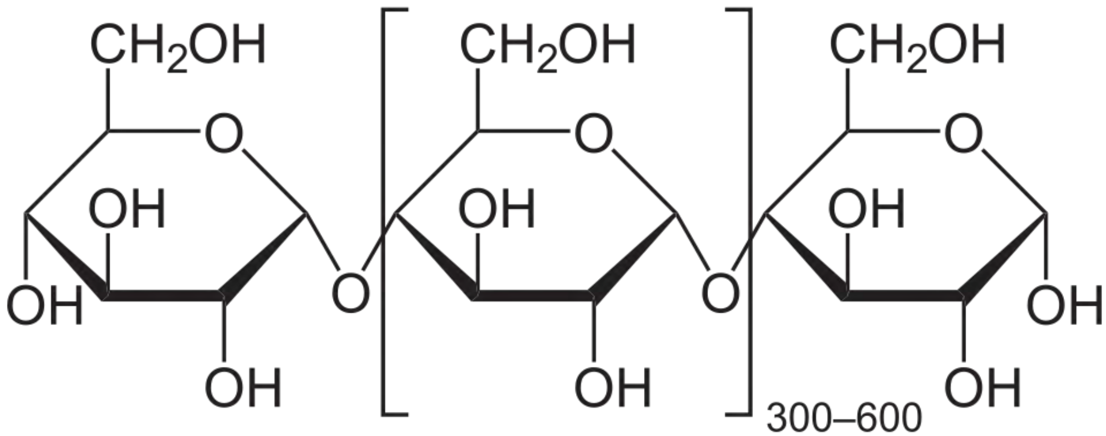
Because cellulose molecules bind strongly to each other, cellulose is relatively difficult to breakdown

Compared to starch, cellulose is also much more crystalline. Whereas starch undergoes a crystalline to amorphous transition when heated beyond 60-70 °C in water (as in cooking), cellulose requires a temperature of 320 °C and pressure of 25 MPa to become amorphous in water

Return to Page 9



Structure of cellulose

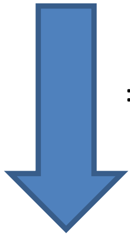


Structure of starch

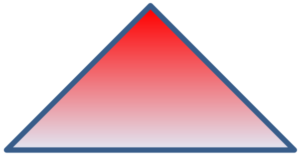
Return to Page 9

Return to Page 20

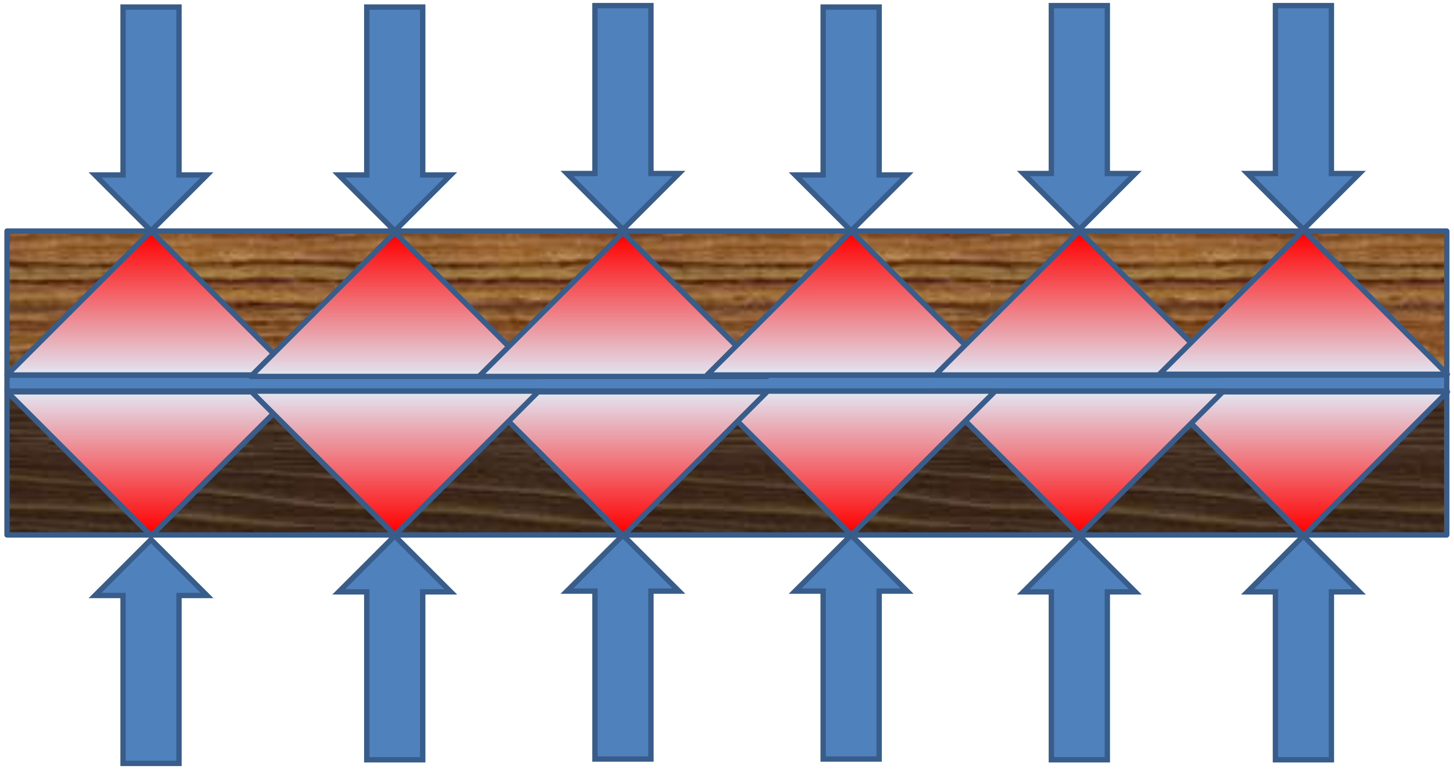
Go to next page ->



= Clamp Location



= Clamping pressure



Note: Clamping pressure must cover entire glue line surface

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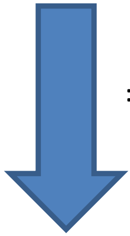

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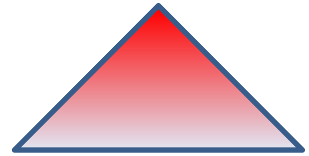
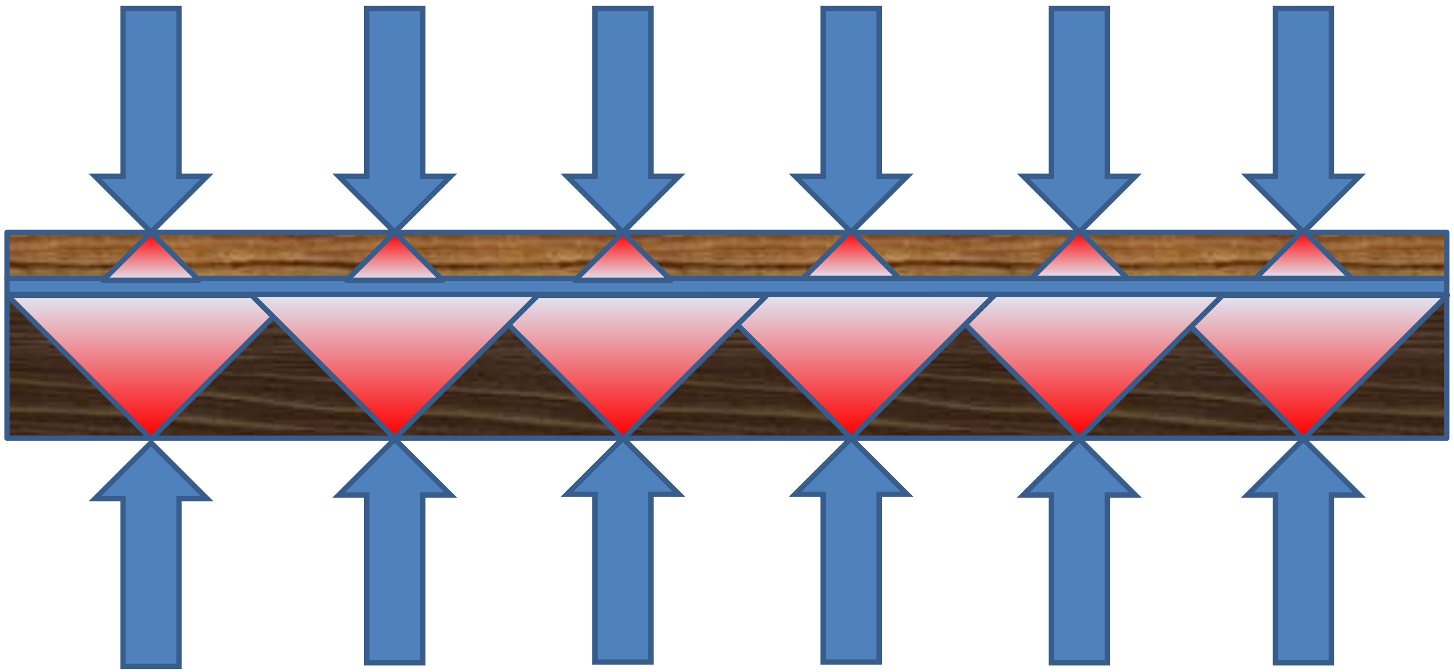
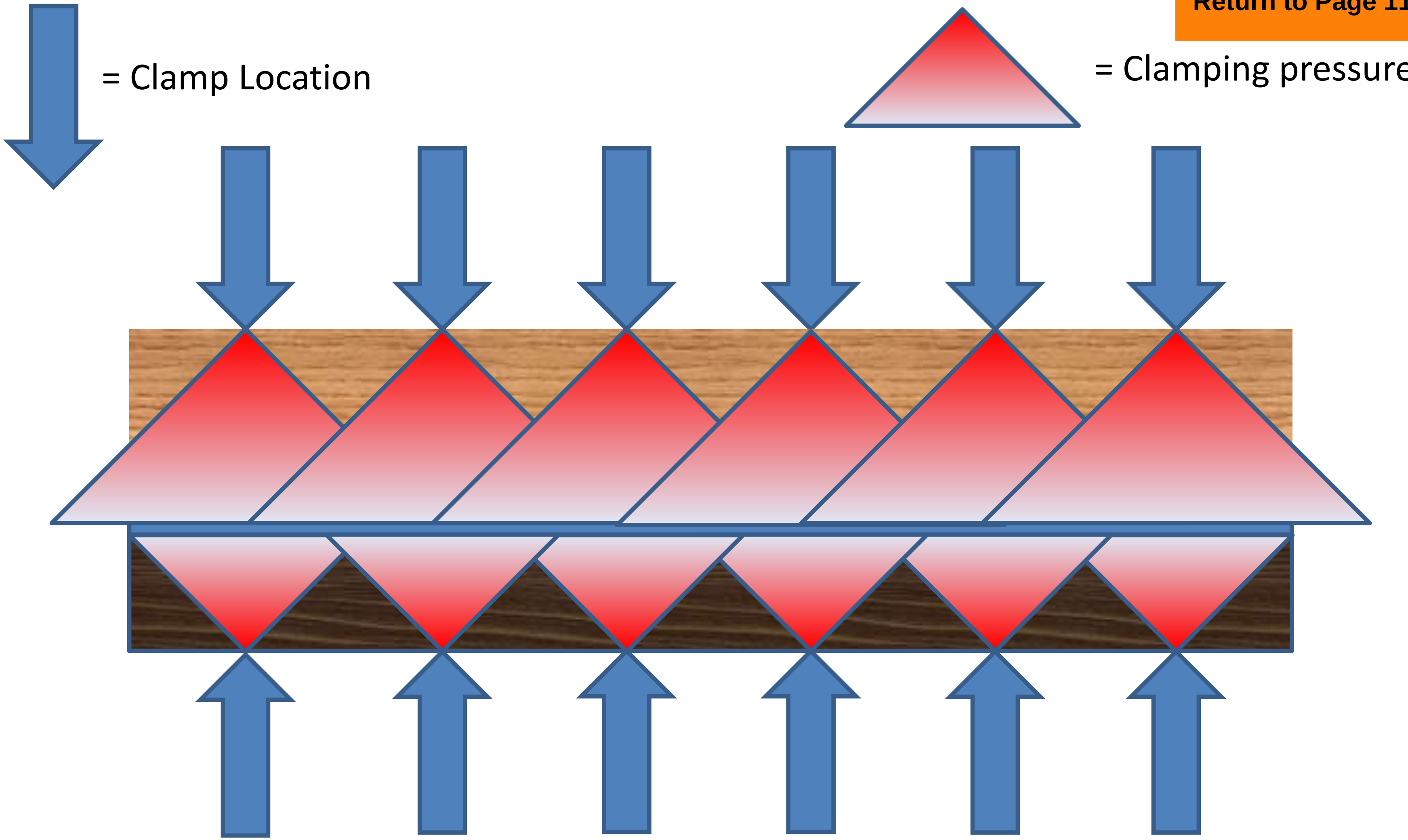


