



Minimizing Warp in Laminated Particleboard and Medium Density Fiberboard

technical

BULLETIN

Introduction

Industrial grade particleboard (PB) and medium density fiberboard (MDF) are widely recognized as ideal substrates for laminated panel products. Their properties - smooth surface, uniform density and thickness, dimensional stability, strength, stiffness, flatness, screw holding strength, and machinability - contribute to the ease of fabrication and to the ultimate performance of laminated panel products such as table tops, countertops, kitchen cabinets, and stereo and television cabinets. These applications require laminated panels to remain flat.

Warp is defined as the "deviation of the geometry of a panel from an initial state of flatness." This document outlines some factors (balanced construction; material handling and storage; and proper laminating, fabricating, and installation techniques) that affect warp, and steps a laminator or fabricator can take to minimize it.

Two other useful documents are "CPA Standard Method for Measuring Warp in Particleboard and Medium Density Fiberboard," which describes the test method

used to measure warp, and "ASTM Test Method D-1037," which describes the test method used to measure moisture content.

Balanced Construction

One of the most common causes of warp in laminated panel products is unbalanced panel construction. As different materials are rigidly bonded together, moisture content changes may occur. In response to the changes in moisture content, the materials attempt to change dimensions. When that happens, stresses can accumulate. Warp results when these stresses become excessive and are no longer balanced on the two surfaces.

This imbalance may be caused by a number of factors, including selection of laminate, laminating environment, component conditioning, product design, installation, and application. Selection of laminates and balanced construction go hand-in-hand. The laminates and/or coatings applied to each side of a PB or MDF substrate should be similar in properties. Generally, this is best achieved by using the same material to cover both sides of a substrate.

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Unusually moist or dry conditions should be avoided in the laminating and storage environments. The moisture content of wood-based materials and laminates is dependent on the amount of moisture in the air. When these materials are moved from one environment to another, the moisture content changes. Resulting dimensional changes can be substantial.

Once assembled, differences in the expansion or shrinkage characteristics of the laminate and substrate can produce stresses which cause warped panels. Ideally, laminates and substrates should be stored and assembled in conditions similar to the finished product application environment.

It is unlikely that the moisture content of the laminate and the substrate will be in equilibrium with the laminating environment when they are delivered. Allow sufficient time for the laminate and the substrate to adapt to the laminating environment. It can take two or more weeks to reach a satisfactory equilibrium. Seasonal changes and air circulation around the materials will influence the time it takes.

Laminates at one equilibrium moisture content (EMC) condition should not be applied to PB/MDF of a different EMC condition. If they are, as the moisture content equalizes, the PB/MDF substrate may expand or contract while the laminate seeks the opposite. When bonded with rigid adhesives, the components cannot move in relation to each other. This creates stresses at the substrate/laminate interface which can result in a warped panel.

Service Environment

Even with a perfectly balanced panel, installation and application conditions can cause moisture unbalance that results in warp. The laminated panel should not be exposed to extreme variations in humidity during final installation. Changes in humidity at the installation site can result in stresses that cause warp as the entire panel equalizes to the new service environment.



Panel conditioning prior to final installation improves reliability.

The design of laminated panel applications must also consider the service environment. Applications that expose one surface of a panel to a warm humid atmosphere and the other to a dry atmosphere will result in moisture unbalance that can cause warp. Long expanses of panels, such as display cases or walls, may warp if they do not include expansion joints or other design considerations allowing for dimensional changes resulting from seasonal variations in the environment. Panels that are butted edge-to-edge and rigidly fastened may buckle (a form of restrained warping) due to expansion stresses as moisture content increases.

