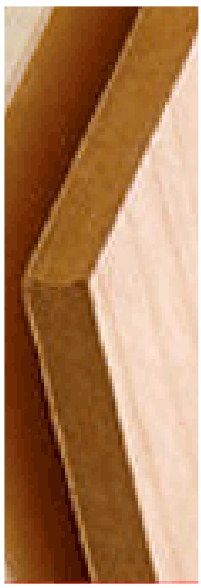
Wood Gluing

SOME BASIC PRINCIPLES AND TECHNIQUES



INDEX

Fundamental Gluing Information

Ready to use glues are widely used for edge, face, assembly and laminating gluing. The most common of these are the liquid hide, aliphatic resin, polyvinyl acetate, catalyzed polyvinyl acetate, polyurethane hot melts and liquid polyurethane glues. All of these glues set by loss of water from the glue line, by chemical reaction, by cooling, or by a combination of these modes.

Essentially, the gluing operation consists of applying a liquid adhesive, whether is it dispersed in water, solvent, or liquefied with heat, and then pressing the substrates tightly together until the glue sets. During the setting process, the glue penetrates the pores of a thin wood surface layer. In the case of the water-based glues, as the water of the glue goes through the pores, the glue is retained on the wood fiber walls. The glue gains strength as the water leaves the adhesive film. The liquid polyurethane glue reacts with moisture. This reaction is quite vigorous and causes the polyurethane glue to foam. The foaming forces the glue into the pores of the wood. The polyurethane hot melts form a surface bond as they cool. Speed of set, assembly time and depth of glue penetration are dependent on the speed of the water removal, the vigor of the foaming, or the temperature of the wood for the hot melts. Strength, amount of wood failure and resistance to water, humidity, solvents, and heat are important factors and are dependent on the nature of the glue.

Many properties of a glue contribute to its successful practical application, so it is essential to know the characteristics of the glue you choose.

1) Viscosity is a measure of the resistance to stirring or thickness of a liquid. It is measure in centipoises (cps.) or poises (a poise equals 100 centipoise). In most cases, the higher the viscosity reading, the thicker the liquid. Viscosity gives an indication of (a) ease of application, (b) coverage obtainable with a brush spread, and (c) ease of pumping through a pipe. A glue with a viscosity of 1,200 cps. will brush and pump much easier than a heavier glue with a viscosity of 3,500 cps. Thixotropic glues, (Figure 1), with a viscosity like whipped cream, spread easily by brush, but are not as easily pumped. This is desirable in some assembly glues, since the squeeze-out does not run down the assembly.

2) Some glues have a built-in wet tack (Figure 2), such as the aliphatic glues. Although this wet tack retards brushability, it does not affect spreadability by a mechanical spreader. Tack prevents a tight dowel from easily scraping off the glue from the inside of a dowel hole. It also holds light parts, such as corner blocks, in place.

3) Water based glues can be diluted by the addition of water. Approximately 5% dilution will reduce the viscosity by one-half. Although spreadability is increased by dilution, so also may excessive penetration into porous substrates be increased, such as on non-tempered hardboard or particleboard.

4) Temperature affects glues. Lowering the temperature of a liquid hide glue to below 68°F, will make the glue thicken rapidly and gel. The spreadability of aliphatic resin, polyvinyl acetate and liquid polyurethane glues are less affected (though they do thicken) as the temperature is lowered towards freezing.

When water-based glues are placed between two pieces of wood, the water in the glue moves out into the pores of the wood and draws the glue particles with it. The loss of the water then pulls the glue particles together to form a continuous film. If the temperature of the wood is below a critical point (i.e. the chalk point) the water evaporation is too slow to pull the molecules together, leaving them in the joint. The glue will appear whiter than normal and this is known as chalking. When this occurs, the bond is not strong and a failure of the wood joint could occur.

Raising the temperature above room temperature affects glue differently. Liquid hide glue is thinned by raising the temperature, although prolonged exposure to elevated temperature, such as 140°F., will decrease their strength. Aliphatic and some polyvinyl acetate glues become thinner as the temperature is raised until they reach 120°F.; at higher temperatures they become irreversibly thick.

5) The strength of any glue, as measured by a block shear test (ASTM D-905), (Figure 3), is

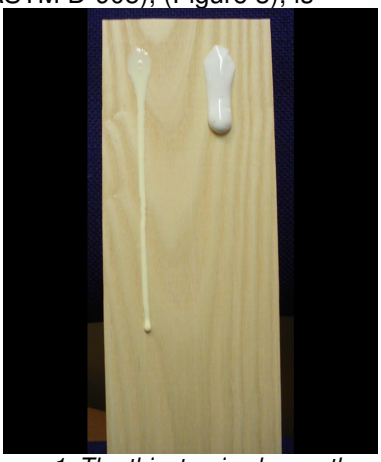


Figure 1: The thixotropic glue on the right side of the above board has run considerably less than the normal assembly glue on the left.

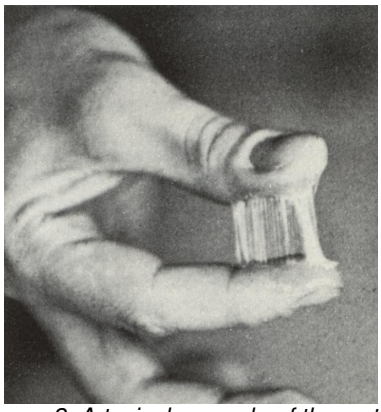


Figure 2: A typical example of the wet grab or wet tack of the aliphatic glues.

Figure 3: An testing machine equipped with a block shear attachment to run ASTM D-905

important. Also the percentage of the bond that breaks in the wood instead of the glue line is important was well. Quality glues are designed to give high shear strength, plus high wood failure (Figure 4). For many applications, only good room temperature strength is important; for others, resistance to humidity, water, solvents, heat and cold flow should be considered and included in a test program for adhesive evaluation.

6) Frequently, proper handling of the glue can increase production without an increase in production or capital investment expense. Proper glue handling may also improve quality and lower rejects.

Production generally increases if the clamp time is decreased. Clamp time can be decreased by increasing the speed of set of the glue.

The minimum clamping time is determined by the time required for the glue to retain its clamped position after pressure is removed. It, therefore, becomes important to introduce as many factors as possible to speed up this acquisition of strength in the glue joint. Some of these factors may be quite obvious; others may be less apparent.

With cold-setting, ready-to-use glues, the rate of strength development (speed of set) is dependent on how fast the liquid glue can dry to become solid enough to hold the joint in place. Since most of the water soaks into the substrate, the materials being glued are important. Obviously, the choice of adhesive is important. Also, the conditions of the gluing have an effect. By combining as many favorable conditions as possible, a maximum speed of set can be obtained. These will be listed and discussed in detail below.

It should be pointed out here that the squeeze-out on the outside of the joint does not indicate the conditions of the glue within the joint, particularly where short clamp times are involved. The bead squeeze-out dries much more slowly than the film in the joint. The thicker or bigger the squeeze-out (Figure 5), the slower the glue will appear to dry.

The materials being glued and the conditions of gluing are controlled by the woodworking plant or by the woodworker in his shop. By manipulation of these factors the woodworker can vary greatly the speed of set of his present glue. It is realized that such things as materials adhered and wood species are predetermined; nevertheless, a discussion of their effect on speed of set may explain some of the problems encountered.

With urethane hot melt adhesives, the determining factor for speed of set is temperature. The temperature of the environment, the wood and the adhesive determines how quickly the glue will set. The cooler the substrates, the quicker the adhesive will form the bond. Care should be taken with using cold to set hot melt adhesives, since the adhesive has to have time enough to form a bond.

With liquid polyurethane adhesives, the speed of set will be affected mostly by the environmental conditions, such as temperature and humidity, and the wood's moisture content and temperature.

Some of the factors which affect the speed of set are:

A. ADHESIVE
   1. Type
   2. Percent solids
   3. Formulation

B. ADHERED MATERIALS
   1. Type and species
   2. Moisture content
   3. Fit or accuracy of joint

C. CONDITIONS OF GLUING
   1. Conditions of glue, wood and room
   2. Assembly time

The speed of set is the rate of strength development and is dependent on how fast the liquid glue can dry to become solid enough to hold the joint in place. This is a relative number comparing the strength of the bond at three minutes to a set figure. The larger the number, the faster the glue will set.

Figure 4: A good wood glue should yield high wood failure on hard maple when given the block shear test.

Figure 5: The assembly above shows the proper and improper amount of glue applied. The line at the top shows a small amount of squeeze-out. The bottom line had much more glue applied than is necessary, as shown by the glue squeezed out. The unnecessary squeeze-out will dry much slower than the glue line in the joint.

Most water-based glues should be applied at a rate of 250 square feet per gallon.

Adhesive

The adhesive affects the speed of set in many ways. An adhesive, with high percent solids, will often set faster than one with lower percent solids. An emulsion adhesive releases its water more easily than an adhesive dissolved in water. Some emulsion adhesives coalesce more readily than others, causing a faster set. Some with a wet tack will give a faster grab than a non-tacky adhesive. Speed of set cannot be simply determined by comparing percent solids of two glues. There is a wide difference in the speed of set of cold glues.

Adhered Materials

With a fast setting cold glue, joint strength increases faster in the initial stages of setting than in the later stages. The strength at one-minute clamp will be doubled at approximately four minutes; and the four-minute strength will be approximately doubled at fifteen minutes

With normal gluing conditions, cold glues set over twice as fast on hard maples as they do on ring porous woods such as walnut, oak, and ash.

Many of the less dense woods, such as pine and poplar in reality set more slowly than maple but their lower strength and resultant lower rigidity reduce the stress placed upon the glued joint when unclamped; the required clamp time is, therefore, not as long as for denser ring-porous woods. Most particleboards set slowly and require a long clamp time.

As speed of set is directly related to the drying of the glue in the joint, it can readily be seen that drier wood with its fast water absorbency, will set faster than higher moisture content wood. Higher wood moisture content will significantly increase the clamp time. This is true also of the liquid polyurethane glues, even though they are moisture cured, since the high moisture content can prevent the polyurethane's foaming into the pores of the wood, which is how this particular type of glue forms a bond.

The same concept carries over into the effect of exposure conditions on the gluing surface immediately prior to gluing. Though no change might be noticed on a moisture meter reading, the exposure of the surface to be glued to high humidity will slow down the speed of set because these surfaces collect a thin film of water. This is particularly noticeable during humid summer weather. The effect is magnified when machining is done some days prior to gluing.

An ideal glue joint should never measure over several thousandths inch thick. With a poor fit, where this might be increased to .030 inches, as with a rub joint or sloppy dowel, this inclusion in the glue joint of many times the optimum amount of glue will slow the speed of set. As indicated previously, the first water removed from the glue film by the dry wood leaves rapidly. After the wood adjacent to the glue becomes saturated, the water leaves much more slowly, causing the glue to set more slowly. If the dried glue film is visible when the joint is ruptured, the glue line was too heavy to get maximum speed of set.

Conditions of Gluing

The temperature of the wood, glue and room are important in determining speed of set. Clamp times at summer temperatures can be one-half that needed in shops in winter.

The uses of air circulation may aid in the removal of water form the glue film and speeds the set.

Speed of strength development is greatly slowed by increasing assembly time. (Assembly time is the time between glue spreading and clamping.) In experiments on strength attained three minutes after clamping, increasing the closed assembly time from 15 seconds to 120 seconds cut the speed of set in half. Contrary to some popular opinions, reducing the assembly time to the minimum practical will hasten the speed of set.

Referring only to the five variables listed under Adhered Materials and Conditions of Gluing (see table on page 3), the required clamp time using all poor gluing conditions would be a great many times that for optimum gluing conditions.

Although hot animal glue appears to set rapidly because of its rapid gelation, it actually attains significant strength much slower than a polyvinyl acetate glue. A moderately fast polyvinyl acetate will attain strength at 2 to 3 times the speed of set of a high grade animal glue. Normally, one part hot animal glue may be mixed with two parts water, yielding a 33% solids solution. The faster setting polyvinyl acetates may have 50% to 60% solids. The lower percentage of water in the polyvinyl acetates will disappear more rapidly than the higher percentage in the hot animal glue. Furthermore, because of the higher solids content, the spread rate for the polyvinyl acetates is less, with even less water introduced to the bond.

The use of a fast-setting cold glue will substantially reduce the required clamping time below that needed for a hot animal glue.

Assembly Time

Assembly time refers to the time lapse between glue spreading and application of pressure. The time between glue spreading and closing the assembly is the open assembly time. The time between closing the assembly and pressure application is closed assembly time.

Most factors which decrease the speed of set increase the assembly time, which may be viewed as increasing the time for the glue line to dry.

Among factors increasing the assembly time are:

a) Type of glue. Liquid hide glues have longer assembly time than aliphatics or polyvinyl acetates.
b) Glue formulation. Frequently lower solids increase assembly time.
c) Glue spread. A heavier glue spread increases assembly time
d) Temperature. A lower temperature increases the assembly time but if the temperature is lowered too much it will cause the joint to fail through chalking
e) Substrate. Use of high pressure laminate or particle board gives a longer closed assembly time than wood veneers. Ring porous woods such as oak, ash or walnut give longer assembly time than maple or poplar.
f) Moisture content. Drier woods or substrates decrease assembly times

Allowable open assembly times are about one-third that of allowable closed assembly times. Open assembly time is also decreased by rapid air circulation.