= Clamping pressure



Note: Thinner wood requires more clamps.

Return to Page 11



Note: Thinner wood requires more clamps or use of a clamping block to Spread the force to a larger area.

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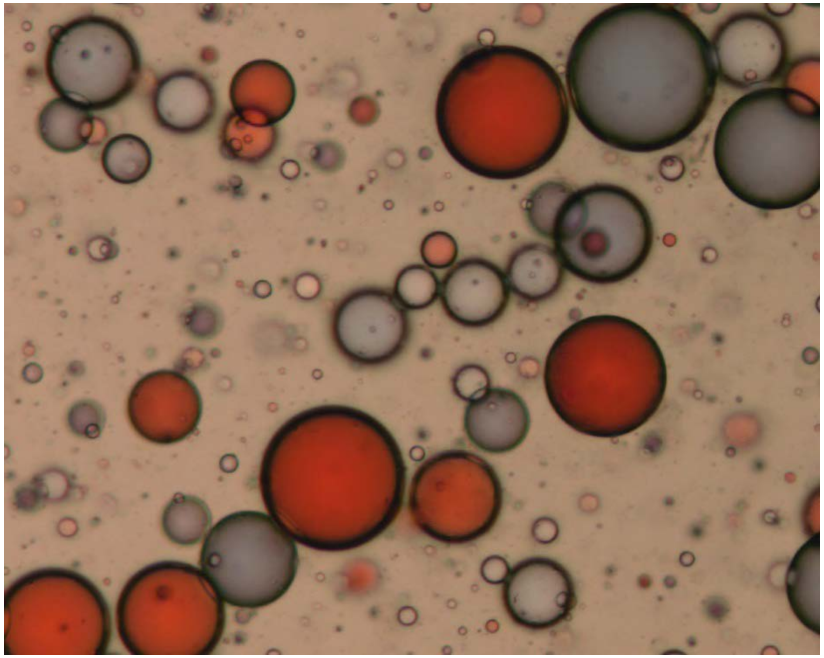
Open and Total Assembly Time

It’s all about moisture management



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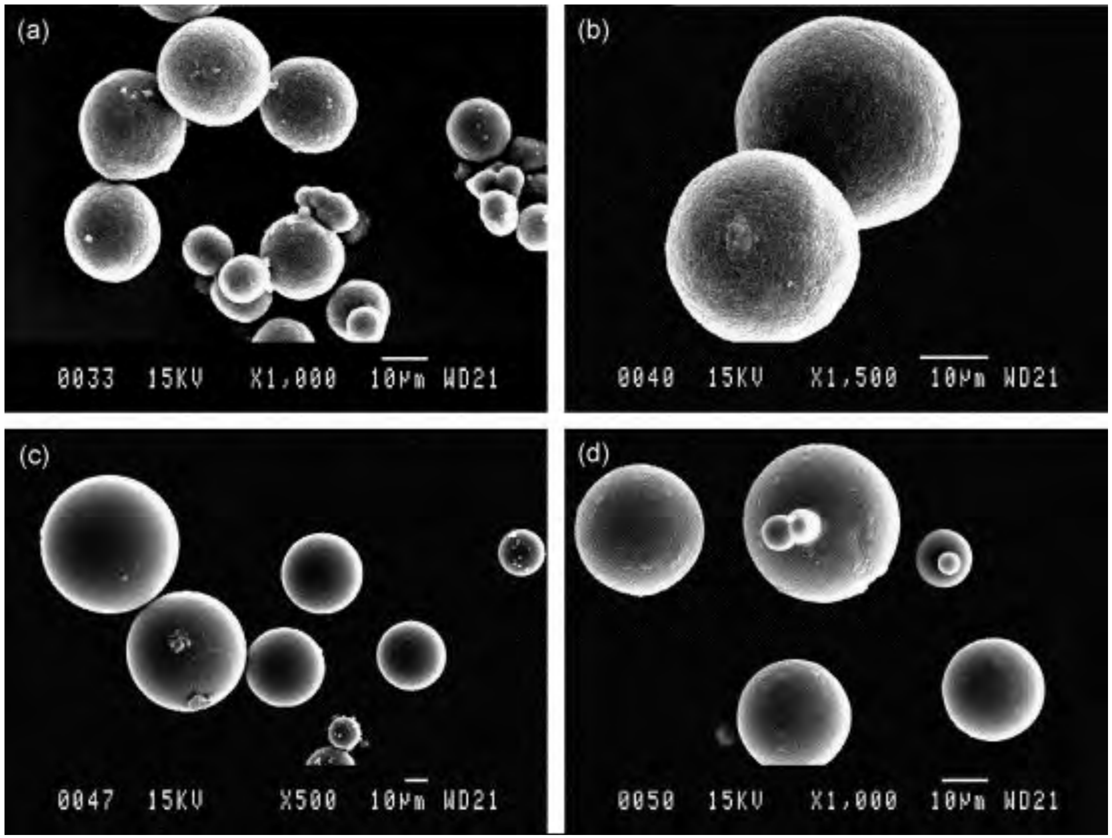
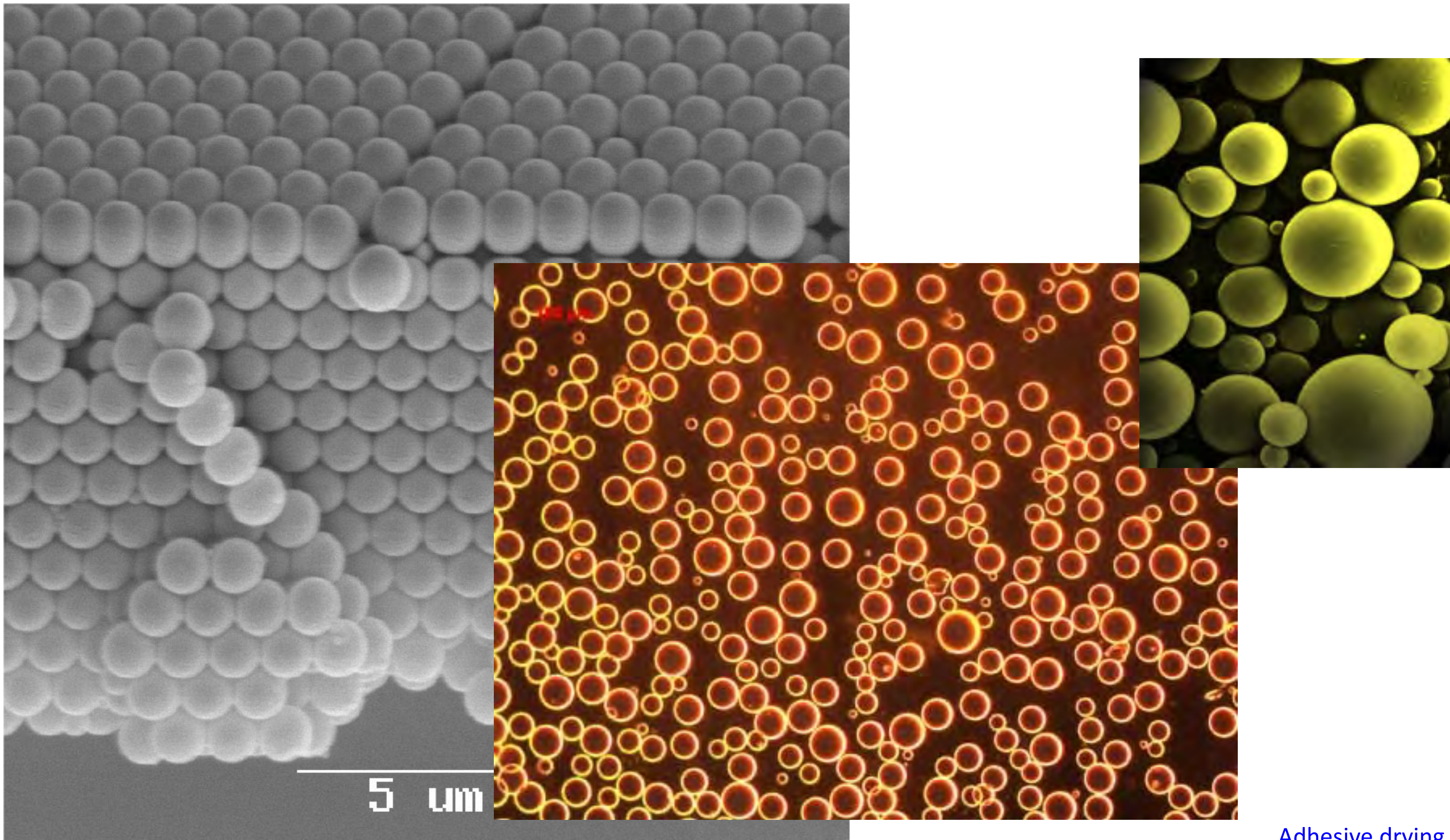
Water based wood glues are microscopic balls of plastic floating in water



