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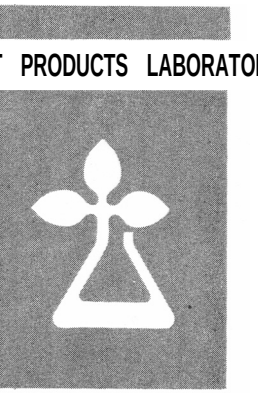

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ADHESIVES FOR BONDING WOOD TO METAL[1]

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During recent years considerable research and development work have been done on high-strength, durable adhesives for use in bonding metals. Much of this is also applicable for gluing wood to metal. The woodworking adhesives, such as animal, vegetable, casein, urea resin, phenol resin, and resorcinol resin, have not been found entirely suitable for this purpose. They usually are not elastic enough to distribute the stresses encountered in service when two dissimilar materials, such as wood and metal, are bonded together. Also, they generally do not adhere well to the surfaces of metals. Therefore, more elastic materials, such as vinyl resins and natural and synthetic rubbers, have been used in combination with such thermosetting resins as phenol-formaldehyde to produce adhesive formulations that have the proper elasticity and adhere well to both wood and metals.

A number of these adhesives are on the market. Many fabricators of wood parts have used them for combining wood and metal to utilize the best properties of both materials. In general, the results obtained have been good. Some fabricators, however, have been cautious about designing parts where wood-to-metal bonds are required, believing that the use of wood-metal adhesives is

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[1] This Note is a revision of Forest Products Laboratory Report TP-120, of the same title, revised in 1962.

difficult, or that the results obtained with these adhesives are often erratic. This short review describes briefly some of the types of wood–metal adhesive processes that are available.

Types of Wood–Metal Adhesives

A number of adhesives have been developed that are reported to be suitable for bonding wood to metal. They vary from types formulated for ease of use at room temperature, for quick setting under field conditions, and for low cost, to those formulated for use where highest strengths are required in the joint and where joints must be resistant to elevated temperatures, high humidities, salt sprays, and general outdoor service conditions. Generally, it has been impossible to incorporate all desirable properties in a single adhesive formulation, and thus each adhesive has its own distinct advantages and limitations.

Work on the bonding of metal to wood at the Forest Products Laboratory has been directed primarily to aircraft applications and has been conducted largely in cooperation with the armed services. For this reason, information available at this Laboratory involves mainly those adhesives that have been developed to produce high–strength durable joints. Consequently, this report is largely limited to this type of adhesive.

It is difficult to classify adhesives used for bonding wood to metal into the various chemical types, as has been done for the adhesives used in gluing wood to wood. The chemical composition of these wood–metal adhesives is more complex. Therefore, these high–strength metal–bonding adhesives have been broadly classified according to the curing temperatures and techniques by which they are used rather than by chemical types. At this time, the three main groups of wood–metal adhesives to be discussed are: (1) the direct–bonding, high–temperature–setting adhesives, '(2) the two step–bonding systems with both an adhesive primer and a secondary adhesive, and (3) the direct–bonding, room–temperature–setting adhesives.

Direct–Bonding, High–Temperature–Setting Processes (One–Stage Bonding)

A large group of the metal–bonding adhesives is included in the direct–bonding type that requires curing the bond under pressure at temperatures ranging from 250° to 350° F. Adhesives of this group are usually composed of at least two resins––one a thermoplastic resin or elastomer (such as polyvinyl

formal, ployvinyl butyral, polyvinyl acetate, a polyamide, or a synthetic rubber) and the other a thermosetting resin (such as phenol formaldehyde). These resins are combined in solvents in such proportions as will provide the necessary characteristics of adhesion to metal, elasticity, flow during cure, heat resistance, and durability of the resultant bonds. In some instances, the two resin ingredients may be applied separately. For example, a liquid resin may first be applied to the surfaces and then a powdered resin is sprinkled into the wet adhesive spread. In addition to the liquid adhesives for direct bonding to metals, a number of film or tape adhesives are now available.

In bonding wood to metal with the direct–bonding, high–temperature–setting adhesives, high stresses are developed as the bonds are cooled because of the different coefficients of thermal expansion of the two materials. Stresses are also developed when the wood expands as it regains moisture. These high stresses tend to distort the metal–wood construction and may even rupture the bond if the adhesive is not sufficiently elastic and strong. In hot pressing, blistering of the bonds can also occur. This blistering is caused by the tendency of the entrapped adhesive solvents to escape. This process does not produce stable, flat panels if metal is bonded to only one surface of the wood.

Two–Stage Bonding

To avoid the limitations of the direct–bonding, high–temperature–setting adhesive, as well as to avoid the need for hot–press equipment, a two–step adhesive process was developed. In this process a priming adhesive is applied to the metal in much the same way as a paint finish might be applied. Many of the high–temperature–setting, direct–bonding adhesives may be used as primers. The primer is cured on the metal without pressure at elevated temperatures in an oven, on the platens of a hot press, or under infrared heating. The cured primer is then bonded to the wood under pressure with room– or intermediate–temperature–setting urea–, resorcinol–, or phenol–resin adhesives of the woodworking type.

Room–Temperature Bonding Systems lone–Stage Bonding)

The third kind of metal–bonding adhesives includes those adhesives capable of forming direct bonds to metals at room temperatures. At the present stage of development, joints of metal to wood made with some of the available room–temperature–setting adhesives do not have the overall strength at room and

elevated temperatures, and after soaking in water and aircraft fluids, of those made with the hot–setting and two–step adhesives. The casein–rubber–latex adhesives have been used successfully at room temperatures for bonding wood to metal for those applications that are not so critically stressed as aircraft construction. However, these adhesives usually have the disadvantage of losing a large part of their strength when the bonds become wet or are exposed to high humidity.

There are a number of mastic and solvent–type adhesives for bonding wood to metal at room temperature. These are mainly rubber–base adhesives of which the neoprene–base "contact" cements are most prominent. These liquid adhesives are commonly applied to both the wood and metal surfaces to be joined and are then air dried or force dried under infrared or oven heating conditions to drive off most of the solvent. The two surfaces are then carefully assembled and pressed momentarily either by tapping or rolling. The nip–roll bonding presses are particularly useful here. These roll presses provide a rather high instantaneous pressure as the assembled panel passes through. The bond continues to develop further strength for several weeks at room temperature as residual solvent diffuses from the glueline. These contact cements develop a generally lower level of strength than do the one– and two–stage processes mentioned previously. This level may be adequate for many nonstructural joints, as €or metal faces on plywood. Their durability characteristics have not yet been adequately established.

The epoxy–resin adhesives, originally developed for metal–to–metal bonding, can be used for bonding wood to metal at room temperature. These are liquid resins, to which curing agents are added just before use. These adhesives typically are exothermic and have a short pot life but under the proper conditions can be used for bonding panels of reasonable size. These adhesives appear to produce joints, under the proper bonding conditions, that are as strong as the wood initially, Their water resistance and durability have not yet been adequately investigated in metal–to–wood joints.

General Comments

As in gluing wood to wood, the choice of the proper adhesive and the adequate control of gluing conditions are equally important to assure uniformly satisfactory joint quality. Since different adhesives for bonding wood to metal vary widely in their use conditions, it is difficult to generalize. The manufacturer's instructions should be followed closely for each adhesive. Of special importance is the preparation of the metal surfaces for bonding. This may vary from a simple degreasing and cleaning with organic solvents to rather elaborate chemical treatments, depending on the type of metal, type of adhesive, and the level of strength and durability required of the joint. More specific recommendations on metal preparation for bonding should be obtained from the adhesive manufacturer.