With cold, ready-to-use glues, pressure may be applied immediately after spreading. There is no minimum closed assembly time.

If glue squeeze out occurs on the application of pressure, the maximum assembly time has not been exceeded. As long as the glue is wet enough to transfer uniformly to the opposite face when pressure is applied, good strength will result.

A Special Word About Urethane Hot Melt Adhesives

Urethane hot melt adhesives form a bond through cooling and reaction. Temperature will have the greatest affect on these products. The lower the temperature, the less assembly time. Figure 6 shows open times at room temperature.

Clamping

The purpose of clamps is to bring the substrates being glued in close enough contact to produce a thin uniform glue line and to hold them in this position until the glue has developed enough strength to hold the assembly together. If the members of a glued construction were to fit together perfectly so that a thin even glue line could be produced, no clamp pressure would be required. But, from a practical standpoint, since machining of stock is never perfect, a certain amount of clamping pressure must be used.

To insure close contact in edge gluing and lumber laminating operations, 100-150 psi is usually required. The pressure of clamp carriers and similar equipment have been measured and found to be in this range. Often, in these operations, the uniformity of pressure is more important than the exact amount.

In the case of panel on frame gluing (where hardboard or plywood faces are glued to frames for cabinet doors) the recommended pressure is approximately 100 psi.

When gluing high pressure laminate to cores for tabletops or similar constructions, the 'show through' or 'telegraphing' of the core through the laminate is accentuated by the clamping pressure used. For this reason pressure should be very carefully controlled so that only the minimum required to achieve good contact is employed. This will be about 25 psi or even less with a very good fit.

The pressures used in assembly gluing depend on the type of construction and can vary from fairly high pressures to practically zero where glue blocks are applied and just rubbed to mark the bond.

HiPURformer	Open Assembly Time	Closed Assembly Time
WW30	30 sec	30 sec
WW60	60 sec	60 sec
MP75	75 sec	75 sec
MP300	5 min	5 min

Wood Glues	Open Assembly Time	Closed Assembly Time
Titebond III Ultimate	10 min	15 min
Titebond II Premium	5 min	10 min
Titebond Original	5 min	10 min
Titebond Dark	5 min	10 min
Titebond Hide	10 min	20 min
Titebond Molding & Trim	5 min	10 min
Titebond Poly-urethane	20 min total	
Titebond Extend	7 min	12 min
Titebond II Extend	7 min	12 min
Titebond White Glue	5 min	10 min

Figure 6

Chalk Temperature

In an emulsion adhesive, the discrete particles of adhesive are suspended in water much as is fine sand in water. Upon drying the loss of water pulls the particles together with enough force to form a continuous adhesive film. If the drying temperature is below a critical point, the force of the water evaporation is inadequate to pull the particles into a continuous film, leaving discrete and unjoined particles in the dry film. This will make the dried film appear whiter than normal (Figure 7). This is known as "chalking" and the critical temperature is the "chalk temperature". When it occurs, the glued joint loses strength. This can be corrected by raising the temperature of the air, glue or wood, or changing to a glue which does not chalk at the operating temperature. (See Figure 8.)

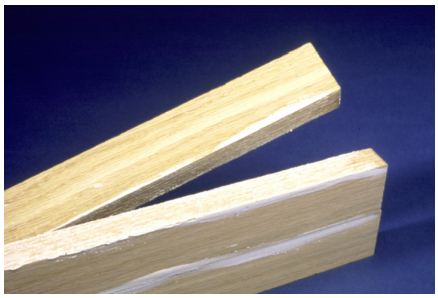


Figure 7: The above glue would dry clear at normal room temperatures. This glue has been dried at temperatures below its chalk point and, therefore, is an opaque white color.

Wood Glues	Chalk Tempera-ture
Titebond III Ultimate	47°F
Titebond II Premium	55°F
Titebond Original	50°F
Titebond Dark	50°F
Titebond Hide	n/a
Titebond Molding & Trim	55°F
Titebond Polyurethane	n/a
Titebond Extend	40°F
Titebond II Extend	60°F
Titebond White Glue	50°F

Figure 8

Wood Glues	Strength on hard maple	% wood failure at room temp
Titebond III Ultimate	4000 psi	57%
Titebond II Premium	3750 psi	72%
Titebond Original	3600 psi	77%
Titebond Dark	3600 psi	77%
Titebond Hide	3591 psi	72%
Titebond Molding & Trim	3000 psi	7%
Titebond Polyurethane	3500 + psi	60%
Titebond Extend	3510 psi	81%
Titebond II Extend	3844 psi	48%
Titebond White Glue	3550 psi	50%

Figure 9

Stains from Glue

There are three types of glue staining:

1) Many of the acidic glues (with a pH less than 7) will absorb iron from a steel container or agitator. This dissolved iron will then react with certain woods, such as oak, walnut, mahogany, cherry and other colored woods, to form a black glue line (Figure 10).

Some glues are chemically treated to reduce this stain. However, it is a wise practice to use the glue in non-iron containers. Plastic, glass, ceramic and stainless steel will prevent an iron stain. Coffee cans are a common source of iron contamination.

2) Spots of glue on the wood surface fill the wood pores, which prevents the absorption of stain or finish by the wood and giving this spot a light color (Figure 11).

3) The newer catalyzed glues like Titebond II, Titebond II Extend and Titebond III have a low pH and, in some cases, will react with the tannic acid in the wood and discolor the area around the joint.

Figure 10: Note the dark discoloration on the oak from dissolved iron in the glue, which normally dries colorless.

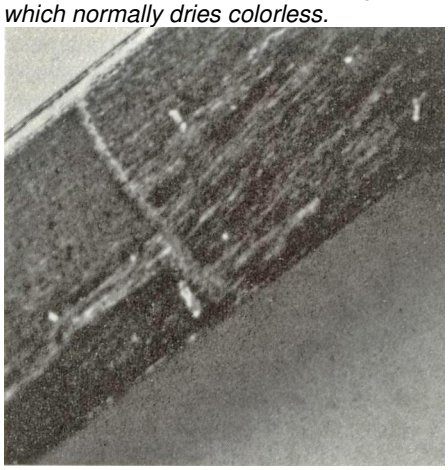


Figure 11: The white spots and the thick glue line are evident under the finish of the lighter color.

Sunken Joints

When surfaces are machined too soon after gluing, a sunken joint may result. A water based adhesive swells the wooden substrates that are on both sides of the glue line. Planing will make the joint flush. Later, when the moisture throughout the panel is equalized, the swollen wood in the vicinity of the glue line will shrink more than the rest of the panel, leaving the wood near the glue line depressed below the rest of the surface (Figure 12).

Sunken joints are more obvious with glossy finishes than with dull or matte finishes.

Also, if the finish is applied before the moisture equalizes, the process of moisture equalization could take months, which is why this phenomenon sometimes occurs long after the piece is in place.

Sunken joints can be corrected by (1) seasoning the glue joint longer before machining, (2) using less glue so that only a slight bead squeeze-out occurs on clamping and (3) using methods to get faster drying at the glue line, (4) the use of faster drying glues, (5) heating the wood and (6) using a non-water based glue such as an epoxy, a polyurethane, or a polyurethane hot melt.

Solvent Resistance

Sometimes the application of a finish to a panel will cause a small ridge at the glue line or even weaken or open the joint. Wash-off solvents may also soften the glue and cause joint failure. The trouble can be corrected by changing to a solvent resistant glue or changing the finish or wash-off solvent. The polyurethanes and polyurethane hot melts are impervious to solvents, the liquid hide glues are impervious to most solvents, except water, followed closely by the aliphatic resin glues. Polyvinyl acetate glues are swelled by a number of active solvents, such as acetone or methyl ethyl ketone.

Glue Penetration

Frequently, pressure is applied to a joint soon after glue spreading. Often glue is spread on only one side of the joint and is transferred to the other side at the time of clamping. It can be readily seen if a glue line is 0.003" thick, and the glue penetrates 0.003" into the wood on each side of the joint, there would be very little glue left in the glue line. This would be called a starved joint. Therefore, deep penetration of the glue into the wood cannot be tolerated in a good glue joint.

If dull cutting tools (such as saws or knives) are used, they loosen but do not remove a layer of surface fibers (Figures 13 & 14). The glue may not penetrate through this debris to the solid wood. When such a joint is ruptured, the glue line is coated with wood fibers and has little bulk wood failure. Sharpening the cutting tools will frequently increase the joint strength.

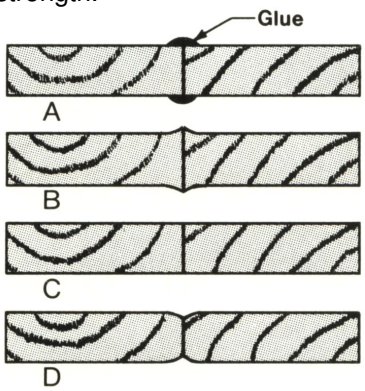


Figure 12: A sunken joint is caused by machining the joint too soon after gluing. Glue in A caused the wood in the vicinity of the joint to swell as in B. If the joint is machined as in C before the moisture in the vicinity of the glue line has been equalized with the rest of the panel, a sunken joint as in D will result.

Figure 13: A dull, vibrating or out-of-line saw will give a poor glue joint, yielding lower strength, slower set, and lower wood failure.

Figure 14: None of the failure is in the glue line but in the wood fibers, partially loosened but not removed by the saw.

Handling of Glues: In the Plant

One of the easiest ways to handle these glues is to place the drum on a stand or cradle and use a valve, (Figure 15a) or a plastic pipe to remove the glue from the drum. Both 55-gallon and 30-gallon drums are provided with a 2" bung in the head so that a valve can be used.

If the glue is to be used at various locations in the plant, an air actuated pump can be installed in the 2" bung (Figures 16, 17, & 18) and the adhesive pumped throughout the plant. An air pump does not apply any pressure to the drum. To prevent rusting, stainless steel equipment should be used. Plastic hose or pipe is a convenient way to distribute the glue.

The five-gallon pails have a built-in pour spout for easy dispensing of the glue (Figure 15b)

Glue Clean-up

The best way to reduce clean-up of glue squeeze-out is to keep it to a minimum. Immediately after gluing, wiping with a damp cloth is an efficient means of glue removal. Alternately the squeezed-out glue may be easily removed with a scraper a short time after gluing (½ - 1 hour).

Using a colored glue to approximately match the finish makes the squeeze-out less obvious in partially concealed joints.

The addition of a fluorescent dye to the glue will enable the woodworker to see any dried glue remaining on the assembly under a black light. The Titebond Original Fluorescent Wood Glue has this dye pre-added (Figure 19).

Figure 15a: Both 55-gallon and 30-gallon drums are provided with a 2" bung in the head so that a valve can be used.

Figure 15b: The five-gallon pails have a built-in pour spout for easy dispensing of the glue.

Figure 16: This pump can be installed in the 2" bung of a 55-gallon drum and used to pump adhesives throughout the plant. For water based adhesives, this should be stainless steel. For filling bottles a 1:1 pump is satisfactory, although for pumping any distance a 6:1 or 8:1 pump is required.

Figure 17: This air pump is attached to a drum cover along with an agitator. In this case, the adhesive goes through a strainer adjacent to the pump.

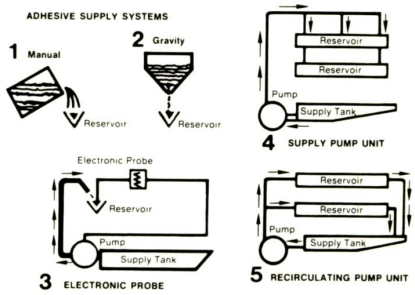


Figure 18: Various methods of supplying adhesives to a spreader are illustrated.

Figure 19: Use of a fluorescent dye in the glue will enable you to remove all of the squeeze-out.

Applying glue using the bottle tip.

Applying glue with the aid of a stick and brush to smooth to an even coating.

Figure 20: The use of urethane hot melt adhesives requires a special applicator. Shown here is the gun applicator for the HiPURformer Advanced Bonding System.

Figure 21: Above are just some of the glue bottles and applicator tips available on the market. In the upper part of the preceding column,

Figure 22: A mil gauge

Handling of Glues: In the Shop

The application of glue in the home woodworking shop is a matter of preference. Knowing the characteristics of the glue before application will help the woodworker to choose a method suited for their application.

For example, the aliphatic resin and polyvinyl acetate glues should not be exposed to iron contamination. Iron contamination will turn these glues black in color as they dry (Figure 10). Therefore, care should be taken to avoid applicators with metal parts. Stainless steel could be used for these products. (See Figure 21.)

Glue should be applied at a rate of 180-260 square feet per gallon, or 6-9 wet mils. A mill gauge will measure the thickness quickly. (See Figure 22.)

The urethane hot melt adhesives such as the HiPURformer Advanced Bonding System require a specialized applicator. The cordless gun is shown in Figure 20. Cartridges of the adhesive are placed in the gun, which then slides onto a base unit to heat the adhesive.

Glue Clean-up

The best way to reduce clean-up of glue squeeze-out is to keep it to a minimum. Immediately after gluing, wiping with a damp cloth or sponge is an efficient means of glue removal. The squeezed-out glue may be easily removed with a scraper a short time after gluing (½ - 1 hour) as well.

Squeeze-out can also be kept to a minimum by using masking or painters tape to mask off the area around the joint. First wipe off the squeeze-out with a cloth or paper towel and then remove the tape.

Using a colored glue to approximately match the finish makes the squeeze-out less obvious in partially concealed joints.