What about Water based Construction Adhesives and Sealants?

Go to next page ->

As water evaporates or gets wicked away by the wood, the particles move closer together

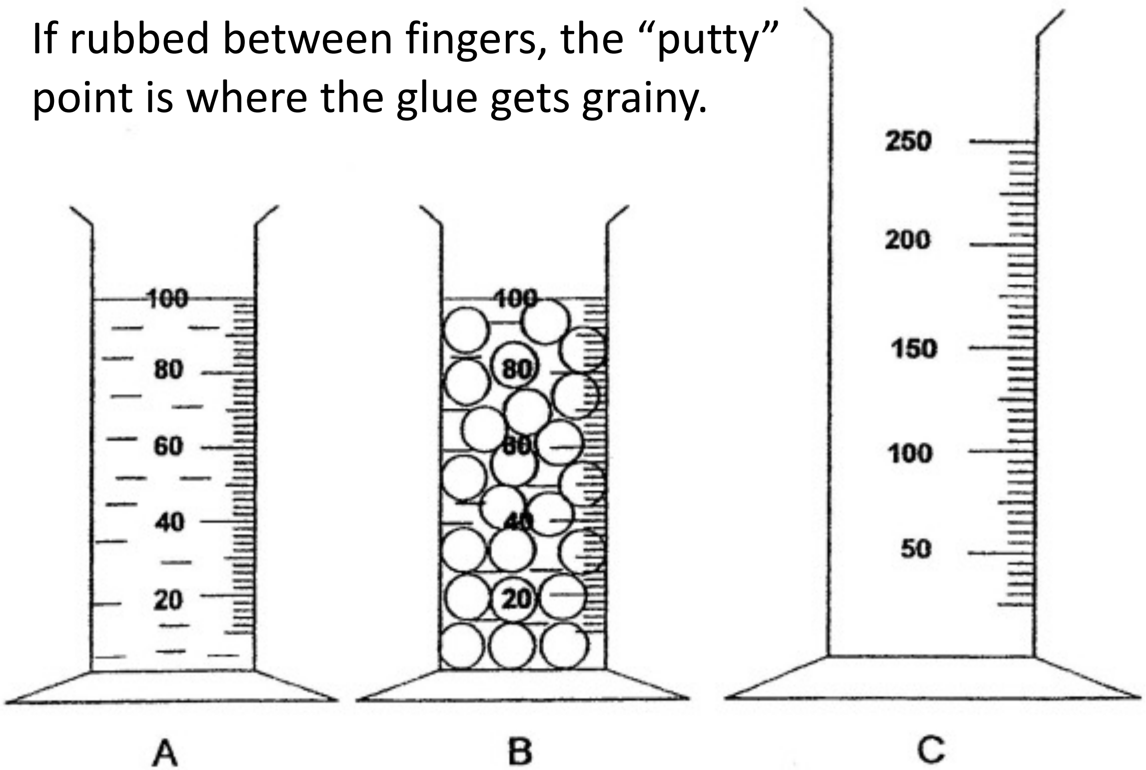


Adhesive drying

Go to next page ->

The theoretical amount of water at the time when particles of the same size start to touch is 33% or when the glue reaches 67% solids. At this point the adhesive can no longer wet out a substrate. This is called the “putty” point.

If rubbed between fingers, the “putty” point is where the glue gets grainy.



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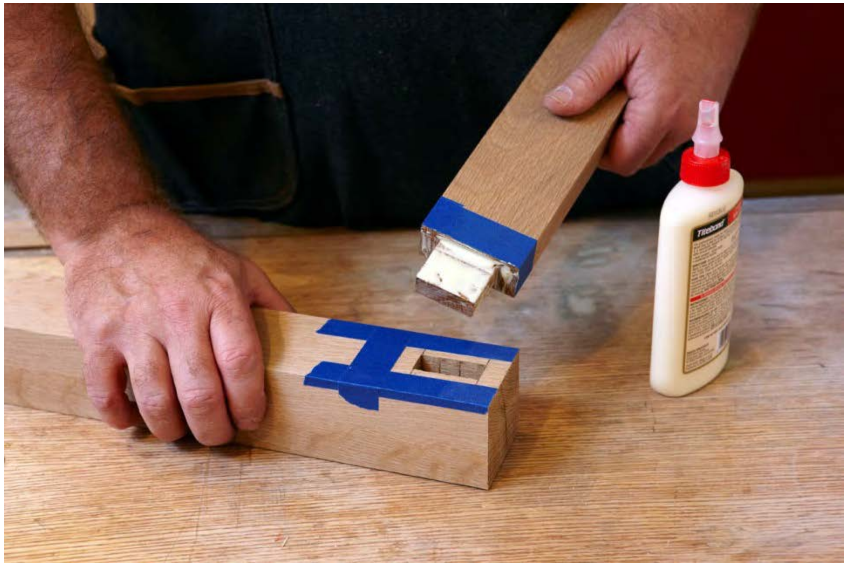
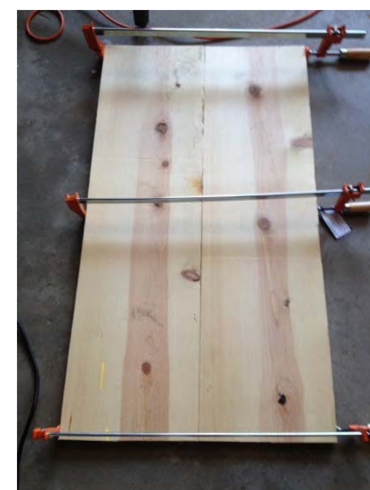
During the open time, water is evaporating from the surface of the glue and getting wicked into the wood. If the glue reaches the "putty" point at this time the unglued surface will not wet properly resulting in a weaker bond.

Weakness of bond will be dependent on how far past the "putty" point glue has dried.



Go to next page ->

Total assembly time is the time from application of glue to final clamp pressure. A thin layer of glue will dry next to the wood and will reach the “putty” point quickly. This layer will get thicker as the water is pulled from the remaining adhesive. If the “putty” layer is broken, the joint will be weaker in proportion to how dry the “putty” layer is at the time it is broken. As long as there is glue that is under the 67% solids of the “putty” point in the glue line, it will flow allowing free movement of the parts without sacrificing joint strength. The Total Assembly Time is used to help determine when the “putty” point has been reached throughout the glue line. During clamping, parts move as pressure is applied.



Return to Page 11

Return to Page 22

One Side or Two Sided Gluing – Which is correct?

- Both are correct with advantages and disadvantages to each method
- One sided gluing gives thinner glue lines but can shorten open times
- Two sided gluing can give a longer Total Assembly Time but will give a thicker glue line
- One sided gluing uses less glue which will allow for shorter clamp times
- Two sided gluing adds more water to the glue line and may require more time for the assembly to reach equilibrium before machining

Select the correct glue for the job

- Use a fast grabbing adhesive for quicker turnaround
- Use a slow setting adhesive for complicated glue ups.

OR: Moisten substrates for longer open time
OR: Humidify air to reduce evaporation

Return to Page 12

- Use of Titebond II on Red Oak on Butt, Biscuit, Pocket hole, Lap Joint, Dowel, Mortice and Tenon in cleavage

Link to various joints video

- Use of Titebond No Run, No Drip, Titebond III and Cascamite on end grain joints

Link to end grain joints video

- Foamed polyurethane glue strength testing

Link to foamed Polyurethane video

Wood Products Notes
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Go to next page ->

Understanding and Minimizing Veneer Checking on Furniture Panels

by

Craig L. Forbes

Assistant Professor and Wood Products Extension Specialist

North Carolina State University

A commonly occurring and costly problem in wood furniture manufacturing is the development of small cracks in the furniture's finish called veneer checks. Veneer checks usually appear as uniformly spaced hairline cracks in the finish or, in severe cases, cracks with accompanying ridges on the wood surface which actually can be detected by touch. In any case, veneer checks always run parallel with the grain of the wood (Figure 1), a characteristic that can be used to distinguish veneer checks from other defects. Random orientation of cracks in the finish (not parallel to the wood grain) generally indicates non-wood-related causes.

