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IMPORTANCE OF BALANCED CONSTRUCTION IN PLASTIC-FACED WOOD PANELS[1]

By

B. G. HEEBINK, Engineer

Forest Products Laboratory, Forest Service
U.S. Department of Agriculture

Requests are frequently received at the Forest Products Laboratory for information on the warping of plastic-faced panels that have cores of plywood, particle board, hardboard, or paper honeycomb. The Laboratory is asked toexplain the causes of the warping and, if possible, to suggest measures to remedy the difficulty.

Examination of many of these panels, and the results of a few tests made over the past years, have led to the conclusion that perfect balance in constructions of this type is seldom obtained. Furthermore, limited observations made on decorative laminates and their so-called companion "balancing sheets" indicate that most cupping and bowing in panels occurs because of inadequate balance between the plastic surfacing sheet and the backing sheet, rather than because of the instability of the core material.

A core of plywood may twist occasionally because of misalinement of the grain in the plies of veneer.[2] Twisting will seldom if ever be a problem with panels consisting of plastic faces and backs on particle board or honeycomb cores.

Essentially, a balanced construction is one that will not be warped by the forces induced by uniformly distributed moisture changes. The principle holds good for all panel constructions from plywood itself to a plastic-faced wood table top.

The dimensional changes that may occur in theseplastic sheet materials are considerably greater than those of a thick plywood core; in addition, most of these plastic sheet materials (composed of parallel-laminated sheets of resin-impregnated paper) have a definite machine direction.[3]

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[1] This Note is a revision of a report by the same title, issued in 1960 as U.S. Forests Products Laboratory Report No, 2197,

[2] Brouse, Don. Some Causes of Warping in Plywood and Veneered Products. Forests Products Laboratory Report No. 1252. Reviewed and reaffirmed 1961.

[3] Heebink, B. G., and Haskell, H. H. Effect of Heat and Humidity on the Properties of High-pressure Laminates, Forest Products Journal XII (11): 542-548. (1962).

The machine direction of these sheets cannot be infallibly determined by assuming that it is parallel to the printed grain pattern, or parallel to the sanding scratches on the back of the sheet. Furthermore, on plain-pattern decorative laminates, or patterns such as linen, there is no direction indicated. The relative bending stiffness and tensile strength parallel and perpendicular to any edge of the sheet are good tests for determining machine direction. Tension tests are relatively time consuming, and require special equipment.

A simple bending test is less time consuming and requires no special equipment. Cut one strip parallel to the end and one strip parallel to the side of the sheet to be tested, each of exactly the same width (between 1/4 and 3/4 inch) and about 8 inches long. Support these two strips on the same fulcrums (such as two pencils laid on a desk top), with the same side up. Measure the distance between the center of the strip and the top of the desk. Now load each strip with an identical weight, sufficient to cause at least 1/8 inch deflection, and again measure the distance between the center of each strip and the desk top. The strip that deflects the least is the one parallel to the machine direction. This same test is equally applicable to backing sheets but the distance between fulcrums will have to be reduced because backing sheets are typically thinner than face sheets.

Figure 1 presents what appears, from limited data, to be typical unrestrained dimensional characteristics of some common sheet materials that are often glued together to form furniture panels. This shows that the unrestrained dimensional movement of decorative laminates and backing sheets associated with a rather large moisture change is roughly two to five times that of thick plywood, depending upon the machine direction of the plastic sheets.

Thick plywood, flat-pressed particle board, and hardboard sheets normally do not have noticeable machine direction. The use of a hardboard backing sheet, in combination with a decorative laminate face sheet (which has a definite machine direction) therefore can sometimes cause a saddle-shaped warp in the panel (concave in one direction and convex at 90°). A saddle-shaped warp can also result from having the machine direction of the decorative laminate face at right angles to that of the plastic backing sheet, and will certainly result if the machine directions of decorative laminates on opposite sides of a relatively thin core are crossed.

Naturally, the problem is not only one of considering unrestrained dimensional movement. It includes such factors as unequal stresses exerted by the materials on opposite sides of the panel (which might be brought about by unequal thicknesses of sheets with the same unrestrained dimensional change), unequal rates of moisture pickup of the face and back materials, and unequal rates of vapor transmission through the two surfacing materials, thus allowing water vapor to get into or out of the core more rapidly from one side than from the other.