The addition of a fluorescent dye to the glue will enable the woodworker to see any dried glue remaining on the assembly under a black light. The Titebond Original Fluorescent Wood Glue has this dye pre-added (Figure 19).

Edge and Face Gluing

Many furniture parts are either edge or face glued. Solid tops, cores, drawer stock, posts, legs or upholstered furniture plates are examples of this type of gluing.

Only adhesives specifically designed for this application should be used. The unique requirements include the following.

The glue must be rigid to resist the stresses applied to the glue line by moisture change, particularly before this moisture interchange is slowed by the finish. Since wood absorbs and releases moisture faster through the end grain than through the radial or tangential face, a moisture change sets up stresses in the panel. In a dry atmosphere, the moisture leaving through the end grain tends to shrink one end of the panel. If the glue joint is weaker than the wood, it will open, otherwise, when the stress becomes great enough, the wood may split. Many times inferior quality joints will remain closed until subject to a moisture change, when the stress will break the joint instead of the wood. This moisture change may occur on exposure to oven heat or with time.

Wood is normally processed for furniture at 6-8% moisture content to minimize expansion and shrinkage in service. (See Figure 23.) 6-8% moisture represents a good average between the extremes of summer and winter exposure. It must be remembered, the application of a finish does not stop the moisture interchange, it only retards it.

Sometimes wood shrinkage is erroneously considered to be negligible.

For example, beech shrinks tangentially 1% for every 3% moisture change. In a 50" wide panel, changing from 8% to 5% moisture content will shrink the panel more than 1/8". Since this will be a

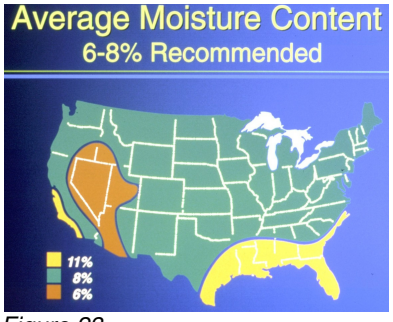


Figure 23

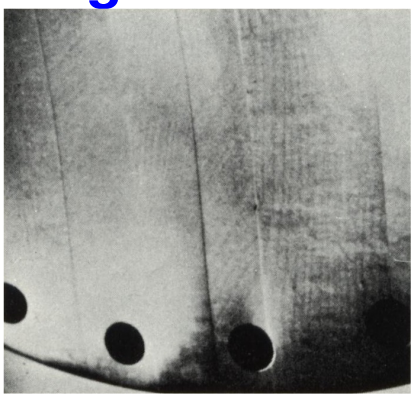


Figure 24: This chair seat was sanded and finished before the individual boards were uniform in moisture content. When the moisture content equalized, the finished surfaces were irregular.

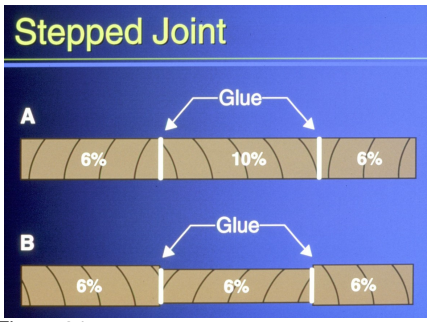


Figure 24a

differential shrinkage, the stress in the panel is considerable.

Edge or face glued panels may be exposed to high temperatures. If the panels are to be used as cores for plywood, a highly heat resistant glue should be used. Finishing ovens may also require a glue with a high heat resistance. The aliphatic resin glues, the liquid hide glues, the liquid polyurethane and the hot melt urethane glues are recommended where exposure to an elevated temperature or high continued stress is required.

Resistance to stress, both at room and elevated temperatures, should be considered in the selection of an edge or face gluing adhesive. The polyvinyl acetate glues generally do not become rigid enough when dry to withstand the continued high stress to which the glue line of edge glued panels and face laminated posts are exposed. Because this stress continues after the furniture has been shipped, the use of an aliphatic resin, a liquid hide glue, a catalyzed polyvinyl acetate, a liquid polyurethane or a hotmelt urethane will, with properly made joints, assure the quality of the

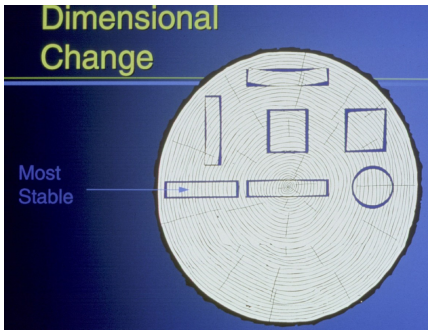


Figure 25: Characteristic shrinkage and distortion of flats, squares, and round as affected by the direction of the annual rings. Tangential shrinkage is about twice as great as radial.

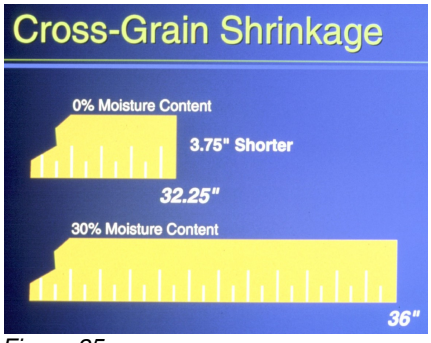


Figure 25a

glue lines for the life of the furniture.

If the boards in a panel are not of uniform moisture content, after gluing and machining to a uniform thickness, the higher moisture content boards will shrink more than the lower moisture content ones giving the finished panel rippled effect at each glue line (Figure 24 and 24a). The same effect will occur if plain and quarter sawn boards of the same moisture content are placed next to each other and the whole panel changes markedly in moisture content. The quarter sawn board will shrink in thickness more than the plain sawn board (Figure 25 and 25a).

Plain sawn lumber shrinks more on the sap side than on the heart side. Therefore, if panels consist of very wide boards or if several boards are glued together with the sap side facing one surface, the panel will warp markedly toward the sap side if the moisture content is lowered. If no board going into the panel is over four inches wide and the annular ring direction is reversed on adjoining boards, cupping and warping will alternate and be less noticeable.

Glue Application: In the Plant

The most efficient method of applying glue for edge gluing is by conveyorized roller spreader. Some are available for spreading adhesive on vertical surfaces.

Sometimes the most precise and fastest method of applying prescribed amounts of glue to shaped surfaces, such as tongue and adjacent shoulders, is with a contoured roller.

Some plants utilize a man tailing the panel matching saw to feed the spreader. It takes no longer for this man to lay the unglued pieces on the conveyor than to lay it on a truck. A truck is also usually provided to take care of any variations in speed between panel matching and gluing. If the gluing operation is faster, a truck of panels to be glued is supplied so the man can supplement the panel matching saw production with additional panels. If the panel matching saw is faster, the extra production from the saw is put on an empty truck.

Three or four clamp carriers require a man solely to feed the conveyor spreaders (see diagrams on the following pages). Normally, the clamp operator places the glued panel on a gravity overhead conveyor which returns the panel to the man who is feeding the spreader. He stacks the panels on a truck for the next operation.

Clamp carrier production rates vary, depending on the operation and the operators. Normally, rates of 250-500 board feet per man hour can be obtained.

The use of a conveyor for each clamp carrier usually yields more production than trying to serve several carriers with one spreader.

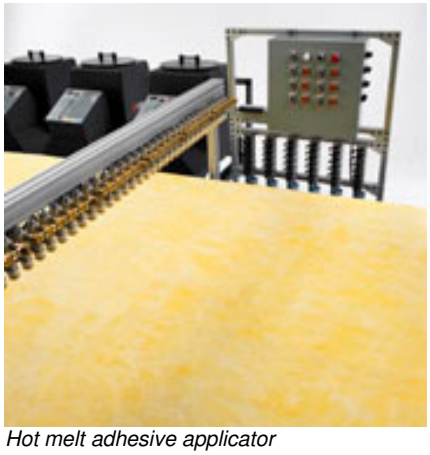
The glue spread should be regulated so that just a bead squeeze-out occurs uniformly along the glue line.

On roller spreaders, in which the roll turns in a glue container, the use of a seamless felt sleeve has proven useful. It has two main advantages over a steel or rubber roll:
1) its flexibility allows complete coverage over the surface to be glued even though some irregularity exists in the lumber. 2) The spread can be adjusted much lower and still obtain complete coverage. Exact measurements of roller circumference and width are needed to specify the proper felt. Modern advances in this technology are evident, and a matter of choice.

It is usually necessary to spread glue on only one surface. It is important, however, that the operator inspect every piece for complete spread before putting the panel into the clamp. A light over the spreader will speed this inspection. Some people mount a mirror on the far side of the spreader so the operator need only turn the glue line towards the mirror for inspection.

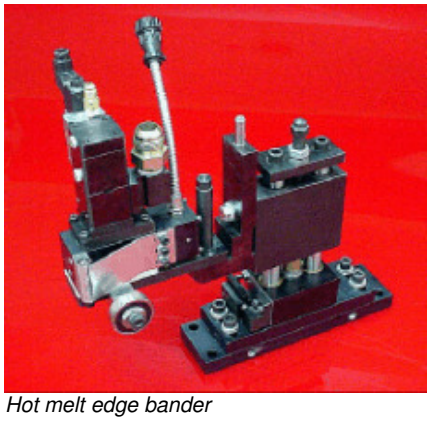
On non-conveyorized spreaders, a table, the top of which is about ¼" below the top of the roll, will help the operator to apply a complete spread on a number of boards at the same time.

Hand held glue spreader



Hot melt adhesive applicator

Adhesive roller coater



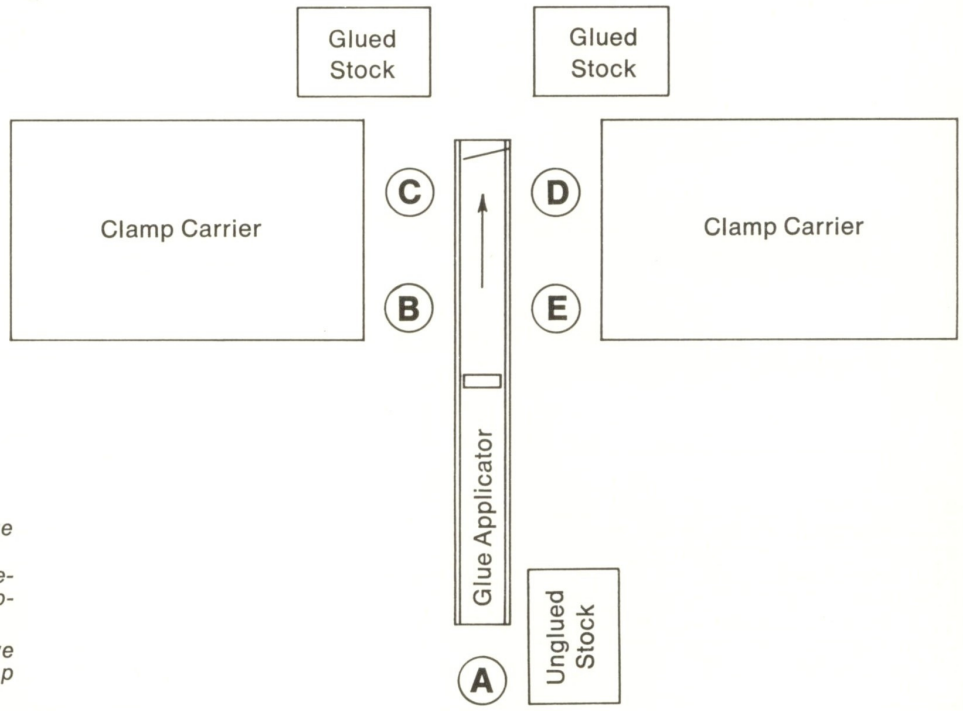
Hot melt edge bander

Clamp carrier and glue spreader

A conveyor and roller coater.

Figure 26: Various glue applicators for use in plants

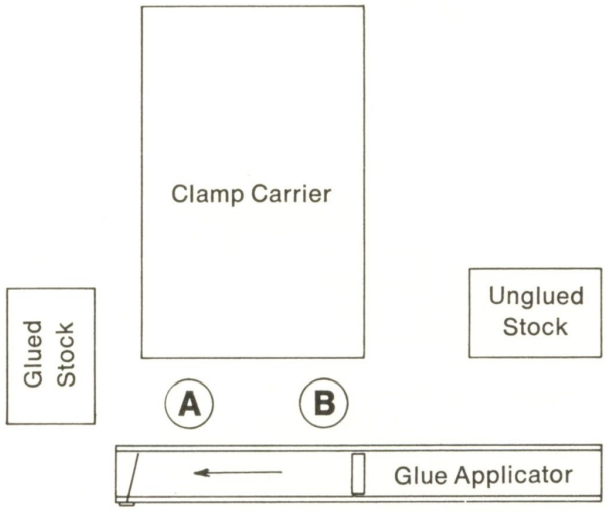
Standard 16′ x 13″ Glue Applicator



Operator "A" places boards on Glue Applicator conveyor.
Operators "B", "C", "D" and "E" remove boards from Applicator and operate Clamp Carriers.

Note: Same arrangement very effective with one operator at each Clamp Carrier.