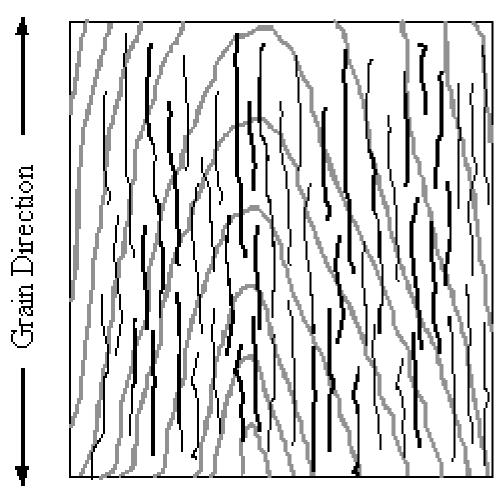


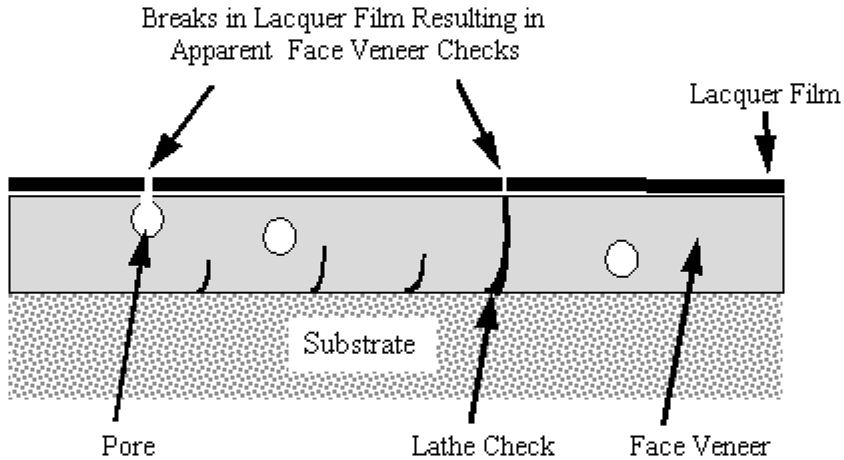
Figure 1. Veneer checks appear as small, uniformly spaced, cracks in the finish which run parallel with the grain direction of the wood.

Veneer checks are formed when stress failures occur in the face veneer, caused by differential shrinkage or swelling between the face veneer and the panel substrate to which it is applied. As the relative humidity of the environment (in which a panel is used) changes, so does the moisture content of the panel. With wood, changes in moisture content mean shrinkage and swelling. Unfortunately, when a veneered panel shrinks or swells, the veneer does not "move" at the same rate as the substrate. This creates considerable stresses within the panel which, if great enough, result in wood failure. Failure will occur at the weakest part of the wood which is generally over deep lathe checks, large pores, or other weakened areas on the face veneer. Such failures in the face veneer then create stress concentrations in

Go to next page ->

the finish which result in the visible cracks we call veneer checks (Figure 2).

Figure 2. Veneer checks are the result of wood failure in the face veneer caused by stresses created from shrinking and swelling of the wood. These failures create stress concentrations in the finish which result in cracks in the finish.



There are many factors which contribute to the formation and severity of veneer checks. For example, veneer checking can result from improper manufacturing practices, poor warehousing conditions, or harsh environments in the consumers' homes. It is usually very difficult, if not impossible, to determine the exact cause of checking for any given incident. However, experience and research have taught us some of the most common and severe influences of veneer checking. These will be discussed below.

The Veneer

The quality, species, and cut of the face veneer all influence the tendency for veneer checking to occur. Tight-cut veneer (veneer with shallow lathe checks or knife marks), has been shown to perform better than loose-cut veneer (deep lathe checks). Likewise, species of wood with fine pores check less than wood with large pores. This is because deep lathe checks and large pores create weak spots on the face veneer which provide less resistance to failure when the face veneer is under stress (Figure 2).

Veneer with straight grain (radial face) has been shown to check less than veneer with a cathedral grain (tangential face). This is because shrinkage in wood is much greater tangentially than radially. Greater shrinkage creates greater stresses and thus, a higher chance of wood failure in the face veneer.

Moisture Content

The most critical factor in preventing veneer checks is control of moisture content, not only of the panel components, but of the finished product as well. Checking only occurs when there is shrinking or swelling of the wood. Likewise, the severity of checking is related to the degree of shrinking or swelling. By controlling the shrinking and swelling of the wood (i.e., controlling the moisture content), the propensity of checking is reduced.

Before panel assembly, the face veneer and substrate should be dried to a moisture content appropriate for the conditions in which the final product will be used (6-8% is most common). It is imperative that *the veneer and substrate* be at the appropriate moisture content *at the time of pressing*. The phenomenon of veneer checking is exaggerated when the face veneer and substrate possess different moisture contents (not dried for the same final atmospheric conditions) at the time of panel pressing (or more specifically, at the time of bond formation of the glue line). In such a case, the dimensional change of the face veneer relative to the substrate is more severe, creating greater stresses, and thus, increased

Return to Page 13

checking.

Manufacturers attempting to carefully control moisture content often overlook certain practices which adversely alter the moisture content of once properly dried panel components. For instance, veneer and panels are often stored in areas with no environmental control. In uncontrolled conditions, wood changes moisture content at a surprising rate. Even in environmentally controlled plants, certain areas may be inadequate for wood storage. For example, veneer stored next to hot presses may lose moisture driven off by the radiating heat. The manufacturer often does not realize that moisture content has changed and assembles the panel, only to have problems later. The solution is to store wood components in an environmentally controlled atmosphere, and check moisture content before panel assembly.

Another consideration often overlooked by manufacturers is the effect of the glue on veneer moisture content. If a high water content adhesive is applied to the veneer, especially with a long assembly time, the veneer can pick up considerable moisture before pressing. Avoiding high water content adhesives, thick spreads, and long assembly times will reduce the likelihood of veneer checks. Manufacturers should consult with their adhesive suppliers, however, before making such alterations.

Once panels have been assembled, it is important that they be conditioned in an environmentally controlled area to allow for the temperature and moisture balances to reach equilibrium. Two days is a common minimum conditioning time.

Finally, the finished product must be stored in an environmentally controlled area. Too often, properly manufactured furniture is stored in a warehouse with no environmental control. Some believe that the finish protects the furniture from moisture changes, so storage conditions are not important. This is not true. Although the finish helps to slow moisture movement, it does not prevent it. Furniture stored in adverse environments will surely check. Plastic wrap around the finished product prior to warehousing will help prevent moisture from damaging the furniture. Manufactures should realize that veneer checks may also occur if the final product is used by the consumer in a different or harsh environment, even if checks were not visible when the furniture left the plant.

Panel Construction

There is also a relationship between panel construction and veneer checking. Panels should be constructed with the tight-side of the face veneer up (lathe checks down) when possible. Tight-cut veneer should be used when veneer matching makes it impossible for the tight side to be laid up. The panels should not be over-sanded, especially to the point of exposing lathe checks. Poor glue bonding has also been correlated with veneer checking. Poor glue bonds may be caused by inappropriate moisture content and temperature of panel components; improper glue mix, glue spread, assembly time, and press time; thick and thin veneer or panel substrate; among other factors. Some research suggests that five-ply construction is less prone to checking than three-ply, and hot pressed panels are less susceptible to checks than cold pressed panels. Evidence also exists that a water rinse after bleaching may also increase the chance of veneer checks.

This report presents a brief explanation of the causes of veneer checks, and discusses some of the major factors which have been shown to correlate with veneer checking. By no means, does this report attempt to address all causes of veneer checking. However, it does provide information which, when combined with logical reasoning, can help manufacturers better control veneer checking problems. By better understanding veneer checking, and taking steps to prevent it, the conscientious manufacturer is sure to reduce problems associated with this expensive defect.

(January 1997)

Go to next page ->

Hot Press Schedule

Hot press cure times can be estimated with this hot press schedule and verified with in-plant trials. See below for suggested hot press cycles using lumber or particleboard cores. *Panels should be stacked after coming out of the press to complete glue curing. Panels should be cool before sanding or additional processing occurs.*

Distance to Deepest Glue Line

	1/32"	1/16"	3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
160°	1'31"	1'53"	2'22"	2'58"	3'42"	4'38"	5'47"	7'15"
170°	1'25"	1'46"	2'13"	2'46"	3'28"	4'20"	5'25"	6'47"
180°	1'19"	1'39"	2'04"	2'36"	3'15"	4'03"	5'05"	6'21"
190°	1'14"	1'33"	1'56"	2'26"	3'02"	3'48"	4'45"	5'57"
200°	1'09"	1'27"	1'49"	2'16"	2'51"	3'33"	4'27"	5'34"
210°	1'05"	1'21"	1'42"	2'08"	2'40"	3'20"	4'10"	5'13"
220°	1'01"	1'16"	1'35"	1'59"	2'29"	3'07"	3'54"	4'53"
230°	1'57"	0'11"	1'29"	1'52"	2'20"	2'55"	3'39"	4'34"
240°	1'53"	0'07"	1'24"	1'45"	2'11"	2'44"	3'25"	4'17"
250°	1'50"	0'02"	1'18"	1'38"	2'03"	2'33"	3'12"	4'00"

Temperatures above 200° F *are not recommended for high pressure laminates by the manufacturers.*

Distance to Deepest Glue Line

	0.5mm	1.0mm	1.5mm	2.0mm	2.5mm	3.0mm	3.5mm	4.0mm
70°C	1'25"	1'38"	1'53"	2'10"	2'29"	2'52"	3'18"	3'48"
75°C	1'20"	1'32"	1'46"	2'02"	2'21"	2'42"	3'06"	3'34"
80°C	1'15"	1'27"	1'40"	1'55"	2'12"	2'33"	2'56"	3'22"
85°C	1'11"	1'22"	1'34"	1'48"	2'05"	2'24"	2'45"	3'10"
90°C	1'07"	1'17"	1'29"	1'42"	1'58"	2'15"	2'36"	3'00"
95°C	1'03"	1'13"	1'24"	1'36"	1'51"	2'08"	2'27"	2'49"
100°C	1'00"	1'09"	1'19"	1'31"	1'45"	2'00"	2'19"	2'39"
105°C	0'56"	1'05"	1'14"	1'26"	1'39"	1'53"	2'11"	2'30"
110°C	0'53"	1'01"	1'10"	1'21"	1'33"	1'47"	2'03"	2'22"
115°C	0'50"	0'57"	1'06"	1'16"	1'28"	1'41"	1'56"	2'13"

Temperatures above 90° C *are not recommended for high pressure laminates by the manufacturers.*

Technical Leadership

With over 70 years of combined hands-on experience, our technical support team is one of the most recognized and respected in the industry. We welcome your calls and encourage you to contact us if you have any questions or concerns regarding any of our lamination adhesives.

