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GLUES FOR USE WITH WOOD

The glues that are adapted for gluing wood may conveniently be divided into six classes, as follows:

1. Animal glues, made chiefly from the hides, bones, sinews, and hide fleshings of cattle. These glues come in dry form and must be mixed with water and melted.

2. Casein glues and vegetable-protein glues, which have similar properties and characteristics. Casein glues are made from the curd of soured milk, lime, and other chemical ingredients. Vegetable-protein glues are made from soybean meal, peanut, and other high protein-containing meals. Both glues are sold in prepared form, requiring only the addition of the separate ingredients to the water.

3. Vegetable (starch) glues, usually made from cassava starch. They are sold in powdered form and may be mixed cold with water and alkali, but heat is commonly used in their preparation.

4. Blood-albumin glues, made from soluble blood albumin, a product recovered from the blood of animals. These glues must be mixed from the separate ingredients just before use, since they deteriorate rapidly on standing.

5. Liquid glues, commonly made from the heads, skins, bones, and swimming bladders of fish. Some liquid glues are made from animal glue and from other materials. They come in prepared form ready for immediate use.

6. Synthetic-resin glues are products of the chemical industry. Most of them are of two types: urea-aldehyde combinations and phenol-aldehyde combinations. They are sold as powders to be mixed with water, in liquid form, and at least one is available as a dry film. The earlier products were often alcohol solutions.

Vegetable glues are the cheapest glues, normally ranging in price from about 4 to 11 cents per pound. Casein and vegetable-protein glues may vary in price from 6 to 24 cents, different grades of animal glue from 12 to 30 cents, and dried blood albumin, suitable for making glue, from 16 to 38 cents per pound. Synthetic-

resin glues range in price from about 12 to 50 cents per pound, depending on the concentration of resin in the glue and on the quantities ordered.

Animal glue, frequently referred to as "hot glue," possesses great strength, particularly in the higher grades; it flows freely, and does not stain wood. So far no glue has been found by the woodworking industry to be as suitable for hand spreading on irregularly shaped joints, although a cheaper glue would be desirable. The price of animal glue, the importance of temperature control in its use, and low water resistance are the chief factors that limit its utility. It may, however, be treated to make it more water resistant.

Casein and vegetable-protein glues have been used commercially for a much shorter time than animal glue, and their possibilities and limitations are not so well known. Casein glue has sufficient strength for either veneer or joint work. It is used cold (although it may also be hot pressed), and when properly mixed it can be spread with a brush. The property most featured is its high water resistance, which makes it suitable for gluing articles to be used under moist conditions. Not all casein glues are water resistant, however; some are made to compete with vegetable glue and claim no great water resistance. Among the disadvantages of casein glues are a tendency to stain thin veneer and a relatively short working life of some kinds. It is claimed that staining has been overcome to a certain extent in some casein glues. The water-resistant casein glues are somewhat harder on tools than animal and vegetable glues. Possibly this objection can be overcome by altering the ingredients in the glue or by using different steel in the tools. While vegetable-protein glues are similar to casein glues in properties and characteristics, some of them do not give quite as high joint strengths.

Synthetic-resin glues became commercially important during the decade 1930-1940. They were known several years previous to that time, but the cost prevented their extensive use in woodworking. The phenol-formaldehyde glues were first available in alcohol solutions, but reached commercial importance in the form of a film ready for use. Later, powders ready for mixing in water were introduced. Generally, the phenol-resin adhesives require simultaneous application of heat and pressure (hot pressing). The joints are characterized by very high resistance to moisture. It is very difficult to destroy a joint well made with phenolic-resin adhesives without destroying the wood. The urea-formaldehyde glues, marketed in liquid form, require the addition of "hardeners" or "catalysts" just before use. To some in powder form the "catalyst" has already been added and to others the "catalyst" must be added when the glue is mixed with water. Like the phenol-resin adhesives, many of the urea-resin adhesives are formulated