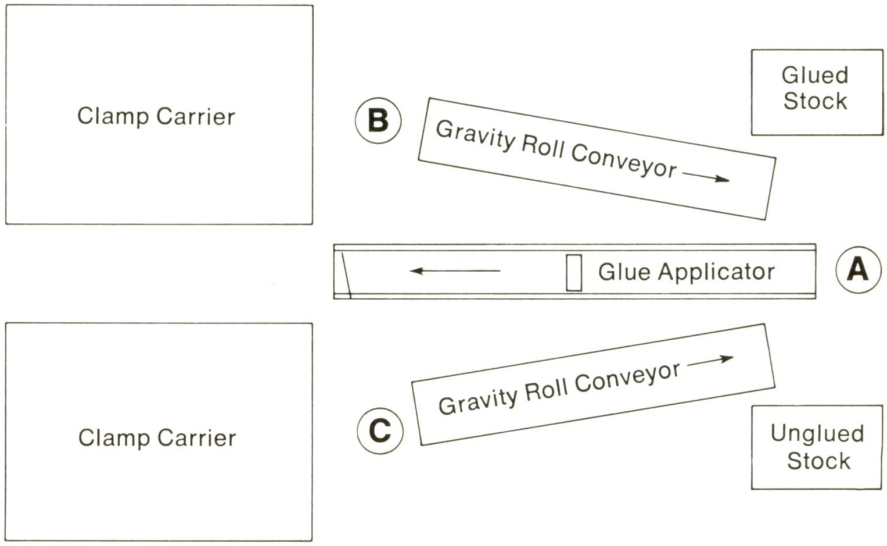
Standard 16′ x 13″ Glue Applicator with Auxiliary Start Button



Operator "A" removes and stacks all glued panels.
Operator "B" places boards for all panels on Glue Applicator conveyor and pushes start button. (Stop wand automatically stops conveyor.)
Operators "A" and "B" each transfers and clamps boards in Clamp Carrier.

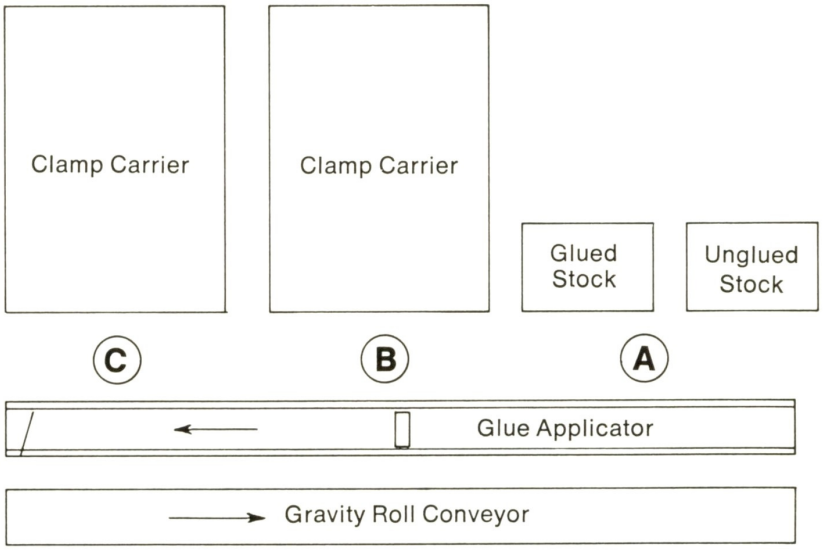
Note: Same arrangement for effective one-man operation.

Standard 16′ x 13″ Glue Applicator with Return Gravity Roll Conveyors



Operator "A" places boards on Glue Applicator conveyor and also inspects and piles glued panels coming to him on gravity roll conveyors.
Operators "B" and "C" remove boards from Glue Applicator and clamp in Clamp Carrier. Glued panels are placed on gravity roll conveyors.

Modified Standard 20′ x 13″ Glue Applicator

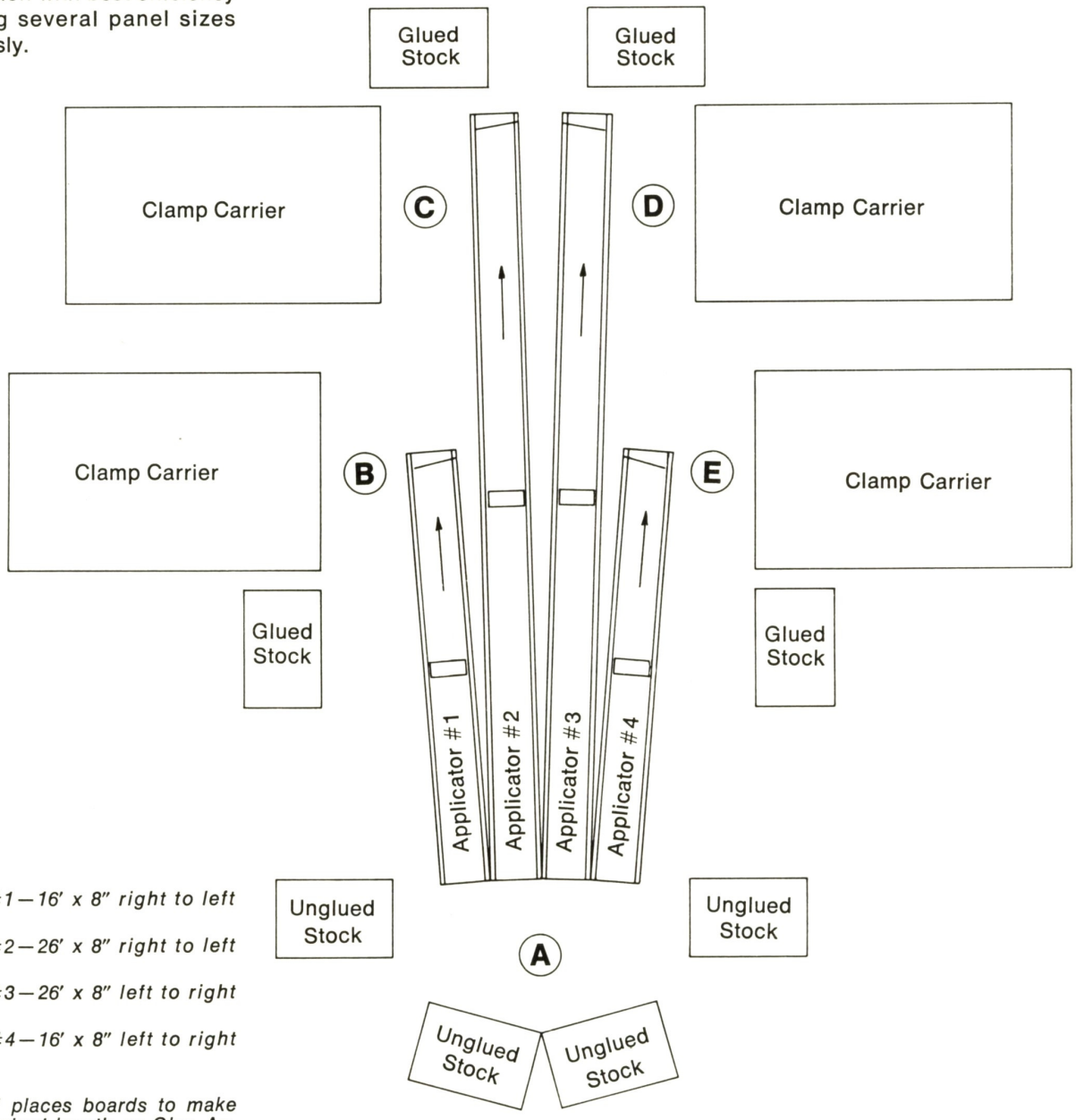


(Conveyor 8″ higher than applicator for clearance.)

Operator "A" places boards to be glued on Glue Applicator conveyor and also removes glued panels from gravity roll conveyor for inspection and piling.
Operators "B" and "C" remove boards from Glue Applicator and operate Clamp Carrier. Glued panels are placed on the gravity roll conveyor for return to operator "A".

Glue Applicator Arrangement for Utilizing Four Clamp Carriers

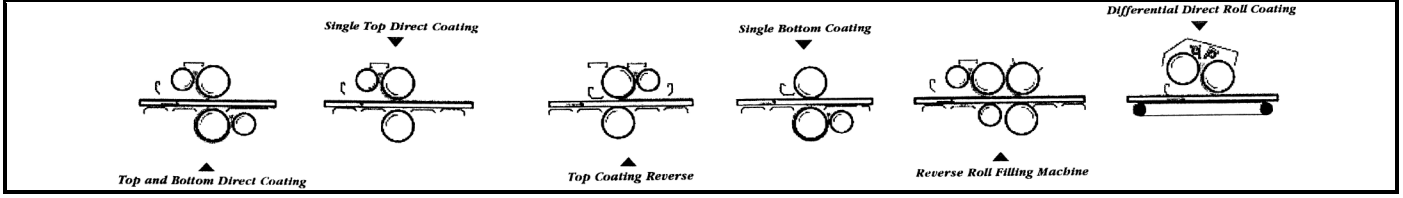
A very versatile arrangement of Glue Applicators and Carriers to obtain high production with best efficiency when gluing several panel sizes simultaneously.



Applicator #1—16' x 8" right to left applicator
Applicator #2—26' x 8" right to left applicator
Applicator #3—26' x 8" left to right applicator
Applicator #4—16' x 8" left to right applicator

Operator "A" places boards to make panels of required length on Glue Applicator conveyors.
Each carrier operator "B", "C", "D", and "E" glues specified sizes.

Roll Coater and Adhesive Spreader Roll Arrangements



Panel Quality

If a panel is poorly prepared, it is impossible to make a high quality panel.

There are several requirements of a good joint for gluing:

1) The joint should fit as closely as possible. A thin glue line is stronger than a thick one.

2) Glue penetration into the wood surface is never more than several thousandths of an inch deep. For this reason, the surface layers of wood being bonded should be sound. Dull or vibrating cutting tools (as, for example, caused by worn bearings) often loosen fibers, but do not remove them, leaving a poor and unsound surface for the glue to adhere to (Figures 13 and 14). Rupture of such a glue line reveals a thin layer of wood fibers covering the glue line.

3) When the cutting edge of a knife becomes worn and rounded off, it beats down the surface fibers, closing them to adequate glue penetration. Sometimes this becomes severe enough with both moulders and saws that the wood turns dark for being burned.

4) The joint should be straight, square and sound.

   a) In some cases, plants do not surface at least one side of the board far enough to be flat before making the edge glue joint. If this is not done, a warped board will produce a glue joint which is not square.

   b) Occasionally a board will hesitate under the planer knife leaving a valley in the board which cannot be brought together in the clamp (Figure 27). Since these cannot be drawn up tight, a weak or an open joint will result.

   c) Planer dubs leave the end of a board too narrow to be brought together in a clamp (Figure 28). Again, a weak or open joint results, causing a discard of this section of the panel.

   d) Use of grit coarser than 50 in final abrasive planning will leave loose fibers on the surface to be glued, reducing the strength of the joint (Figure 29).

Surfacing of lumber for gluing should be done just prior to gluing. Many rough mill operations plan their production so that joints are glued the same day they are made. This produces a surface essentially uncontaminated by wood resins and one which has not deformed from moisture change.

When preparing woods high in oil or tannic acid, the wood should also be wiped down with acetone or denatured alcohol. The solvent should be allowed to dry or flash off before the glue is applied.

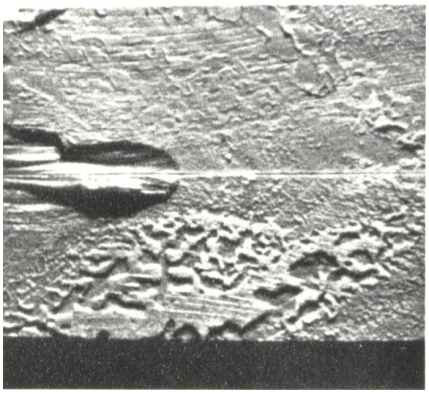


Figure 27: This depression from defective machining caused a thick and weak glue line.

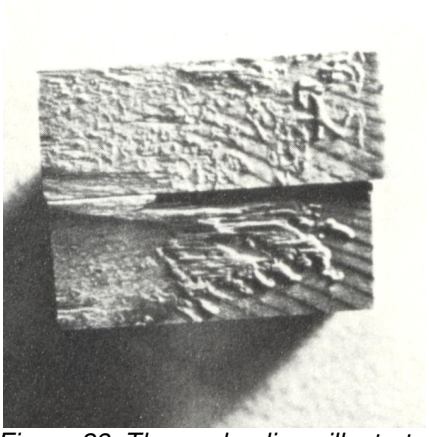


Figure 28: These glue lines illustrate poor machining.

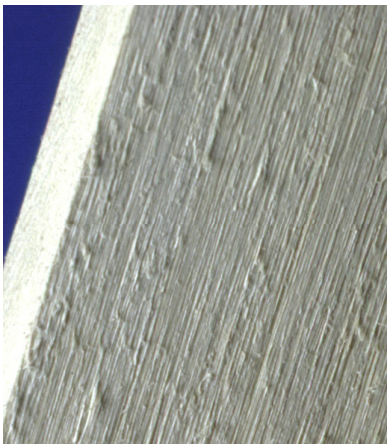


Figure 29: 36 grit abrasive paper to finish a joint for gluing will cause a weak joint as wood fibers are loosened but not removed.