1.800.877.4583
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gluing guide
Adhesives for Lamination

Franklin Adhesives & Polymers ™

Press time

Press time is dependent on the adhesive used, gluing stock type, moisture content of the stock and environmental conditions. Typical press times range from 30 minutes to two hours in a cold press. Press times should be determined under plant conditions. Environmental conditions should be managed inside the plant during seasonal changes. Wood should be kept in an environmentally controlled area. Moisture content of veneer should be between six and eight percent and held at this level before and after pressing.

Minimum temperature

Curing temperatures should be higher than the minimum use temperature of the adhesive. This includes the temperature of the stock to be glued as well as the air and adhesive temperature.

Consult your account manager for guidance in selecting the adhesive that best suits your operation and equipment.

Hot Press Lamination

Hot press laminating offers the versatility of pressing many different shaped panels without extensive equipment changes. Hot press gluing generally consists of either all-veneer constructions or composite-core veneer constructions. To achieve optimal results using our adhesives in hot press lamination applications, please follow the below guidelines.

Spread

Generally, 35-45 pounds of adhesive per 1,000 square feet or 170-220glm^2 of glue line is adequate. Lower spread rates require closer stock tolerances and shorter assembly times. Commonly, a mechanical glue spreader is used to apply a uniform spread to the gluing surfaces.

Assembly time

Assembly time can vary greatly depending on the adhesive used, glue spread, porosity and moisture content of stock, environmental conditions, etc. A small bead of adhesive squeeze-out around the perimeter of the bottom panel in the stack is desirable. Generally accepted assembly times range from five to 20 minutes at room temperature – assembly time should be kept at a minimum. We recommend gluing veneer with the tight side out.

Tolerances

Gluing stock should be uniform in thickness. Variation in thickness should not exceed ±0.005 inches or ±0.125 mm. Sanding to thickness should be performed using higher than 50 grit abrasives. Tight-cut veneer is recommended. Panels should not be over-sanded, especially to the point of exposing lathe checks.

Pressure

Pressure is dependent upon the species or material to be glued and joint preparation. Direct contact of the gluing surfaces must be made to obtain maximum strength. Suggested pressures for various wood densities are: low 100-150 psi or 2.1-5.6 kglcm^2; medium 125-175 psi or 7.0-10.5 kglcm^2; high 175-250 psi or 7.0-17.6 kglcm^2.

Press time

Press time should be determined under plant conditions. Times will vary according to platen temperature and distance to the deepest glue line. Press time is dependent on the adhesive used, stock type and moisture content of the stock and environmental conditions. Radio frequency press times should be determined by in-plant testing on each machine. Environmental conditions should be managed inside the plant during seasonal changes. Wood should be kept in an environmentally controlled area. Moisture content of veneer should be between six and eight percent and held at this level before and after pressing. Regular glue audits from technical professionals should occur.

Go to next page ->

Franklin's recommended lamination adhesives

Advantage 310 with Catalyst A

A versatile two-part, high performance, water-resistant adhesive that can be used for finger jointing, edge gluing, hot pressing and radio frequency curing.

Doorbond 200

A moderately fast-setting, water and heat resistant, one-component flush door adhesive. It has been designed for hot or cold pressing of flush and architectural doors and formulated to prevent bleed-through.

Laminating 6W

Excellent choice for cold-press laminating of fancy face veneers to particleboard, medium density fiberboard or other core stock.

Laminating 25

Moderately fast-setting adhesive for cold pressing high-pressure laminate to a variety of core materials.

Multibond MX-90

Water resistant adhesive designed for use in hot press laminating.

Multibond SK-8

Highly water resistant adhesive for the manufacture of skateboards in cold and hot press operations.

Multibond 2000

Produces a water-resistant bond recommended for hot or cold press, radio frequency, edge and face and assembly gluing applications.

Multibond 2015

Ideal for hot or cold press veneering and performs well for edge and face gluing in radio frequency applications.

Multibond 2025

Recommended for hot and cold pressing of veneers and high-pressure laminates to various cores. It also offers excellent bleed-through protection with porous veneers.

Multibond 4000 FF

Formaldehyde free, water resistant adhesive that can be hot pressed, cold pressed and used in edge and face gluing.

Multibond EZ-1

Produces a water resistant bond for hot or cold press applications.

Multibond Advantage 2 with Catalyst A

Highly water resistant two part adhesive with a good catalyzed pot life.

Multibond X-016 with Catalyst A

A highly water-resistant, two-part adhesive with a light-colored glue line. Multibond X-016 is an excellent choice for finger jointing, cold press, radio-frequency and hot press applications.

Titebond Quickset 2000

A fast setting adhesive which can be used in a variety of ways including: continuous heated-panel laminating systems, pinch roll and dead stacking; or limited lay-up time cold-press operations designed to bond HPL to particleboard and fiberboard.

ReacTITE EP-925 Hardener 200

A two-part, highly water resistant adhesive that can be utilized with cold press, hot press or radio frequency press equipment.

Go to next page ->

Adhesives for lamination

Franklin Adhesives & Polymers offers a complete line of high-quality glues for all types of laminating applications, including hot and cold press lamination. Our traditional line of water-based PVA glues has set the industry standard for hot and cold pressing of plywood, veneers and laminates. Our technical service teams have compiled extensive research on hot and cold press techniques and use this data to create the highest quality products. We offer wood adhesives designed specifically for skateboards, plywood and non-wood substrates. In addition, we have "no-added formaldehyde (NAF)" and "formaldehyde-free" products included in our line. To determine an appropriate product option for your application, please contact your account manager.

Hot Press Trouble Shooting Guide

Below is a listing of the most common problems, causes and recommendations when hot pressing.

	Problem	Possible cause	Recommendation
	*Spotty bonds*	▪ *Low spread* ▪ *Uneven core thickness* ▪ *Low pressure* ▪ *Cold spots in platen* ▪ *Pressure*	▪ *Increase adhesive spread* ▪ *Calibrate cores to uniform thickness* ▪ *Increase pressure* ▪ *Check bond line temperature with thermocouples* ▪ *Decrease assembly time*
	*Glue bleeds through face veneers*	▪ *Excessive glue spread* ▪ *Excessive pressure* ▪ *Face veneers high in moisture content* ▪ *Wrong adhesive type*	▪ *Reduce glue spread* ▪ *Use higher viscosity adhesives* ▪ *Reduce pressure* ▪ *Dehumidify plant in wet seasons* ▪ *Contact your account manager*
	*Warpage of panels*	▪ *Excessive spread* ▪ *Unequal spread* ▪ *High moisture content* ▪ *Unbalanced construction* ▪ *High press temperature*	▪ *Reduce adhesive spread* ▪ *Make sure that top & bottom spread are equal* ▪ *6-8% moisture content recommended* ▪ *Check grain orientation* ▪ *Reduce platen temperature*
	*"Telegraphing" of core defects or banding*	▪ *Excessive pressure* ▪ *Uneven or variable thickness* ▪ *Foreign material on core*	▪ *Reduce pressure* ▪ *Re-sand cores* ▪ *Pre-clean core*
	*Precure*	▪ *Glue left exposed too long* ▪ *Thin spread*	▪ *Add pressure faster* ▪ *Increase spread rate* ▪ *Switch to an adhesive with a longer open time* ▪ *Check planers, blades & spreader rolls*
	*Checking & cracking*	▪ *Moisture content of stock too high or low* ▪ *Improper conditioning* ▪ *Press temperature too high* ▪ *Press period too long in hot press*	▪ *Do not dry stock below 5% moisture content* ▪ *Humidify plant if below 25% relative humidity* ▪ *Dehumidify plant during rainy seasons* ▪ *Be sure stock is at 6% - 8% moisture content* ▪ *Panels should be squarely dead stacked & weighted for 12 hours after removing from press* ▪ *Do not use high temperatures to attain short pressure periods unless moisture content is carefully controlled* ▪ *Avoid excessive drying or over-curing* ▪ *Remove panels as soon as hot press is opened*
	Steam blisters	▪ *Excessive adhesive spread* ▪ *High moisture content* ▪ *High press temperature* ▪ *Non-uniform moisture (wet spots)* ▪ *Press or assembly time too short*	▪ *Reduce adhesive spread* ▪ *Check planners, blades & spreader rolls* ▪ *6-8% moisture content recommended* ▪ *Dehumidify plant in wet seasons* ▪ *Reduce temperature* ▪ *Avoid worm-holes, dents, knots & fillers* ▪ *Use longer assembly time*

Return to Page 13

Cold Press Lamination

Cold press laminating is desirable when large numbers of like-sized materials need to be glued. The materials used can vary widely. Cold press laminating normally falls into one of three categories: panel-on-frame, veneer/solid core laminating or high-pressure laminate gluing. To obtain optimal results in using our adhesives, please follow the guidelines below.

Spread

Generally, 35-45 pounds per 1,000 square feet or 170-220 g/m^2 of glue line is adequate. Lower adhesive spreads require better stock tolerances and shorter assembly times. Commonly, a mechanical glue spreader is used to apply a uniform spread to the gluing surfaces.

Assembly time

Assembly time can vary greatly depending on the adhesive used, glue spread, porosity and moisture content of stock, environmental conditions, etc. A small bead of adhesive squeeze-out around the perimeter of the bottom panel in the stack is desirable. Generally accepted assembly times range from five to 20 minutes at room temperature – assembly time should be kept at a minimum. We recommend gluing veneer with the tight side out.