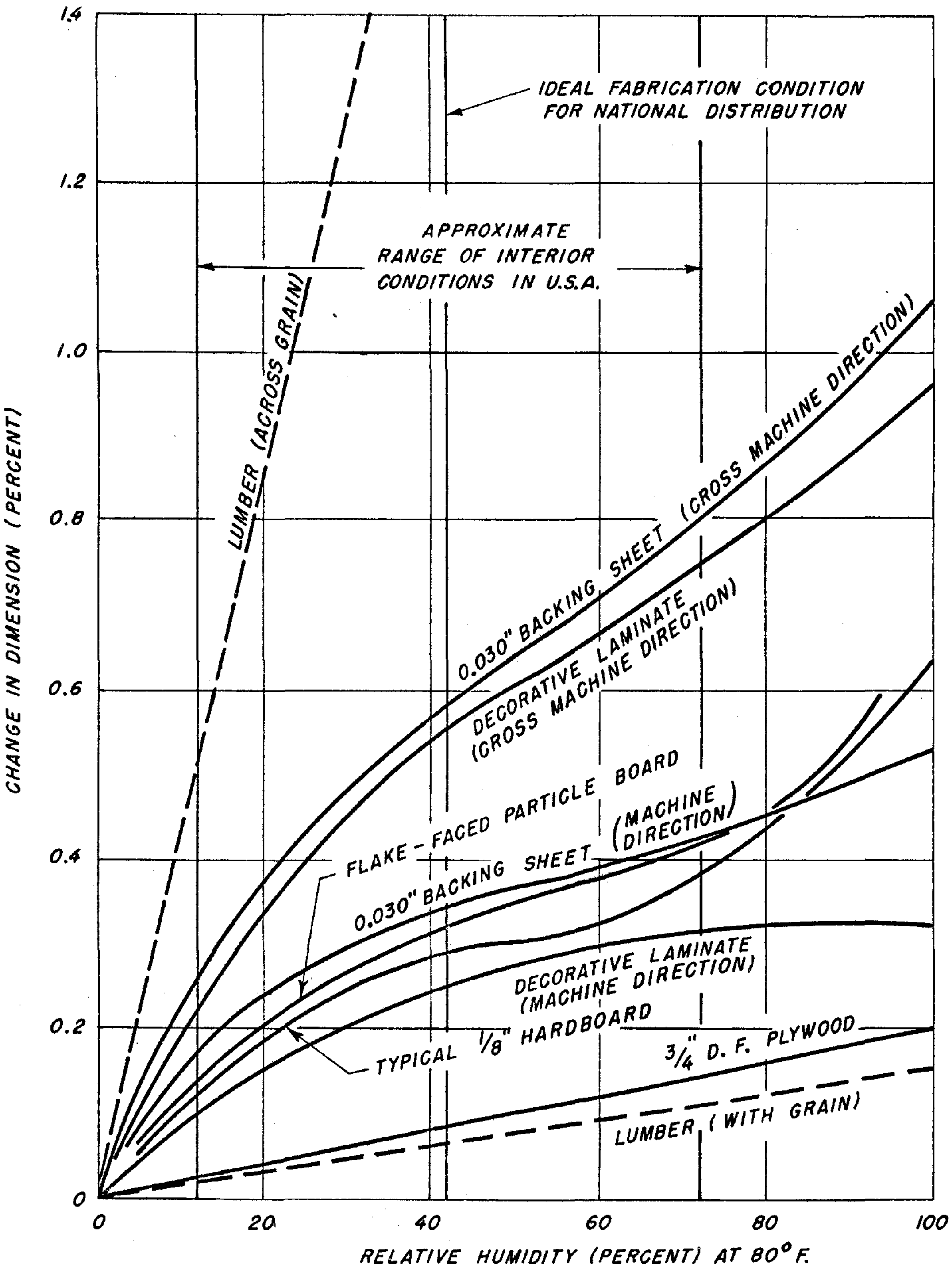

Figure 1. --Typical unrestrained dimensional characteristics of some common sheet materials.

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A practical cure for warping is difficult to recommend, especially since warping is particularly troublesome when the panels are relatively long and thin. Making the core twice as thick will theoretically reduce the warp to one-half, and may be a practical cure when using a relatively inexpensive core such as paper honeycomb. Using a stiffer core will also reduce the effect of unbalance. For example, plywood is normally stiffer than particle board of equal thickness, while paper honeycomb core has practically no stiffness.

One basic solution would be to obtain a suitable backing or balancing sheet of plastic from the supplier of the decorative laminate face. It should be similar to the decorative laminate in composition and machine directional properties, and of approximately the same thickness. This increases cost, but may well be worth it if rejections due to warp have been excessive.

As a second suggestion, the use of a somewhat elastic adhesive, such as some of the polyvinyl emulsion adhesives or the rubber-base contact cements, might be considered. For example, if a contact adhesive is used, it is possible to bond a decorative laminate on one side of 3/4-inch plywood, with no backing, and have it remain satisfactorily flat, if properly fastened down, for such applications as kitchen cabinet tops. If these tops are self-edged, however, there is likely to be a slight edge projection of the decorative laminate at certain times of the year.

One general recommendation, regardless of the materials that are used, is that all materials, before assembly of the panel, be brought to equilibrium in an atmosphere of about 40 to 45 percent relative humidity. This is exceedingly important, particularly for the facing materials and the balancing sheets. For example, if the c or e and backing material for a table top are in equilibrium at this relative humidity at the time of gluing, and the decorative laminate is considerably drier, the top will warp (convex on face side) when all of the materials come to their respective moisture contents in equilibrium with an atmosphere of 40 to 45 percent relative humidity.

Sometimes tops are glued with all of the component materials at the proper equilibrium moisture content, but are unbalanced in construction because the face material can exert or resist more stress than the backing. Then the tops seldom warp until the entire panel changes in moisture content, as during the first winter exposure in a northern climate. By this time the top is probably in the hands of the consumer and therefore, unless he registers a complaint through the proper channels, the manufacturer of the top may not be aware of the difficulty.

The U.S. Forest Products Laboratory has underway a broad, basic evaluation of the warping of panels of many types. When this work is completed, it will make available additional information, the use of which may predetermine the performance of composite panels of most combinations of faces, cores, and backs, if the conditions under which they are to be used are reasonably well known. Use of basic data (the unrestrained dimensional movement, modulus of elasticity, vapor transmission, rate of dimensional change with change in moisture content, and creep properties of adhesives) should make possible the design of tops with a known degree of unbalance; this known unbalance would be counter–acted by certain other factors, such as stiffness of the assembly, to make the construction suitable for the specific application.

In the meantime the importance of balanced construction cannot be overstressed, unless one is prepared to take a calculated risk on the results of offering unbalanced panels.

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