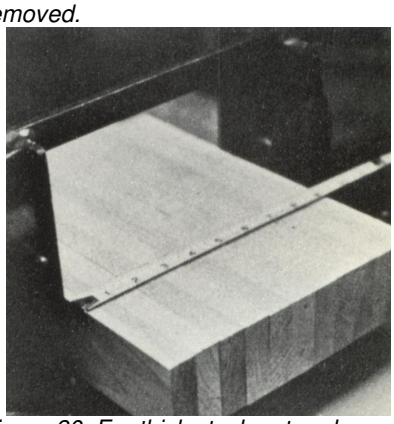


Figure 30: For thick stock, a top draw bar is essential to apply edge pressure equally to top and bottom faces of the glued stock.

The joint strength of resinous woods, such as pine, is frequently improved by machining the joint to be glued just prior to gluing.

It is usually easier to make a straight and square joint than to try to pull it up in a clamp.

For edge or face gluing, pressures of 50-300 p.s.i. should be used. The minimum is dependent on the resistance of the panel to be brought up tightly. The maximum is limited by the crushing strength of the wood. Pressure serves only to bring up the joint snugly and hold it there until the glue has enough strength to do so. Excessive pressure may strain the clamp causing a bow in the panel, which will give a weak joint.

The use of a top draw bar should be used when thick stock is glued in a clamp carrier (Figure 32). The distance between the front and back jaws at the bottom should equal the distance at the top when full pressure has been applied to the clamps. This should be checked regularly for best results. Figure 31 illustrates the result of inadequate pressure.

The uniformity of pressure is also very important. Frequently, clamps are spaced too far apart or too far from the panel ends. 7-10 inches between clamps usually give a good distribution of pressure. Narrow boards should be placed in the center of the panel and not at an edge. For gluing up posts in a carrier, a heavy (4”x4”, for example) wood square (or equivalent stiffness in steel) should be placed at the front and back of the clamp to ensure an even application of pressure to the outside glue lines between the clamps (Figure 32). A manual clamp carrier is shown in Figure 33. Stacking clamps (Figure 34) are useful, where a clamp carrier is not available.

If, for any reason, the pressure must be released from a panel before the glue has set (such as to replace a defective board), each glue line should be re-spread with glue before re-clamping. Otherwise, a weak panel will result.

Figure 31: All illustration of a glue line showing the results of inadequate pressure.

Figure 32: The above clamp carrier applies pressure evenly on stock for face gluing. Note the reinforcement blocks.

Figure 33: An example of a manual clamp carrier

Figure 34: If production does not justify a clamp carrier, stacking clamps are useful.

Several improvements have been made in clamp carriers, utilizing pneumatics or hydraulics to tighten the clamps and pressure hold-downs. This improves the clamping and is cost-effective, especially when computerized. The pressure applied is uniform day after day and is not dependent on the operator.

Pressure hold-downs eliminate the pounding ordinarily used to flatten panels prior to applying full edge pressure. The hold-down levels the panels and holds it against the bed of the clamps until full edge pressure is applied. It is then moved to the next panel and slides out of the way when the clamp carrier is turned.

The adoption of these two improvements has resulted in faster production and better quality of panels. Product rates of 12 ft^2 x 210 cycles or 2520 ft^2/shift and more can be obtained with a clamp carrier equipped in this way.

The squeeze-out on the outside of the joint will be much softer at the time of removal from the clamp than the interior of the glue film. With short clamp times, the joint may have been clamped long enough even though the squeeze-out is soft.

Controlling the spread so that a small, uniform bead of squeeze-out is obtained can result in the following:

1) Glue savings
2) Less cleanup on floor under clamp from squeezed out glue
3) Faster set
4) Less trouble from stacked panels sticking together
5) Less tendency toward sunken joints

With a suitable adhesive, edge and face glued panels can be produced in a radio frequency (RF) gluer (Figure 36 a and 36b). Curing may run from 30 seconds to several minutes depending on the generator capacity, glue line area, adhesive used, joint fit and moisture content and species of wood.

Figure 35: The addition of pneumatics or hydraulics to tighten the clamps is an improvement on the clamp carrier.

Figure 36a: A radio frequency gluer, with the appropriate adhesive, can decrease press time from more than 30 minutes to less than a minute. Figure 32B shows a hand-held radio frequency gluer.

Figure 36b

The time between spreading and clamping of a glue joint should be minimized to prevent getting a thick or 'fat' joint (Figure 37).

Daily testing of panels or posts should be made to check the glue joint quality being obtained in production. A chisel can be used if no better testing equipment is available. At least ten glue lines should be tested every day to get a meaningful result. Figure 38 shows the effect of chisel direction on the wood failure obtained. If the daily test average of wood failure shows results lower than normal, additional panels should be opened. If the results are still low, the cause should be determined at once. (See Adhesive Trouble Shooting.)

A record should be kept of gluing conditions to enable a plant to locate and correct the source of the trouble and rejects. Following is a form used in conjunction with an RF gluer. This form is part of the tag accompanying the part through production. (See next column.)

Use of a soap solution, such as Bates Boothcoating/Glue Release from U-C Coatings Corporation (P.O. Box 1066, Buffalo, NY 14315 Phone: (716) 833-9366), or a thin coat of oil, grease or wax will prevent glue sticking to the clamps or conveyor spreaders. Too heavy an oil coat will transfer to the panels and should be avoided.

Some people use aluminum or plastic (polyethylene) film in the bottom of the spreaders to make clean-up easier.

By covering a spreader tightly with a plastic sheet or covering with a damp cloth, cleaning the spreader every night is unnecessary. For good housekeeping, a spreader may be cleaned each weekend.

Date_____
Room Conditions
Temperature_____R.H.____
Number of panels per charge_____
% Catalyst_____ or
Product used_____
Top pressure_____
Side pressure_____
Power setting_____
Press time_____
Breaking strength from test_____
Inspector's results
No. inspected_____
No. rejected for glue joints only _____
If this were not connected to the tag or sheet accompanying the part, the following information should be added:
Wood species_____
Part No_____
If it is a clamp carrier operation, the following data should be included:
Clamp time_____
Squeeze-out_____

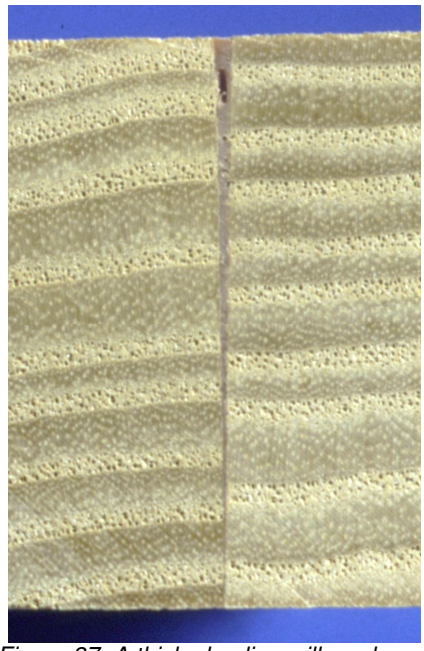


Figure 37: A thick glue line will produce a weak bond. This is a v-joint, which is the result of a poor fit or improper clamping. A thick glue line can also result from a long assembly time.

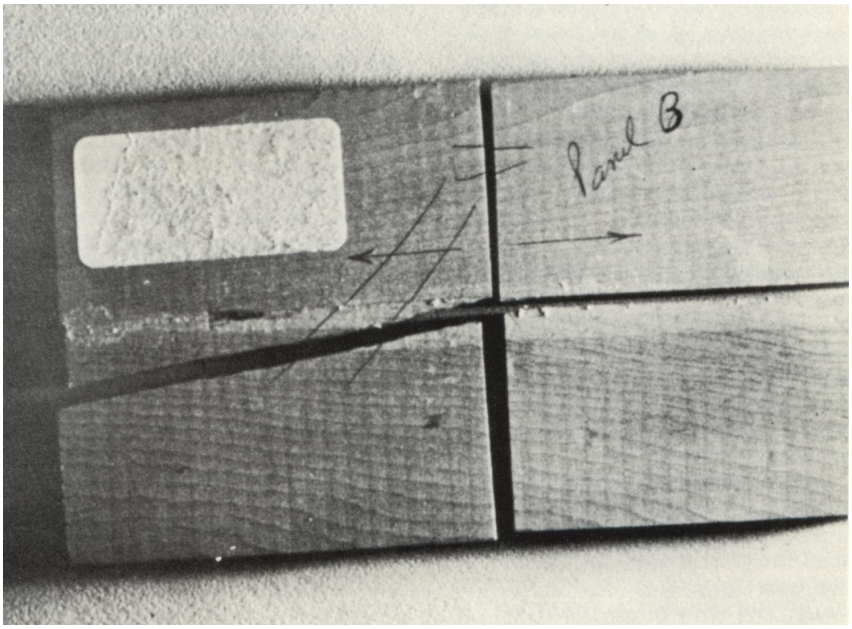


Figure 38: The two boards shown were glued together and then sawed across the panel. The joints were then chiseled open in the direction of the arrows. The difference in apparent wood failure (0-100%) indicates the unreliability of the wood failure read from any one chisel result. Only an average of at least 10 different chiseled glue lines has significance.

In the Shop

In the woodworking shop, cabinet shop or in the home woodworking shop, clamping or pressing is as essential for the success of a project as it is in the plant.

Clamps come in various shapes and sizes. The clamp should be chosen to fit the job at hand. Some examples are shown in Figure 39.

Clamp time

Clamp time is dependent on the wood species, the moisture content of the wood and your particular environmental conditions. For most of the Titebond wood glues, we recommend clamping an unstressed joint for 30 minutes to one hour. Stressed joints, such as bent laminations, need to be clamped for 24 hours. For every 10° (Fahrenheit) your shop and materials drop below 70°, add at least an hour of clamp time.

Do not stress the new joint until it is totally cured, 24 hours in most cases.

A note concerning polyurethanes:

For the Titebond Liquid Polyurethane Glue, we recommend clamping for at least 45 minutes. The glue is completely cured within 6 hours.

For the HiPURformer Advanced Bonding System, which utilizes polyurethane hotmelt adhesives, the clamp time is very short, since the bond forms as the adhesive cools. The cross-linking bond begins forming over a period of time ranging from hours to days and bond strength builds proportionately. But, keep in mind the initial bond has enough strength to allow assemblies to be machined or finished immediately after bonding and the adhesive has set. Load bearing joints should not be stressed for 24 - 48 hours, so that the cross-linking reaction can occur.

A note concerning liquid hide glue:

The Titebond Liquid Hide Glue is extremely sensitive to environmental conditions, especially high humidity. Clamp time is dependent upon your particular environmental conditions. First, make sure the glue is within its shelf life. Once the assembly is glued up, place a few drops of the glue on a scrap piece of wood and set that with the assembly. When those drops of glue are dried completely, the clamps can be removed from the assembly.

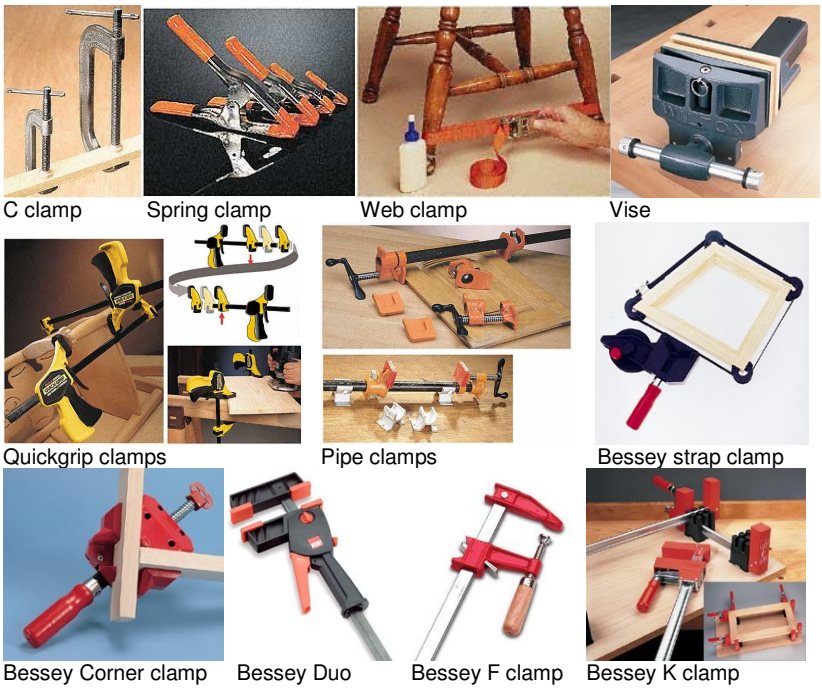


Figure 39: A variety of clamps.

Clamping Guidelines

Pressure Recommendations:

High Pressure Laminate	30 - 80 psi
Veneer	100-125 psi
Low Density Wood	100-150 psi
Medium Density Wood	125-175 psi
High Density Wood	175-250 psi

Clamp Spacing

Two clamps minimum
1" from each end
Additional clamps
evenly spaced at 8-10" intervals

Application Tips:

Allow projects glued with water-based glues to dry for several days before sanding or planning. This allows the swollen wood on both sides of the joint time to dry and shrink, thus preventing “sunken joints”.

Do not use metal tools with any Titebond Wood Glue. While it will not adversely affect the strength of the glue, iron may contaminate the glue and darken the glue line.

Apply a sufficient amount of glue to ensure adequate adhesion. You should experience glue coming out of the joint or “squeeze-out”.