Properties and characteristics of different classes of woodworking glues

Property or characteristic:	Animal glues	Liquid glues	Vegetable (starch) glues
Mixing and application.....	Soaked in water and melted; applied warm by hand or mechanical spreaders.	Require no mixing; applied warm or cold, usually by hand.	Mixed with water and alkali with or without heat; applied cold by mechanical spreaders.
Tendency to foam.....	Usually slight; sometimes pronounced.	Of little practical importance.	Very slight; some air usually embodied in mixing.
Temperature requirements.....	Control important for glue, wood, and room.	Sometimes necessary to warm glue.	Used at ordinary room temperatures.
Spreading capacity: ¹ Extremes reported ²	20 to 55.....	No data.....	35 to 120.
Common ranges ²	25 to 35.....		42 to 60.
Working life.....	1 day or less.....	Several hours to many days.	Many days.
Consistency.....	Variable from thin to very thick with temperature changes.	Variable from thin to medium.	Normally thick.
Rate of setting.....	Rapid.	Rapid to medium.	Slow to rapid.
Strength ¹	Very high to low.	High to very low.	Very high to medium.
Water resistance.....	For 2.....	Low.	Low.
Tendency to stain wood.....	None to very slight.	None to very slight.	Slight to marked with some woods.
Dulling effect on tools ²	Moderate.	Moderate.	Moderate.

Property or characteristic:	Casein glues ²	Blood-albumin glues	Synthetic resin glues
Mixing and application.....	Mixed cold with water; applied cold by hand or mechanical spreaders.	Mixed cold with water; applied cold by hand or mechanical spreaders.	Mixed with water and applied with mechanical spreader or used in the form of a film.
Tendency to foam.....	Very slight to medium.	Slight to pronounced.	Slight.
Temperature requirements.....	Used at ordinary room temperatures.	Heat usually required to set glues; cold-press formula an exception.	Usually hot pressed. A few cold-setting, urea-resin adhesives are available.
Spreading capacity: ¹ Extremes reported ²	30 to 80.....	30 to 100.....	No data.
Common ranges ²	35 to 55.....		30 to 40.
Working life.....	Few hours to several days.	Several hours to a few days.	Few hours to many days.
Consistency.....	Thick to medium.	Variable, thin to thick depending on formula.	Medium.
Rate of setting.....	Rapid.	Very rapid with heat; otherwise slower.	Very fast when hot pressed.
Strength ¹	Very high to medium.	Medium to low.	High.
Water resistance.....	Low to high.	Very high.	Very high.
Tendency to stain wood.....	Marked with some woods.	None, except that the dark glue may show through thin veneer.	None to very slight.
Dulling effect on tools ²	Moderate to pronounced.	Slight.	Moderate.

¹Expressed in square feet of single glue line per pound of dry glue for veneer work.

²Based on reports from commercial operators.

³Animal and casein glues are likely to deteriorate seriously if kept liquid more than 1 day.

⁴Based chiefly on joint strength tests.

⁵The water resistance of animal glues may be increased by chemical treatment.

⁶Glues made from vegetable proteins, such as soybean and peanut meal, resemble casein glues in general properties and characteristics.

for hot pressing, although the pressing temperatures are generally below those of the phenols. A few urea-resin adhesives are available that can be spread and pressed entirely at room temperatures. The urea-resin adhesives are characterized by a high degree of resistance to water at ordinary temperatures and to attack by micro-organisms. The synthetic-resin glues are slightly acid in reaction and there is little tendency to stain the wood.

Vegetable glues have found wide use because they are cheap, can be used cold, and remain in good working condition free from decomposition for many days. They are extremely viscous, and it is not practicable to spread them by hand. Their use is limited because they lack water resistance and usually cause staining in thin veneer. They set relatively slowly and for this reason are not extensively used for joint work. Vegetable glues have been studied and developed almost entirely by private initiative, and there has been much litigation over patent rights.

Blood-albumin glues have shown notably high resistance to moisture, especially in the boiling test. The chief drawback to their use has been the necessity for hot-pressing. A water-resistant blood glue may be made which can be cold-pressed, but its usefulness is limited by its low to moderate strength.

Liquid glues are similar in properties to animal glues. Some brands are equal in strength to good joint glues, but others are weak and unreliable. Their great advantage is that they come in prepared form, ready for immediate use, making them particularly suitable for patch work and small gluing jobs. Factors that limit their use are high price, lack of water resistance, and the difficulty in distinguishing between good and poor brands.

Generally speaking, phenolic-resin, vegetable, blood-albumin, and vegetable-protein glues are veneer glues, while animal, casein, and urea-resin glues are used for both veneer and joint work. As between animal and casein glue for joint work, if freedom from staining is important animal glue is preferable; if water resistance is of importance then a casein or a cold-setting, urea-resin glue should be selected. Because of the necessity of heat in the preparation and use of animal glue, the casein or the cold-setting, urea-resin glue will probably be favored if they are otherwise equally well adapted.