Tolerances

Gluing stock should be uniform in thickness. Variation in thickness should not exceed ±0.005 inches or ±0.125 mm. Sanding to thickness should be performed using higher than 50 grit abrasives. Tight-cut veneer is recommended. Panels should not be over-sanded, especially to the point of exposing the checks.

Pressure

Pressure is dependent upon the species or material to be glued. Direct contact of the gluing surfaces is required to obtain maximum strength. Suggested pressures for various substrates are: high-pressure laminates, 30-80 psi or 2.1-5.6 kglcm^2; solid core stock, 100-150 psi or or 7.0-10.5 kglcm^2; all-veneer constructions, 100-250 psi or 7.0-17.5 kglcm^2.

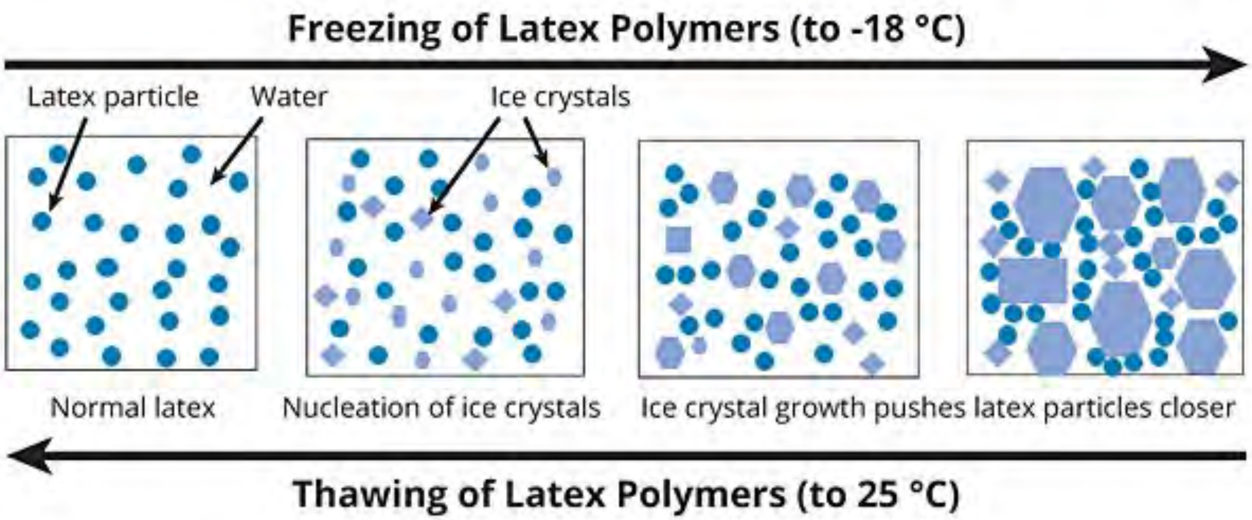
Cold Press Trouble Shooting Guide

Below is a listing of the most common problems, causes and recommendations when cold pressing.

	Problem	Possible cause	Recommendation
	Total delamination with little or no substrate failure	■ Pre-cure (no glue transfer) ■ Low pressure (poor contact) ■ Short press time	■ Increase glue spread ■ Decrease assembly time ■ Increase pressure and/or increase press time
	Spotty bond	■ Uneven surfaces ■ Worn spreader rolls ■ Pre-cure (no glue transfer)	■ Calibrate cores to uniform thickness and/or increase pressure ■ Replace or regroove rolls ■ Increase glue spread ■ Decrease assembly time
	Glue bleeds through face veneers	■ Excessive glue spread ■ Excessive pressure ■ Wrong adhesive type	■ Reduce glue spread ■ Reduce pressure ■ Contact your account manager
	Telegraphing of core defects or banding	■ Excessive pressure ■ Uneven or variable thickness ■ Foreign material on core	■ Reduce pressure ■ Re-sand core, pre-clean core ■ Reduce glue spread
	Warpage of panels	■ Excessive or unequal spread ■ Unbalanced construction ■ Excessive moisture	■ Equal spread on both sides ■ Check grain orientation & number of plies ■ 6-8% moisture content recommended
	Brilliant white on glue squeeze-out and/or glue line	■ Chalking caused by low temperatures	■ Raise temperature of plant, wood and adhesive above minimum use temperature of adhesive

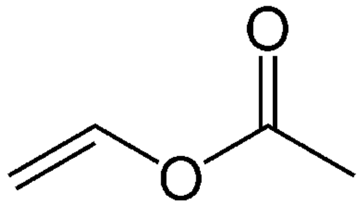
Return to Page 16

FIGURE 1 » Freezing and thawing of latex polymers.



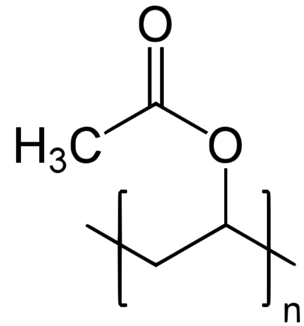
Go to next page ->

Polyvinyl acetate water based adhesives



Vinyl Acetate

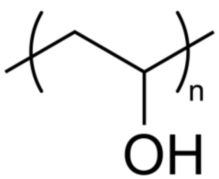
+ Heat
+ Oxidizer

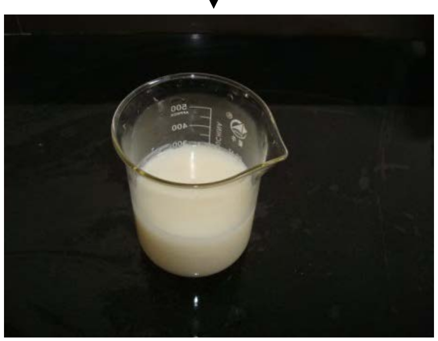


Polyvinyl Acetate

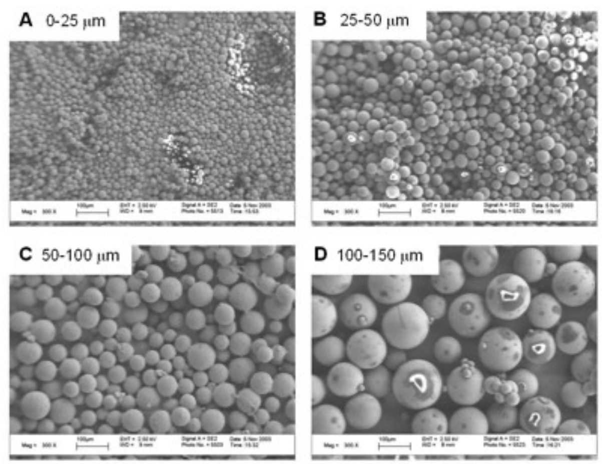
Water based polymerization allows higher molecular weight with lower viscosity but uses water sensitive additives to form emulsion. Cross-linking additives are used to reduce or eliminate water sensitivity.