Glue joint “squeeze-out” may make the area around the joint difficult to stain. Although sanding the area will help, we recommend using masking tape to cover the areas around the joint. Using a damp sponge to remove the squeeze-out immediately after clamping can also be effective.

In the shop, continued

Increasingly, in woodworking shops and in plants, vacuum presses are being used. They are particularly suited for veneer applications. (See Figure 40a and 40b.)

The small vacuum press consists of nothing more than a vinyl bag with a pump attached to evacuate the air from the bag. The press relies on atmospheric pressure to press the veneer against the substrate while it is being glued. Vacuum presses produce a surprising amount of clamping pressure - at 25 Hg (inches of mercury) a vacuum press will exert 1872 lbs. of pressure on a 1 square foot piece of wood. And for all of the advantages that a vacuum press offers, it's a fairly easy to use piece of equipment.

Most vacuum presses are operated with an electric air pump, which operates using compressed air to create a vacuum by running air through a small orifice. Some use a very simple hand pump to evacuate air from the veneering bag.

Water-based glues generally take longer to dry in a vacuum bag press. The press time can be decreased with the addition of a scrap piece of wood, which will absorb the water.

Covering the vacuum press with an electric blanket can speed the drying time of water based glues.

Figure 40a: A large vacuum press suited for plant use

How long does it take for the glue to dry? Drying time normally depends on several factors:

- Type of Glue: With water based glues the more open time the glue allows, the longer the set time
- Temperature of the shop: The warmer the shop, the faster the set time
- Substrate Material: With typical water based glues, the water will be absorbed into MDF, particle board, etc., faster than a solid wood like oak, therefore, the drying time is shorter.

A small vacuum press with a hand pump

A small vacuum press with an electric pump

A vacuum press with a cover, as opposed to a bag

Figure 40b: Smaller vacuum presses

Drying time guidelines:

Type of glue	Press time	Comments
Aliphatic resin	1-4 hours	Small pieces can dry in as little as 20 to 30 minutes. 4' x 8' panels can take as long as 3-4 hours.
PVA	2-6 hours	

Assembly Gluing

Assembly gluing covers many types of joints, such as dowel, mortise and tenon, panel and groove, dovetail, corner block, miter, cleat, inlay, biscuit or variations of these.

Most involve gluing side grain to side or end grain. Generally clamp times are relatively short, ranging from 5 to 30 minutes. Speed in processing through a limited number of jigs is often essential. The stresses involved in assembly joints are usually not as high as those experienced with edge glued joints. For this reason, polyvinyl acetate glues find wide use because of their faster set in many operations.

Often assembly joints fit too loosely or too tightly. A dowel should not fit a hole so tightly that all of the glue placed on the side of the hole is forced to the bottom when the dowel is inserted. A 1/64" clearance is desirable. In practice the dowel should be just loose enough so that it can be pushed in by hand. A dowel that has to be hammered in place is too tight. Sometimes miter joints are cut with a gap at the inside corner to make certain the point is always tight. These miters should be well reinforced with dowels or splines.

Pre-sizing of the end or miter grain surfaces before gluing will increase the quality of the glue joint. This may be done by diluting the glue with, perhaps 25% to 50% water. Use this to coat the surface and allow to dry before gluing in a normal fashion with a full strength glue. Dilution should be sufficient so that hard drops of glue do not collect at the bottom area of the coated surface, which would prevent the parts from coming snugly together in the clamp. Dilution should not be so great that the effect of sealing off the open wood pores is lost. Another method (easier but less effective) is to coat the open-grained surfaces with full strength glue, allow to stand 5-10 minutes, recoat, if necessary, and clamp as would normally be done. Only the polyvinyl acetate (Titebond White Glue) and aliphatic resin glues (Titebond Original Wood Glue, Titebond Dark, Titebond Extend) should be used in this manner, when the sizing is permitted to dry.

Figure 41: The brass tips, shown above, give better glue distribution and last longer than plastic tips. Some are designed for dowel holes, some for grooves.

The use of the crosslinking glues as sizing is possible, with care. If the crosslinking glues are permitted to dry, or even to skin over, the result is a seal that is water resistant (in the case of Titebond II Premium Wood Glue and Titebond II Extend) or waterproof (in the case of Titebond III Ultimate Wood Glue) and the application of the full strength glue will not adhere. To size using these products the addition of water should be in the same amount (i.e. 25-50%). The dilution should be applied, allowed to soak in for a few minutes, being careful not to exceed the open assembly time of the glue used in the dilution. A full-strength application of the glue should then be applied and the assembly should be clamped.

Generally, a fast drying, gap-filling glue is preferred on miter or end grain joints (assuming it meets the other requirements placed on the adhesive.)

Glue Application

Perhaps the most familiar glue applicator in the cabinet room is the plastic squeeze bottle. Usual sizes are 8-ounce, 16-ounce and 32-ounce. Tips or caps for these bottles is a matter of preference, and should be determined by the application. Many specialized tips can be purchased.

Too many dowel hole applicators put glue in the bottom of the hole. A uniform coating should be put on the side of the dowel hole. Glue in the bottom does no good unless the dowel hits the bottom and forces the glue up around the dowel. This is frequently impossible and when it does occur, the spread is uneven. A plugged pipe with holes around and near the end can give a uniform spread (Figure 41). The outside diameter should be 1/16" to 1/32" smaller than the dowel hole diameter. By flaring the pipe or attaching a flange to the open end it can be inserted into some of the tips. A similar tip can be made to apply glue to the sides and bottoms of grooves.

Variations of the above types of tips are available which operate from a pressurized tank or from a pump in a 55-gallon drum. Such tips are made by many companies (See Figures 42).

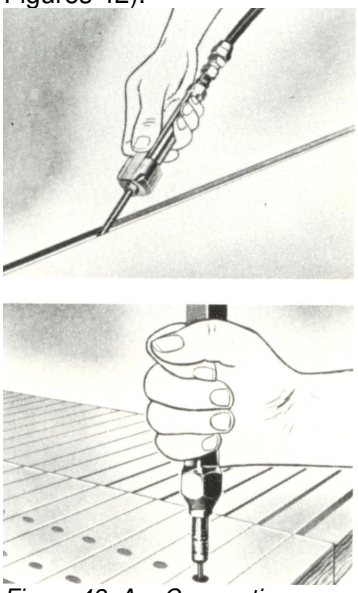


Figure 42: Aro Corporation manufactured valves and tips for glue application for pressurized systems.

Figure 43: An Alexander Dodds dovetail gluer for applying adhesive to both ends of a drawer side at one time. The distance between the two applicators is adjustable.

Dovetail joints are normally spread with a glue applicator (Figure 43). Speed of set and sandability are usually required for a dovetail glue. The glue should have a low viscosity (to insure a minimum squeeze-out) and colored (to match the wood finish).

Pre-doweling is frequently done with a dowel driver. When buying a machine, cold glue applicator tips should be ordered (Figure 44). Special roller spreaders have been designed to conform to the contours of assembly joints. Many plants use a stick or brush to spread hot animal glue. When switching to a cold glue, the size of the stick or brush should be reduced, lest too much glue is applied to the joint and clean-up problems result.

Figure 44: A dowel insertion machine

Preparation of assembly joints

To get glued assemblies of maximum quality, joints should be cut accurately with sharp tools (Figure 45). A joint should fit snugly when assembled and/or clamped (Figure 46). Glue should not be expected to act as a gap filler although some glues do fill minor irregularities better than others. A dull cutting tool may glaze or even burn a joint. A dull saw will loosen but not remove wood fibers from the surface to be glued. Keeping cutting tools sharp will quickly pay off due to improved quality of glued joints and reduction of rejects or reworked pieces.

It is important that the tip not be larger than any other part of a chucked spindle, otherwise the glue will be pushed to the bottom of the hole, leaving an insufficient amount of glue to make a good joint.

A properly compressed chuck will made a good joint. It is important that so much compression does not occur that the exterior wood fibers are fractured. This is more likely to occur with very dry wood.

Many types of clamping devices are used for assembled joints. Because of the wide variety and shapes of pieces to be assembled some presses and jigs are made by the plant for its own use. They may be built from eccentric clamps (Figure 47). For longer runs these clamps may be replaced by air cylinders to give faster production. Clamp carriers (Figure 49) are available, which will give a short clamp time for the glue to set before release from pressure. Radio frequency presses (Figure 50) are available which will set the glue line in a matter of seconds to a few minutes. In some cases, the press is used to pull the assembly together and then a staple or nail can be used in an obscure location to hold the joint intact until the adhesive has set.

Mastics are finding more application in the assembly of furniture parts.

In many places where corner blocks are used, a bead of a mastic will make a cheap and satisfactory substitute. The mastic can be extruded for the desired length in the place where the corner block would normally be applied. This method saves money by eliminating:

1) The cost of the corner block
2) The use of any staples
3) Rub-in time with conventional glues

It also allows the amount of support to be varied by the operator of the adhesive.

Mastics are widely used to hold decorative plastic parts to wood. Excellent strength is obtained between wood, or wood materials and the plastic. The adhesive method of attachment has the following advantages over mechanical fasterners:

1) Better strength
2) No crack or splitting of the plastic
3) Hold down over the complete area
4) Better sound deadening
5) No surface repair, such as filling nail holes

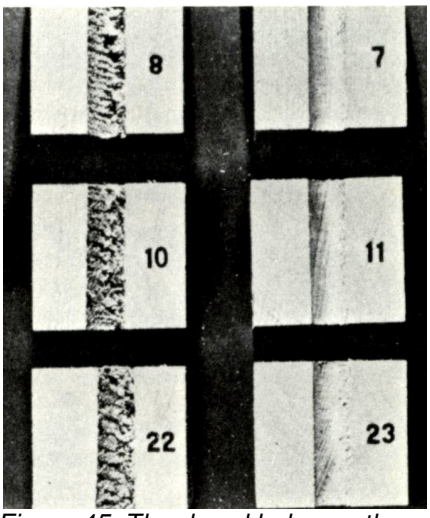


Figure 45: The dowel holes on the right have been properly cut, leaving a strong solid surface on which to adhere. The holes on the left are heavily coated with fibers – a poor gluing surface.

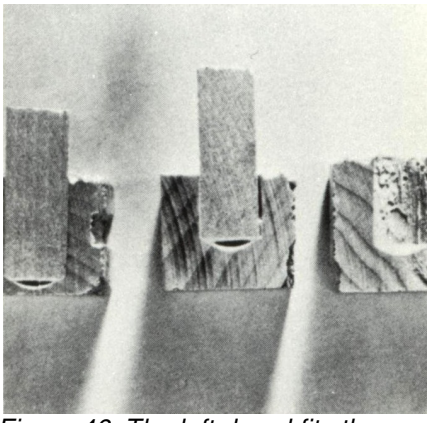


Figure 46: The left dowel fits the hole well. The middle dowel is too loose. When the latter is removed, the dried glue pattern, on the right, indicates the poor fit.

Titebond Glues for dowel insertion:
Titebond Doweling Glue
Titebond Doweling Glue LV

Titebond Glues for radio frequency:
Titebond II Premium Wood Glue
Titebond II Extend
Titebond III Ultimate Wood Glue

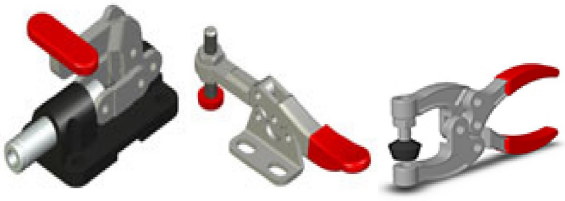


Figure 47: Manual eccentric clamps, mounted in a jig, can be used to quickly apply directed, uniform pressure on an assembly. These are also available as air-operated clamps as seen below.

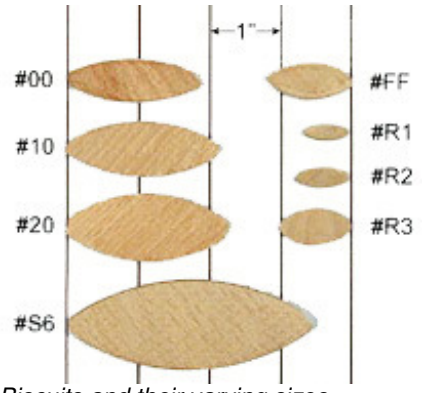
Figure 48

Figure 49: This clamp carrier applies side pressure in both directions during the cycle time.

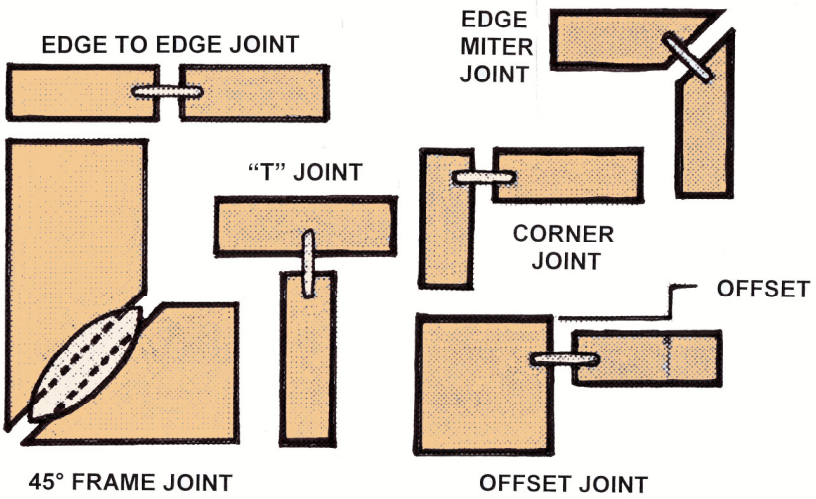
Figure 50: This radio frequency gluer is for doors and applies pressure in both directions. It will cure the adhesive in an assembly in as dew seconds without the need for mechanical fasteners.