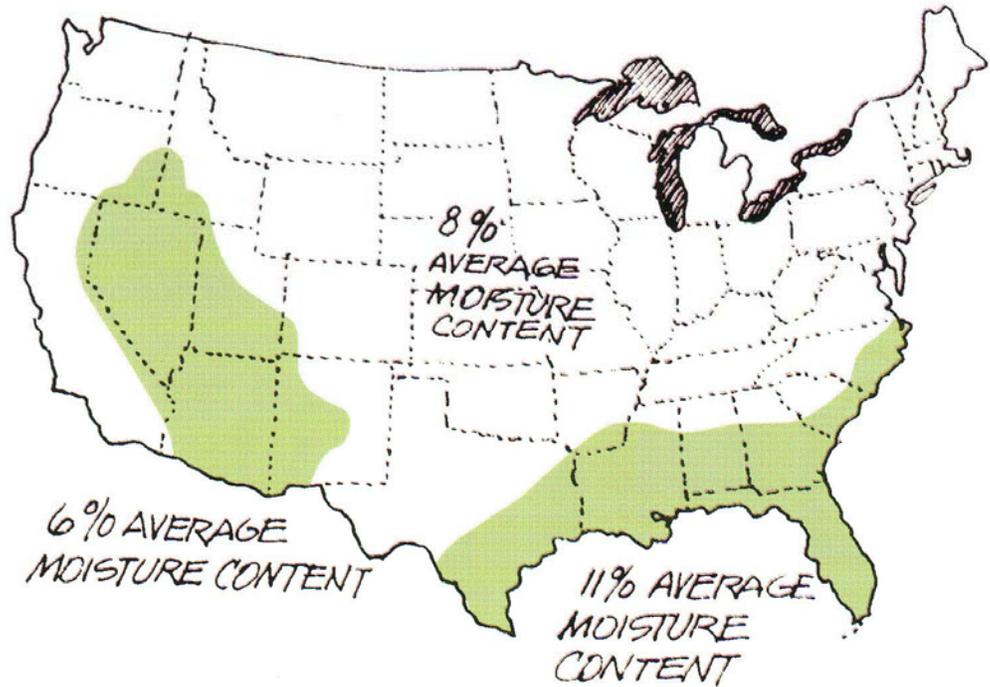
A balanced laminated panel is one that will not warp when subjected to forces induced by uniformly distributed moisture changes. Balanced panel construction and subsequent dimensional stability in service are best achieved when:

- The moisture content of the PB/MDF substrate and laminate materials are similar at the time of lamination.
- Materials with similar expansion/shrinkage coefficients are utilized.
- The moisture content of the finished product is similar to the moisture content to be encountered in service.

A well-balanced laminated panel can exhibit temporary warp due to unequal rates of moisture gain or loss by the face and back laminates. However, as soon as the laminates equalize, these stresses diminish, and the panel returns to its flat condition. This ability to equalize and return to the flat condition at any humidity is an important attribute of the balanced panel.

Substrates

Selection of PB/MDF for laminating applications should follow basic guidelines. Always select flat panels for substrates. Flatness indicates that the substrate is balanced and free of stress. Consider the substrate properties, including stiffness (MOE), thickness, linear expansion, and uniformity. These can be evaluated from the manufacturer's specifications or standards. The greater the MOE or thickness of the material, the better it will resist moisture related expansion stresses. Measure the panel moisture content and set guidelines of acceptability. Evaluate all of these properties with respect to laminates that will be applied.



Approximate equilibrium moisture content zones in the United States for wood-based products. Values may vary with local and seasonal conditions.

Storage and Handling

Rules for substrate and laminate handling and storage are generally the same. Materials should be stored flat and kept dry. For best performance:

1. Do not store materials outside or in locations where they may be exposed to water or high humidity.
2. Keep material off the floor, use bolsters of the same thickness, and allow adequate space between units.
3. Avoid storage conditions where extremes of temperature and humidity can occur.
4. Before final assembly, allow materials a satisfactory conditioning period to equalize.

Laminates

High-pressure laminates, resin-saturated papers, vinyl films, heat transfer foils, decorative papers, and wood veneers comprise types of overlay materials commonly

applied to PB/MDF substrates by the laminator.

High-Pressure Laminates (HPL)

High-pressure laminates consist of multiple layers of kraft paper saturated with phenolic resin, a decorative layer of paper saturated with melamine resin, and a very thin top sheet of paper heavily saturated with melamine resin. As does any wood-based product, HPLs expand and contract with changes in moisture content.

The HPL and the substrate materials should be brought to equilibrium at the same humidity and temperature before laminating. This conditioning period may be two weeks or even longer. If laminated panels are fabricated from materials conditioned at radically different humidities, warp will most likely occur when the finished panel comes to equilibrium with the surrounding environment.