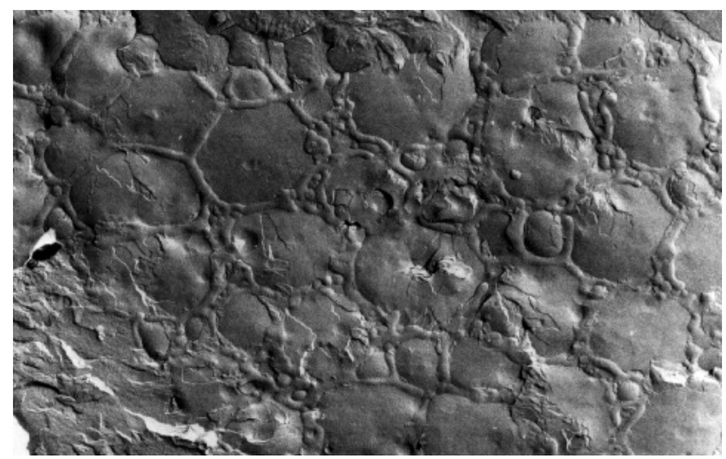
+ Heat
+ Oxidizer
+ Water
+ PVOH



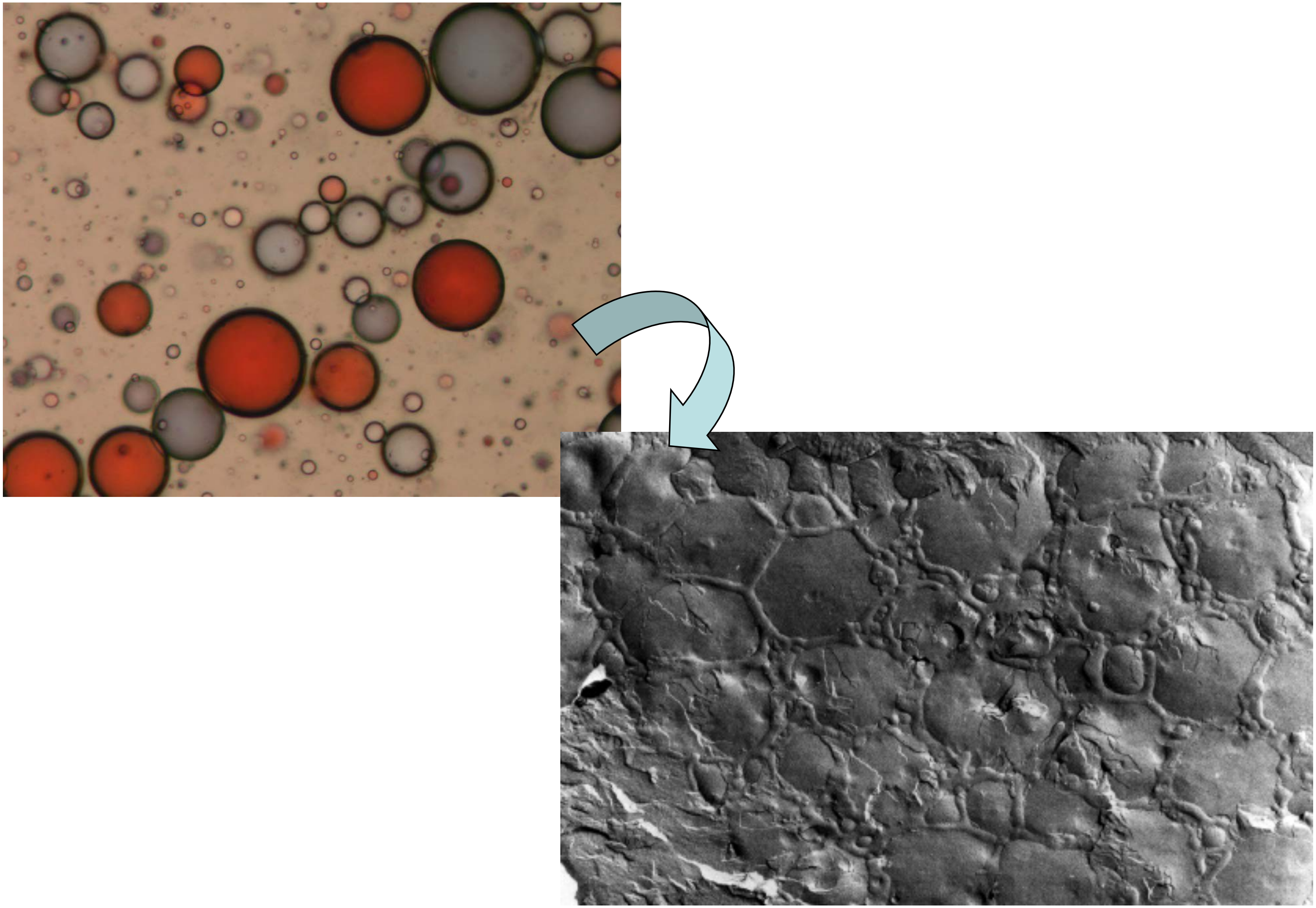


- Particles must coalesce (melt) into a film to bond
- Attempts to bond below chalk point temperature leaves adhesive as particles