Biscuit or Plate Joints

A biscuit joint is reinforced with an oval wooden biscuit, half of which is inserted into a crescent shaped hole in the opposite edges of the two pieces of wood. The biscuits are made from compressed beech wood stamped into an oval shape. Water based glues will soak into the biscuit, causing it to swell and tighten up in the joint.



Biscuits and their varying sizes



Various joint configurations that can utilize biscuits for additional strength

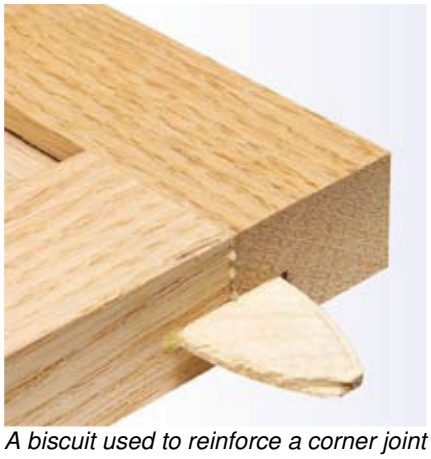
Cutting the slots for biscuits

Using biscuits to reinforce a t-joint

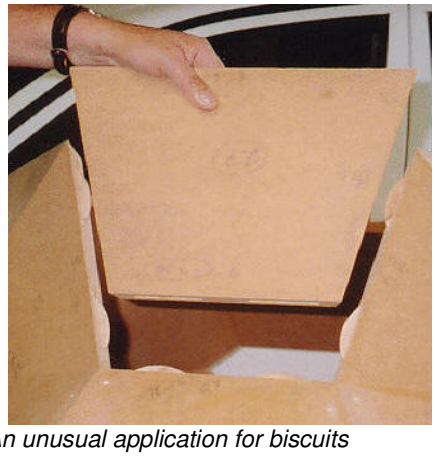
A special glue applicator for biscuit slots

Dry assembly ensures proper alignment

Biscuits used to reinforce part of a tabletop



A biscuit used to reinforce a corner joint



An unusual application for biscuits

Selection of an Assembly Glue

There are many factors entering into the selection of an assembly glue. Strength is of primary importance, regardless of operation. In addition, there are many more characteristics which should be considered.

FAST SET

Usually speed of set is of prime importance and reference tables are helpful in picking the glue most suitable to the clamp and assembly times desired. The speed of set is the rate of strength development and is dependent on how fast the liquid glue can dry to become solid enough to hold the joint in place. This is a relative number that compares the strength of the bond at three minutes to a set standard. The larger the number, the faster the glue will set. (See Figure 51.)

Titebond Glue	Speed of Set*
Titebond III Ultimate	0.98
Titebond II Premium	1.26
Titebond Original	1.37
Titebond Dark	1.37
Titebond Extend	1.00
Titebond II Extend	0.90
Titebond Cold Press for Veneer	0.93
Titebond Cold Press for HPL	0.96
Titebond Doweling	1.34
Titebond Doweling LV	1.01
Titebond Fluorescent	1.37
Super Titebond	1.11

*These numbers are averages, and are meant only as guidelines.

Figure 51

ASSEMBLY TIME

In general, the faster the speed of set the shorter the assembly time. Liquid hide glue will give a very long assembly time. Relative assembly time can be roughly estimated by referring to their speed of set. (See Figure 52.)

Titebond Glue	Open/Closed*
Titebond III Ultimate	10/15
Titebond II Premium	5/10
Titebond Original	5/10
Titebond Dark	5/10
Titebond Hide	10/20
Titebond Molding & Trim	5/10
Titebond Polyurethane	20
Titebond Extend	7/12
Titebond II Extend	7/12
Titebond White Glue	5/10
Titebond Melamine	5/10
Titebond Doweling	5/5
Titebond Doweling LV	5/10
Titebond Cold Press for HPL	5/10
Titebond Cold Press for Veneer	5/10
Titebond Fluorescent	5/10
Super Titebond	7/12

*These numbers are in averages at room temperature

Figure 52

VISCOSITY

Low viscosity may be desirable for dowel or finger joints, where minimum squeeze-out or spread is desirable. Some pumping distribution systems require low viscosity. In other places, a higher viscosity is desirable for certain spreaders for adequate spread. Normally, a viscosity of 2,500 to 3,500 cps. Seems desirable for most operations. A low viscosity does not necessarily mean low solids. (See Figure 53.)

Titebond Glue	Viscosity*
Titebond III Ultimate	4200
Titebond II Premium	4000
Titebond Original	3200
Titebond Dark	3200
Titebond Hide	4000
Titebond Molding & Trim	36500
Titebond Polyurethane	8500
Titebond Extend	3500
Titebond II Extend	3500
Titebond White Glue	5600
Titebond Melamine	12000
Titebond Doweling	1500
Titebond Doweling LV	140
Titebond Cold Press for HPL	4500
Titebond Cold Press for Veneer	4500
Titebond Fluorescent	3500
Super Titebond	4500

*These numbers are in cps., are averages, and are meant only as guidelines.

Figure 53

RUN DOWN (SQUEEZE-OUT)
Sometimes excessive squeeze-out and run-down can be corrected by using a low viscosity glue which reduces the problem. At other times, a thixotropic glue is desireable so the glue squeeze-out does not run

SANDABILITY
Sanding generates heat and that is the reason the glue (because they are thermoplastic) gums onto the sand paper. Where the assembled joint is flush, such as dovetail drawer or front frames on kitchen cabinets, the squeeze-out may be removed with a sander. The loss of sander belts, due to loading, may cost more that the glue. Liquid hide glue or aliphatic glues are desirable since they do not load a sander belt, thereby saving money and time. If the glue is heat resistant, it will not load the sander belt.

Titebond Glues with excellent heat resistance and therefore better sandability are: Titebond Liquid Hide Glue, Titebond Liquid Polyurethane Glue, Titebond Extend and Super Titebond.

SOLVENT RESISTANCE
Since aliphatic, catalyzed pva, liquid polyurethane, hotmelt polyurethane and liquid hide glues possess solvent resistance, they should be used in applications where this is important.

HEAT RESISTANCE
Some stressed joints passing through finishing-drying ovens require a heat resistant assembly glue, such as the aliphatics, catalyzed pvas, liquid polyurethane, hotmelt polyurethane, and liquid hide glues.

GAP FILLING
A high solids glue normally gives excellent strength on loose fitting, end grain or miter joints. Gap filling is partially dependent on percent solids and speed of drying. (See Figure 54.)

Titebond Glue	**% solids***
Titebond III Ultimate	52
Titebond II Premium	48
Titebond Original	46
Titebond Dark	46
Titebond Hide	52
Titebond Molding & Trim	60
Titebond Polyurethane	100
Titebond Extend	42
Titebond II Extend	48
Titebond White Glue	45
Titebond Melamine	59
Titebond Doweling	51
Titebond Doweling LV	43
Titebond Cold Press for HPL	42
Titebond Cold Press for Veneer	42
Titebond Fluorescent	46
Super Titebond	44

*These numbers are averages.

Figure 54

SPECIAL SURFACES
Special glues may be needed to adhere some surfaces. Laboratory evaluation is generally needed to determine the best adhesive for the operations in question. For example: The Titebond Melamine Glue is designed to bond melamine to a porous substrate. Most wood glues will not adhere a nonpourous material such as metal or plastics, but liquid polyurethane glues, such as the Titebond Polyurethane, and the hotmelt polyurethanes, such as the MP75 and the MP300, will.

Cold Press Laminating

Cold press laminating is usually used for panel-on-frame, solid ply or hollow core construction.

Panel-on-frame materials are usually sheets of hardboard, high pressure laminate, or thin plywood glued to a wood frame. The frame is frequently a low cost species, or particle board. The selection of the materials for the framing is somewhat dependent on the method of finishing, i.e., natural, grained, veneered or shaped, and the method of attaching other members, such as legs. For cold pressing, most frames are assembled before gluing on the panel. Frame assembly may consist of stapling or nailing and may or may not include gluing the corner joints. Generally, the corner joints are glued if they are left exposed. If the frame is thick, these corner joints may also be reinforced with dowels or splines.

Solid ply construction may utilize hardboard, high pressure laminate, veneer and backing sheets to a lumber or particle board core. Usually an odd number of plies is involved to yield a balance or relatively warp-free construction. For economy reasons, sometimes high pressure laminate is glued to particle board without a backing sheet, This type of construction will tend to warp when exposed to changing moisture conditions.

For maximum freedom from warping:

1) The grain in alternate plies should be perpendicular.
2) The backing sheet should match the face sheet in regard to speed of moisture transmission.
3) There should be an odd number of plies.
4) All plies should be at the same equilibrium moisture content.

Figure 56a: An example of a hot melt roller coater

Figure 56c: A double roll spreader can spread both sides of either a core or veneer with one pass.

Figure 55a: A Black Brothers cold press with glue spreader.

Figure 56a: Another example of a roller coater

Figure 57: A large side loading cold press.

Cold press laminating is adaptable to high production of uniform size components. Where sizes vary and the number of each size is small, contact cements are frequently used.

Normally, a cold press set up inclused a single or double roll spreader, a table to build a stack and one or more presses (this may be a multi-sectional press). There may also be a mechanical feeder for the cores or frames. Materials may be delivered by truck or roller conveyor. Glued panels may be removed by similar means. (See Figure 55.)

Suitable spreaders can be obtained from many companies (see Figures 56a, b and c). Suitable presses are made by companies such as Newman Machine Company (see Figure 57). Other examples of cold presses can be seen in Figure 58 and 59.

To obtain even, uniform coatings of adhesive with a roller spreader, the rolls should be properly grooved. Composite grooving of 12 or 14 by ½" will normally give the proper spread for use with lumber, particle board, OSB, MDF or plywood.

Glue Spread

Thirty to fifty pounds of adhesive per 1000 square feet is usually adequate. A lower spread requires better equipment and better stock preparation as well as a shorter lay-up time.

A common arrangement is to stack the cores on the infeed side of the glue spreader. The stack of glued panels is built close to the outfeed end of the spreader, so that the man tailing the spreader only need to turn 90° or 180° to reach the stack. Another man places the faces and backs on the core, which has been spread with glue. The outer plies are usually placed face to face and back to back. They may be assembled this way prior to gluing or as the gluing operation proceeds. The stack is built against suitable guides to make certain it is vertical and may also be designed to regulate the overlap of the faces and the backs beyond the core. After the stack is built, pressure should be applied evenly to the whole surface, The clamping arrangements should be such that pressure is not released until the required clamp time has been completed

Figure 58 An example of a large cold press

Figure 59: A multi-section press

Glue Spread

Mils	Lbs/MSGL	Coverage (Sq Ft/Gal)
5	28	320
7	39	229
9	50	178

Coverage for the Titebond Wood Glue and the Cabinet Shop Program Wood Glue Lines:
A good rule of thumb for the coverage of these glues is 250 square feet per gallon, or 1.95 square feet per ounce

A special note for the Titebond HiPURformer Advanced Bonding System: These products extrude out of a cartridge in a 1/16 of an inch bead size. The coverage is 71 lineal feet.

Comparison of Spread in Various Terms of Measurement

Film in Mils	Pounds of glue per M sq. ft.*	Gals of glue per M sq. ft.	Sq. ft. coverage per gallon of glue
0	0	0	0
1	5 ½	.6	1667
2	11 ¼	1.3	769
3	16 ¾	1.9	526
4	22 ½	2.5	400
5	28	3.1	323
6	33 ¾	3.7	270
7	39 ½	4.4	227
8	45	5.0	200
9	50 ½	5.6	179
10	56	6.2	161

* Based on glue weighing 9 pounds per gallon. For glues with weights differing from 9 pounds per gallon, a suitable factor will have to be applied.

Approximate Coverage per size bottle:

Container size:	Approximate coverage in square feet:
4 ounce	7.81
8 ounce	15.625
16 ounce	31.25
32 ounce	62.5
1 gallon	250
5 gallon	1250
52 gallon	13000

Gluing Operation

Normally the frames or cores are delivered to the glue operators in stacks. The frames and cores should be of uniform thickness. Greater variations than +/- .005 may cause trouble, particularly if the deviation is cumulative. Some plants alternate core edges in the pile to compensate for thickness variations in the setting of the two sides of the drum sander. Better control of the thickness frames is obtained if they are sanded to thickness shortly before gluing. In spite of this care, some plants insert pieces of corrugated rubber matting to absorb any irregularities in the stack.

Normally, if a 3-ply laminate is to be made, the core is run through a double roll spreader, applying glue on both sides at the same time. If a 5-ply laminate or panel-on-frame construction is to be made, the glue may be spread on one side of the two cores or frame at a time with a double roll spreader or on one side of one core or frame with a single roll spreader.

If a mechanical feeder is available, two men can build the stack for clamping. With an efficient operation 50 panels (medium size) can be obtained every six minutes. If no mechanical feeder is used, three men are generally required. With three men, one man feeds cores to the spreader; one man tails the spreader and places it in the stack; and the third man stacks the backing and facing sheets (face to face). Clamping may be as short as 30 minutes with a stack of 50 panels. The time to build a stack will regulate the clamping time required.