The key factors for obtaining balanced HPL panels are:

1. Proper conditioning of component materials before laminating.

2. Selection of HPL faces and backer sheets with similar linear expansion, stiffness and thickness properties.
3. Lamination of HPL face and backer sheets with machine directions parallel.
4. Following the adhesive manufacturer's recommendations for storage, method of application, spread rates and end use.

In some applications, such as countertops, it may be appropriate to use a face laminate without a backer sheet. In these cases, using an elastic adhesive (for example, rubber-based contact cement) reduces the amount of stress transferred to the substrate by the face laminate and thereby reduces the tendency to warp. Attached countertop installations further reduce the tendency to warp by restraining residual stresses that may be transferred to the substrate.

Saturated Papers

Saturated papers, or low-pressure laminates (LPL), are preprinted or solid color decorative papers that have been saturated with either a melamine, a phenolic, or a polyester resin. LPLs, like HPLs, are wood-based products and will shrink and expand with changes in moisture content.

In addition to the key factors listed for the successful use of HPLs, the following should be kept in mind:

1. During assembly, load and close the press as quickly as possible. Use a cool caul on the bottom, when cauls are used for panel insertion.
2. Hot boards should be stacked flat and be well supported while cooling. Units with fewer pieces cool more evenly. Avoid cooling panels too rapidly. Cool panels uniformly on both sides.
3. Follow manufacturer's instructions for storing papers. Do not use papers that are overaged or dried out.
4. Be sure that press platen temperature and conditions are set to properly cure both sides

when using different papers.

5. Avoid degradation of the substrate when using phenolic papers with elevated press temperatures and extended press times. Proper cooling of the panels is critical.
6. The linear expansion properties of resin-saturated papers are often greater than that of particleboard and MDF under the same conditions.
7. Use as few press openings as possible: too many openings tend to increase precure by slowing closing time.

Wood Veneers

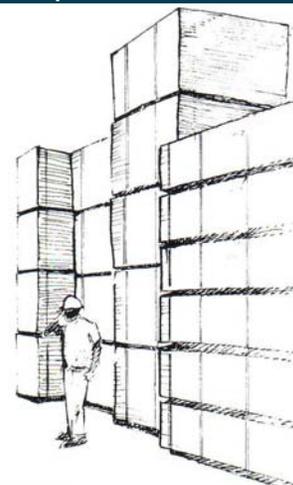
A major application of wood veneer is as a decorative laminate material over PB/MDF substrates. The general handling and storage requirements discussed previously also apply to veneer and PB / MDF combinations. In addition, the materials should be laminated with their moisture content in the 6-9 percent range. And, since balanced panel construction is essential to prevent warp, the same thickness and grade veneer should be used on both sides.

Different veneer species can be used, but they must have similar strength properties and dimensional behavior patterns. Problem areas, such as tension wood, burls, and knots, and their effect on stress must be specifically considered. Finally, the glue spread rate should be uniform.