Go to next page ->

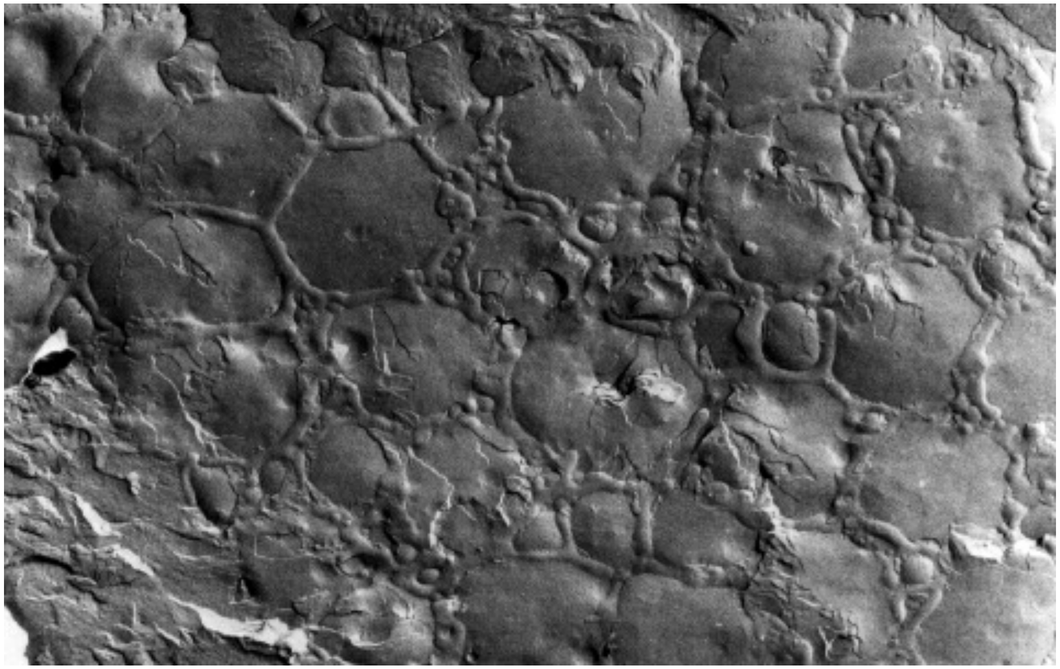


Return to Page 16

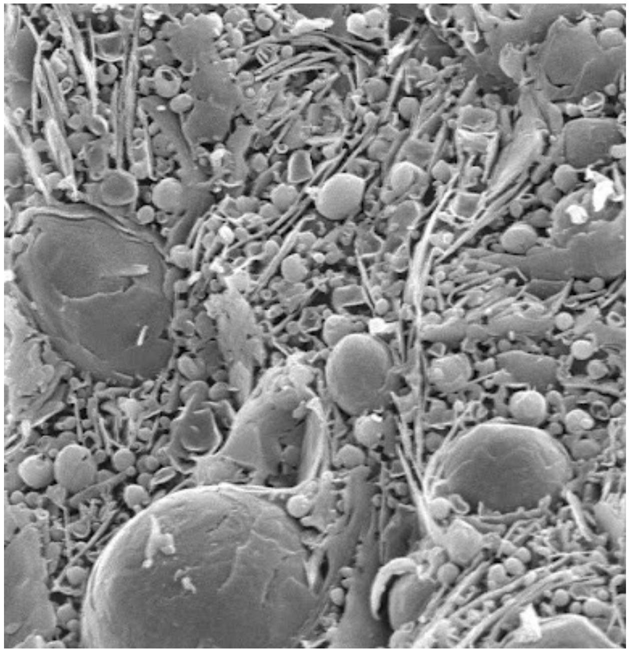
Return to Page 22

Return to Page 43

Chalking Temperature – where particles melt together

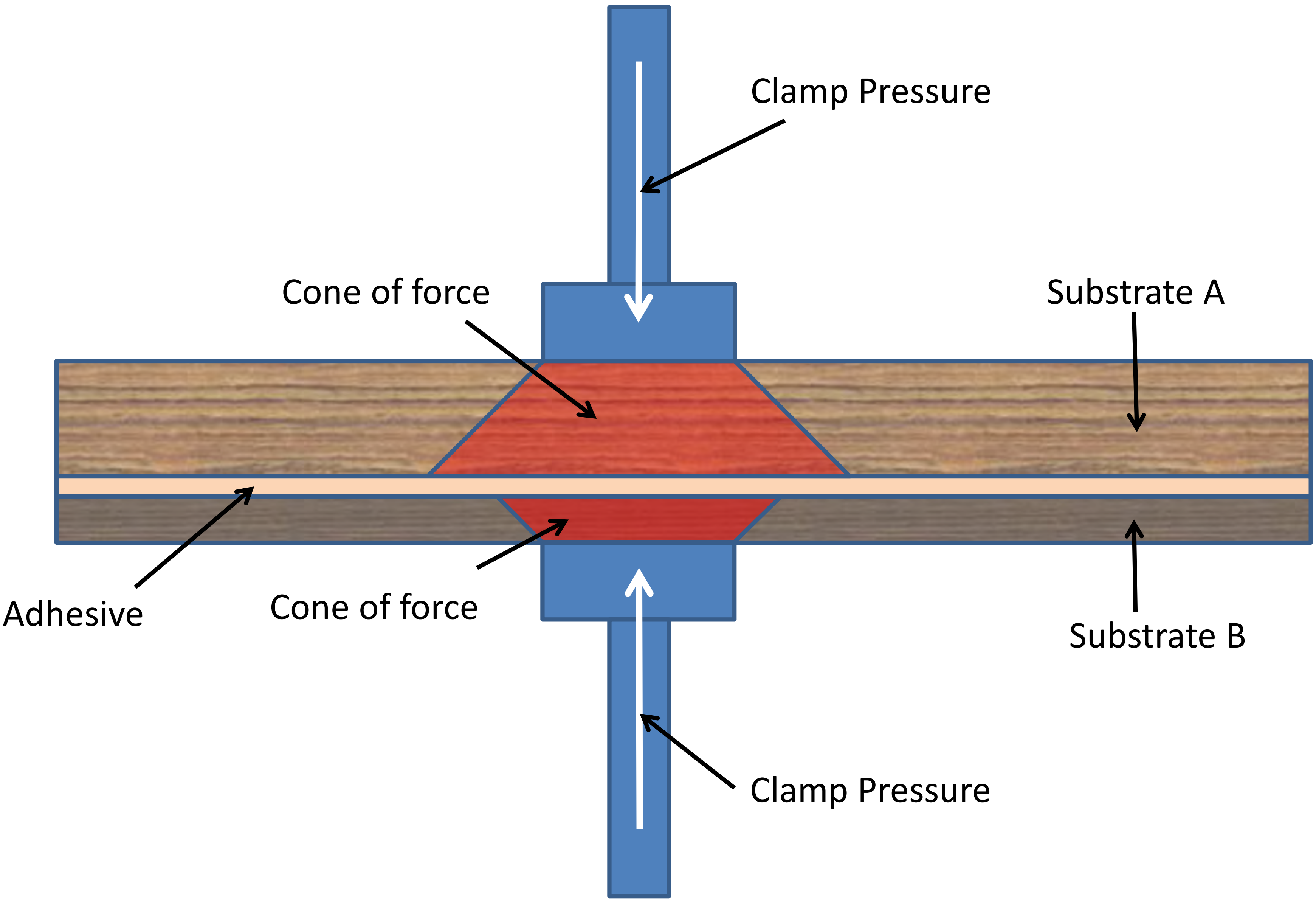


Coalesced



Chalked

Return to Page 17



Return to Page 7

Return to Page 20

Titebond Wood Glue Comparison Chart

Titebond Product Name	Franklin Industrial Name	Formula Number	Type	Solids	Solids Spec	Viscosity (cps)	Viscosity Spec (cps)	Viscosity Spec Temp (°F)	pH	pH Spec	VOC (g/L)	Chalk Point (°F)	Open Time (min.)	Total Assembly (min.)	Strength RT (psi), (WF%)	Strength 150°F (psi), (WF%)	Dry Film Color	Features	Official Shelf Life	Sizes	Freeze Thaw Stable	Weight (lbs.) per Gallon
Titebond Genuine Hide Glue	Franklin Liquid Hide Glue	1103	Protein	50%	48.0 - 52.0%	4,500	3,000 - 6,000	82-84	7.0	6.5 - 7.5	0.0	N/A	10	20-30	3,591 (72%)	3,207 (59%)	Amber	HR,S, WS	24 months	4,8,16,5G	Yes	9.6
Titebond White Glue	Franklin Assembly Glue White Glue	1106	PVA	46%	44.5 - 48.0%	8,500	7,500 - 9,500	82-84	4.5	4.0 - 5.0	10.7	50	5	10-15	3,550 (50%)	1,600 (15%)	Translucent	S, WS	24 months	G,5G,55G	Yes	9.1
Titebond Carpenter's Glue	Assembly Glue Carpenters Glue	110601	PVA	46%	44.5 - 48.0%	5,500	4,500 - 6,500	82-84	4.5	4.0 - 5.0	10.7	50	5	5	3,400 (45%)	1,550 (15%)	Cream	S, WS	24 months	G,5G,55G	Yes	9.1
Titebond Original Wood Glue	Franklin Assembly Hitack	2213	M-PVA	46%	44.5 - 47.0%	3,875	3,250 - 4,500	82-84	4.3	3.8 - 4.7	10.7	50	4-6	10-15	3,600 (77%)	1,600 (10%)	Cream	S, WS	24 months	4,8,16,Q,G,PJ,5G,55G	Yes	9.0
Titebond Extend Wood Glue	Franklin Titebond Regular	3120	M-PVA	43%	41.0 - 45.0%	3,750	3,000 - 4,500	82-84	4.4	3.7 - 5.0	3.1	40	15	20-25	3,510 (81%)	3,120 (61%)	Cream	HR,S, WS	12 months	16,G,5G,55G	Yes	9.7
Titebond II Premium Wood Glue	Franklin Titebond II	5000	X-link PVA	47%	45.5 - 49.0%	3,750	3,000 - 4,500	82-84	2.7	2.0 - 3.3	3.0	55	3-5	10-15	3,750 (72%)	1,750 (6%)	Orange	WR,S,RF	24 months	1.25,4,8,16,Q,G,PJ,5G,55G	Yes	9.1
Titebond II Dark Wood Glue	Franklin Titebond II Dark Brown	500006	X-link PVA	48%	46.0 - 49.7%	3,900	3,000 - 4,800	82-84	2.8	2.0 - 3.5	3.0	55	5	10-15	3,750 (72%)	1,750 (6%)	Brown	WR,S,RF	24 months	8,16,G,5G,55G	Yes	9.1
Titebond II Extend Wood Glue	Franklin Multibond 2015	4295	X-link PVA	49%	47.5 - 50.5%	3,650	3,000 - 4,300	82-84	3.0	2.5 - 3.5	3.8	60	15	20-25	3,844 (48%)	1,820 (6%)	Orange	WR,S,RF	12 months	16,G,5G,55G	Yes	9.3
Titebond II Fluorescent Wood Glue	Franklin Titebond II Fluorescent	500008	X-link PVA	48%	46.0 - 49.7%	3,900	3,000 - 4,800	82-84	2.8	2.0 - 3.5	5.5	55	5	10-15	3,750 (72%)	1,750 (6%)	Orange	WR,S,RF,UV	24 months	G,5G,55G	Yes	9.2
Titebond III Ultimate Wood Glue	Franklin Multibond SK-8	6192	X-link PVA	50%	47.5 - 52.5%	3,250	2,000 - 4,500	73-77	3.0	2.4 - 3.5	0.0	45	8-10	20-25	4,000 (57%)	800 (0%)	Brown	WR,S	24 months	1.25,4,8,16,Q,G,PJ,5G,55G	Yes	9.3
Titebond No Run, No Drip Wood Glue	Franklin Titebond Wood Molding Glue	6006	PVA	61%	58.0 - 63.0%	36,000	32,000 - 40,000	82-84	4.4	3.8 - 5.0	2.4	50	3-5	10-15	3,000 (7%)	650 (0%)	Translucent	Thick,S,WS	24 months	16	2 cylcles	9.2
Titebond Translucent Wood Glue	Franklin All Purpose White Glue DEV	6303	PVA	37%	36.4 - 38.4%	6,150	4,650 - 7,650	70-72	4.8	3.9 - 5.6	10.7	50	5	10-15	3,550 (50%)	1,600 (15%)	Translucent	S, WS	24 months	8	Yes	8.9
Titebond All Purpose White Glue	Franklin All Purpose White Glue DEV	6303	PVA	37%	36.4 - 38.4%	6,150	4,650 - 7,650	70-72	4.8	3.9 - 5.6	5.5	55	5	10-15	3,550 (50%)	1,600 (15%)	Translucent	S, WS	24 months	8	Yes	8.9
Titebond Melamine Glue	Franklin Titebond Melamine Glue	6071	M-PVA	57%	53.0 - 60.0%	11,800	8,300 - 15,300	82-84	4.0	3.5 - 4.5	77.0	40	5	10-15	329 (100%)	No data	Clear	Bonds melamine	24 months	16,G,5G,55G	No	9.0
Titebond Cold Press for HPL	Franklin Laminating 25	4169	M-PVA	41%	39.5 - 42.5%	4,600	3,900 - 5,300	82-84	4.8	4.3 - 5.3	3.2	50	15	15-20	2,711 (32%)	1,890 (1%)	Beige	Bonds HPL	12 months	5G,55G	Yes	9.8
Titebond Cold Press for Veneer	Franklin Laminating 6W	4172	M-PVA	42%	41.0 - 43.0%	4,650	3,800 - 5,500	82-84	4.5	4.0 - 5.0	2.0	50	15	15-20	2,508 (6%)	656 (0%)	Brown	No bleed through	12 months	Q,G,5G,55G	Yes	9.3
Titebond Quickset 1000	Franklin Quickset 1000 DEV	6187	EVA	61%	59.0 - 63.0%	3,700	2,400 - 5,000	82-84	4.5	3.9 - 5.0	5.0	35	7	5-10	N/A	N/A	Clear	Fast set	12 months	5G,55G	No	9.2
Titebond Quickset 2000 Wood Glue	Franklin Quickset 2000	6186	EVA	61%	58.0 - 64.0%	4,875	3,200 - 6,550	82-84	4.5	4.0 - 5.0	2.4	35	5	5	N/A	N/A	Light Blue	Fast set	12 months	5G,55G	No	9.1
Titebond Quick and Thick Multi-Serface Glue	Franklin Titebond Wood Molding Glue	6006	PVA	61%	58.0 - 63.0%	36,000	32,000 - 40,000	82-84	4.4	3.8 - 5.0	2.4	50	3-5	10-15	3,000 (7%)	650 (0%)	Translucent	Thick,S,WS	24 months	8	2 cylcles	9.2
Titebond Speed Set Wood Glue	Franklin Assembly Glue 65 Fluorescent	221103	PVA	60%	58.5 - 62%	3,600	3,000 - 4,200	82-84	4.5	3.9 - 5.0	5.6	59	2-4	8-10	4,178 (35%)	1,527 (4%)	Translucent	WS, S, UV	24 months	G,PJ,5G	No	9.3
Super Titebond Wood Glue	Franklin Titebond 50	3130	M-PVA	46%	44.2 - 47.0%	3,750	3,000 - 4,500	82-84	4.5	4.0 - 5.0	2.2	40	5	15-20	3,976 (85%)	3,090 (75%)	Orange Cream	HR,S, WS	12 months	5G,55G	Yes	9.6
Titebond Dowling Glue	Franklin Assembly Glue 8	2221	PVA	52%	50.5 - 54.0%	1,650	1,300 - 2,000	82-84	4.4	3.8 - 5.0	10.2	50	5	5	3,650 (68%)	1,250 (1%)	Translucent	Fast set	12 months	5G	Yes	9.1
Titebond Dowling Glue L.V.	Franklin Assembly Glue 161	2238	PVA	44%	42.0 - 46.6%	215	160 - 270	82-84	4.4	4.0 - 4.8	9.6	45	5	5	2,711 (32%)	1,890 (0%)	Translucent	Low viscosity	12 months	5G	No	9.0
Titebond MH-101	Franklin Willbond 10	4156	PVA	42%	41.0 43.5%	3,750	3,000 - 4,500	82-84	4.8	4.2 - 5.3	3.4	35	2	10	3400 (70%)	1400 (15%)	Off White	Fast set	12 months	5G,55G,Tote	Yes	9.5
Titebond Polyurethane Glue	Franklin Polyurethane Glue	3810	PU	100%	N/A	3,350	2,100 - 4,600	76-78	N/A	N/A	0.0	N/A	N/A	25-30	3,500 (60%)	3,000 (50%)	Yellow	WR,S	12 months	4,8,12,5G,52G	Yes	9.5
Titebond Instant Bond-Thin	Titebond Instant Bond-Thin	F6201	E-CA	100%		5	3 - 12				20.0	N/A	5 sec.	8 sec.	3,500	No data	Clear	Fast set	24 months	2,4	Yes	8.8
Titebond Instant Bond-Medium	Titebond Instant Bond-Medium	F6211	E-CA	100%		120	90 - 140				20.0	N/A	7 sec.	12 sec.	3,500	No data	Clear	Fast set	24 months	2,4	Yes	8.8
Titebond Instant Bond-Thick	Titebond Instant Bond-Thick	F6221	E-CA	100%		2,400					20.0	N/A	10 sec.	18 sec.	3,500	No data	Clear	Fast set	24 months	2,4	Yes	8.9
Titebond Instant Bond-Gel	Titebond Instant Bond-Gel	F6231	E-CA	100%		4,000					20.0	N/A	30 sec.	50 sec.	3,500	No data	Clear	Fast set	24 months	2,4	Yes	9.1

Clamp Pressure - 100-125 psi for softwood, 125-175 psi for medium woods, 175-250 psi for hardwoods
Coverage - 6 mils or 250 ft2 per gallon
HR - Heat Resistant, WR - Water Resistant, WS - Water Sensitive, S - Excellent Sandability, RF - Radio Frequency Curable
Strength values tested as per ASTM D-905 hard maple block shear