Several plants use only one man for the gluing and clamping. The frames (or cores) are placed in a hopper behind the spreader. The operator activates a claw that pulls the bottom frame into the spreader which delivers the spread piece to the operator. He builds his own stack on a roller conveyor, alternating frames and face sheets. When eight to twelve frames have been stacked, an air cylinder is actuated which pushes the frames under a long pressure roll (a length of roller conveyor with weights on top). The ram of the air cylinder is retracted and another stack assembled and the air cylinder pushes this stack under the rolls, pushing the first stack further along between the pressure rolls. The system is designed to provide pressure for six to eight minutes before they reach the end of the conveyor. This requires a fast setting glue with a short assembly time and short clamp time.

Choice of Glue

Several factors determine the choice of a glue for laminating:

a) Strength
b) Heat resistance
c) Solvent resistance
d) Assembly time
e) Speed of set
f) Clamp time
g) Water resistance
h) Adhesion to plastic surfaces
i) Temperature of gluing
j) Materials being glued

In most cases, the glue joint strength to break the weakest of the materials adhered, is desirable. This may be hardboard or particle board or other materials.

Heat resistance is desirable for countertops or laminations passing through ovens. Also, some plants smooth the edge with a belt sander, which develops heat and may require a heat resistant glue to avoid excessive gumming of the sandpaper.

The use of lacquer or wash-off solvents may make a solvent-resistant glue desirable.

The assembly time and clamp time are interrelated. For short clamp times, a fast setting glue with a short assembly time is generally used. Where a long assembly time is required, a longer clamp time is usually required.

Water resistance is usually not important for interior use, but will be a factor when manufacturing exterior doors, furniture or assemblies.

Most operations try to keep the glue off the plastic surfaces as it would have to be cleaned off later and it makes the pile more difficult to break down. Some of the stronger glues may remove plastic from the surfaces when the pile is broken down, after standing overnight. The best remedy is to change the operation so that glue does not get on the plastic faces. Another help is to break the pile down soon after removal from the clamp.

Since the speed of set of a glue and the allowable assembly time are affected by temperature, a change of temperature may make a change of glue desirable. In cold weather, a faster setting glue may not only be permissible but also desirable; while in warm weather, a slower setting glue may be demanded.

A given glue used on more water absorbent materials, such as wood to wood, will set faster than the same glue on high pressure laminate to particle board. When there is some doubt if the allowable assembly time has been exceeded, the first panel laid up in the stack (the bottom panel) should be checked for adhesion on removal from the press.

If there is predrying of the glue, a heavier spread, or a shorter stack will correct the trouble.

A few highly tempered hardboards require either scuff sanding or an alkaline glue to get adequate bite or adhesion.

Cost

Cold press clamping with ready-to-use glues can produce, in a limited floor area, a strong, wood tearing bond with minimum labor cost. Operations have been observed where two men (with mechanical feeder for cores) lay, clamp and unclamp 50 panels in five to six minutes time. This is at a production rate of 500 panels per hour or 250 panels per man hour. (Without mechanical feeder, an added man is required.)

A glue spread of 30-40 pounds of glue per thousand square feet of glue line is customary. With an efficient and fast operation, clamp times of 30 minutes are usually adequate, meaning that a minimum floor area can produce a lot of glued panels rapidly. Affixing a cost to the above factors must be done by each operation, depending on the wage rate, equipment used, cost of the glue, spread used and production achieved.

Trouble Shooting

Warping of the panels is caused by the differential expansion or contraction of the laminate components. Therefore, it is important to have all components at the same equilibrium moisture content and temperature before gluing.

Many backing sheets allow a faster transfer of moisture than does the facing sheet. This will encourage warping. The relative moisture transmission rates of face and backing sheets should be equal.

Telegraphing is a term used to describe imperfections in the facing sheet after gluing. An examination of the nature and regularity of occurrence may give some indication of the cause.

1). Occasional small bumps, which occur irregularly over the surface may be due to materials in the glue, such as shavings or dust, resulting from inadequate cleaning of the core material before gluing. The core should be brushed clean of dust before spreading glue (Figure 60).

2) A wavy irregularity may be due to waves in the face of the core or the back of the material.

3) Excessive moisture in the glue line or excessive clamping pressure may cause the top layer of the particle board surface to show through on the surface. The particle board surface chips are swelled by water in the glue. Lower glue spread and/or lower pressures will improve or correct this problem. The problem is aggravated by the use of thin high gloss facing sheets.

Sometimes an edge, which has been machined smooth and flush, will develop an uneven edge at the glue line. Rupture of the joint may show no glue failure. This flaw is caused by a slight movement at the glue line. By adjusting the moisture content of components to the same EQUILIBIRUM MOISTURE CONTENT, the stress will be minimized. Use of a more creep-resistant glue, such as an aliphatic resin, hide glue or polyurethane glue, will resist this movement.

Figure 60: The above machine removes dust and dirt which telegraphs through the finished surface.

With panel-on-frame gluing, use of materials of unequal equilibrium moisture content may result in telegraphing the frame through to the decorative surface. On large frames, where a center cross piece is used to reinforce the frame; it is usually good practice not to glue this support to lessen any tendency to distort the top. By making the cross pieces 1/8" to 1/16" thinner than the rest of the frame, it will not pick up glue when put through the spreader and, therefore, will not bond.

Predrying of the glue is indicated by little or no glue transfer to the face (Figure 61a and b).

If the glue set before pressure was applied, several corrective measures can be taken:

1) Apply heavier spread
2) Decrease assembly time by:
   a) Building of smaller stack of panels, or
   b) Using an additional man to speed the operation
3) Use a slower setting glue

If the predrying is spotty, the trouble may be due to the uneven pressure or uneven core thickness.

Bleed through can occur in short grain face veneers, such as crotch or burl slices. Thin veneers or veneers from ring porous woods are also prone to bleed through. It may cause problems by bonding together consecutive panels in the stack or discoloration in the finish. It can be prevented by:

1) Choosing an adhesive with limited penetration into the wood
2) Reducing the amount of adhesive spread
3) Reducing the pressure applied

For most production operations, cold press laminating will yield a higher quality product at a lower labor cost than will other methods.

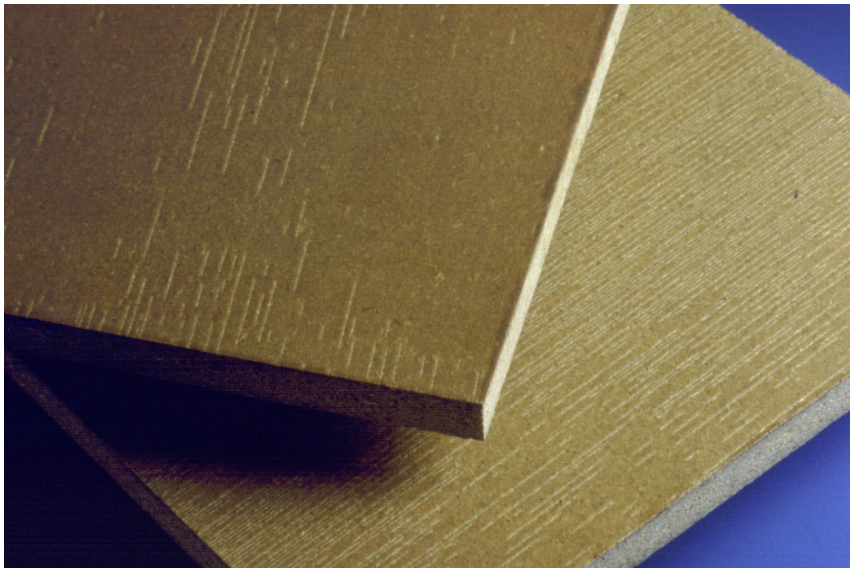


Figure 61: The dried spreader marks on the surface spread with the adhesive, indicate the glue dried before suitable pressure was applied.

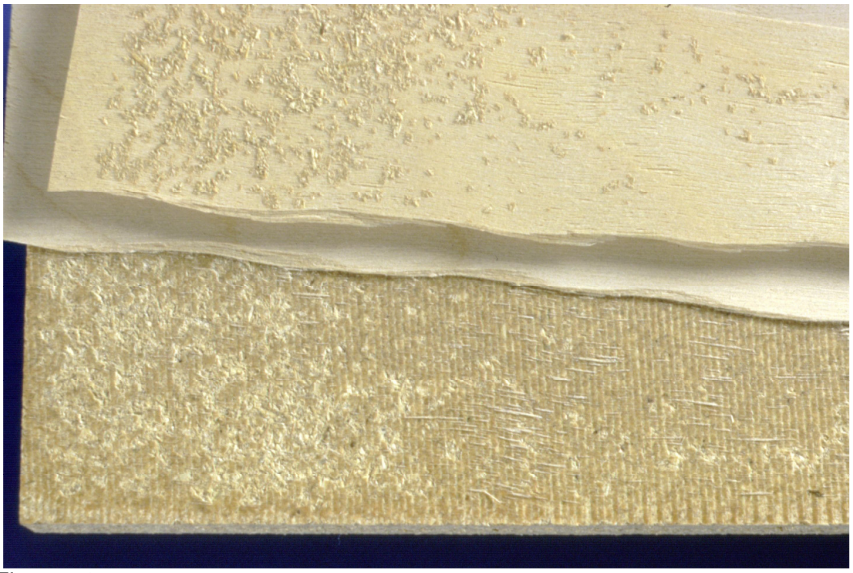
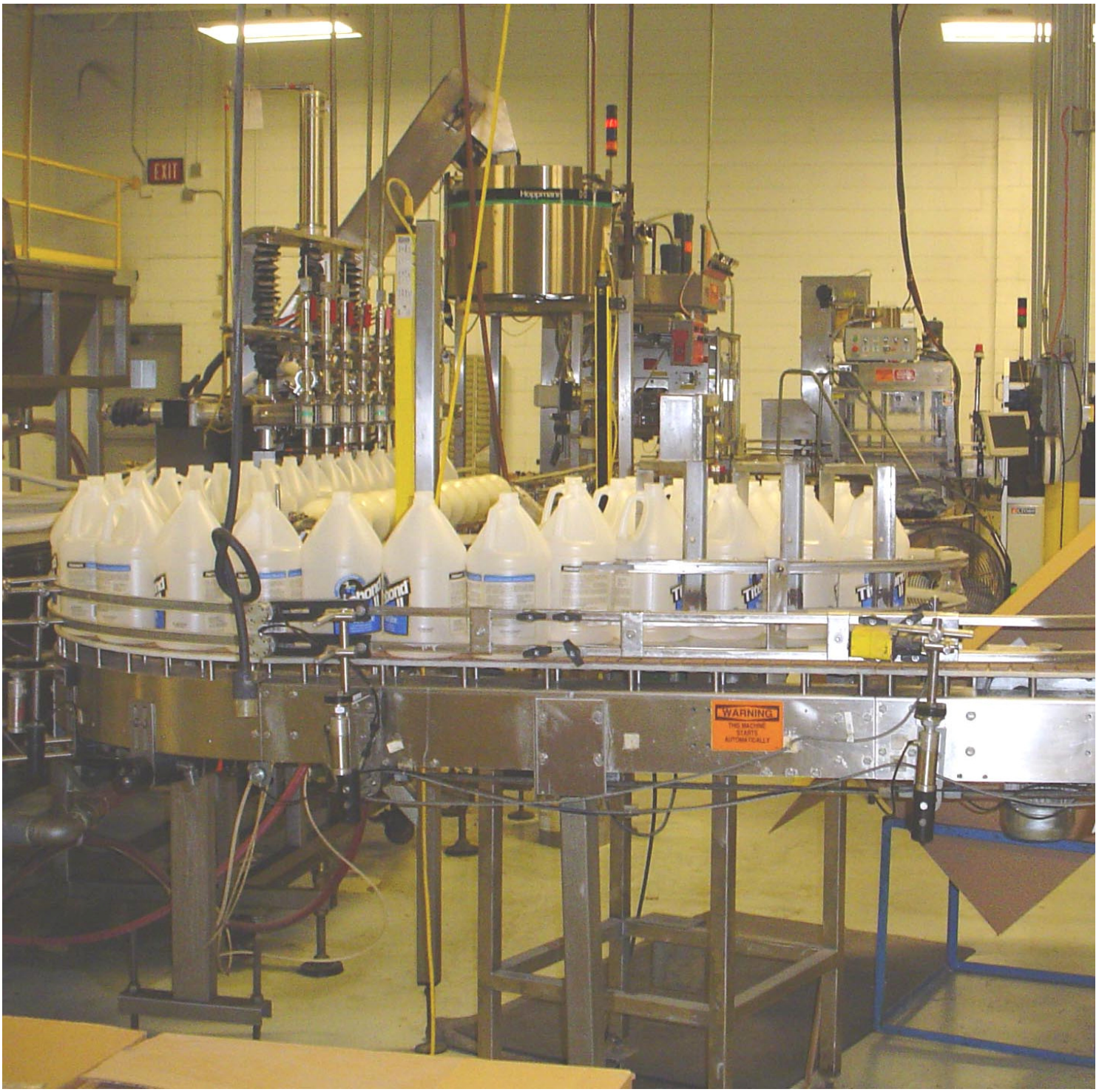


Figure 61a



The packaging line for Titebond II Premium Wood Glue

Franklin International

2020 Bruck Street
Columbus, Ohio 43207