Other Overlays

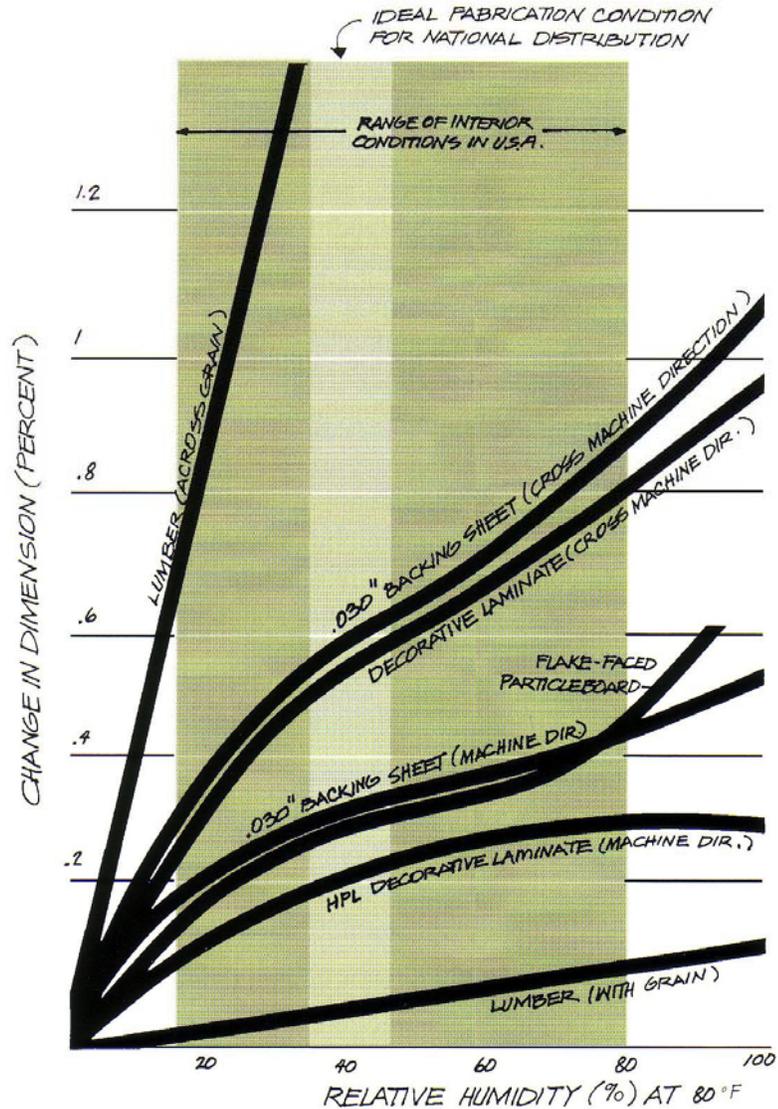
Vinyl films, low-basis-weight papers, and foils should all be applied using good balanced-lamination practices. Generally, the application of a film or paper to one side only, or different overlays on each side of a PB/MDF substrate will not result in warp. However, one-sided application of any laminate may act as a moisture barrier creating a transitory imbalance which can result in warp over time.

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TYPICAL DIMENSIONAL CHARACTERISTICS



Summary

An imbalance in moisture-related expansion or contraction frequently causes warping of laminated panels. Such an imbalance is activated by changes in moisture content. A change might be temporary, as in the case of wetting one side of a flat panel. The resulting "transient warping" is beyond the control of the laminated-panel manufacturer. In theory, "structural warp" resulting from a built-in imbalance can sometimes be prevented.

Balanced lamination is the key to consistently manufacturing flat panels. The

natural variability of the laminate and substrate properties is a common cause of warping, particularly in the case of a thin substrate with relatively thick laminate faces. Controlling the variability between the laminates can effectively reduce warp in laminated panels.

The concept of balance does not end with the manufacture of a balanced panel. The installation and the end-use environments can also be sources of moisture imbalance that create internal stresses resulting in warp. To ensure acceptable laminated product performance, design and engineering must consider the product application and environment.

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Composite Panel Association

The Composite Panel Association (CPA), founded in 1960, represents the North American composite panel industry on technical, regulatory, quality assurance and product acceptance issues. CPA General Members include 38 of the leading manufacturers of particleboard, medium density fiberboard and hardboard and other compatible products. Together they represent nearly 95% of the total manufacturing capacity throughout North America.

CPA also brings together the complete value chain affiliated with the composite panel industry. CPA's 200 members worldwide, primarily in the US and Canada, are committed to product advancement and industry competitiveness. Associate Members include manufacturers of furniture, cabinets, decorative surfaces and equipment as well as laminators and distributors.

CPA is a vital resource for both producers and users of industry products. As an accredited standards developer, CPA writes and publishes industry product standards. It also participates in the standards development work of ANSI, ASTM and others, sponsors product acceptance activities and works with federal and state agencies and model building code bodies. In addition, CPA conducts product testing and third-party certification programs, while helping manufacturers create in-plant quality control programs.

Outreach and education are also focal points of the CPA. The Association publishes industry performance data and conducts seminars to assist specifiers, manufacturers and other users of composite panels. CPA produces a series of technical bulletins and develops publications, videos, and other materials to inform key audiences about the attributes of industry products.