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Technical Bulletin

Dimensional Stability of **Particleboard and Medium Density Fiberboard (MDF)**

COMPOSITE PANEL ASSOCIATION

Introduction

Moisture is always present in wood or wood products. As moisture enters and leaves wood, the volume and properties of wood are changed accordingly. Since there is no guaranteed method for keeping moisture out of wood, appropriate design measures must be taken when building with wood products to ensure dimensional stability.

This Technical Bulletin is intended to explain the factors that contribute to dimensional change in wood products—with a primary focus on linear expansion, and secondarily with thickness swell—and balanced construction practices that **ensure dimensional stability.** Voluntary national consensus standards for particleboard (ANSI A208.1) and medium density fiberboard (MDF) (ANSI A208.2) provide performance criteria for linear expansion, thickness swell, and other properties.[1]

Balance of Moisture in Wood and Air

When wood is green, it is saturated with water in both the cell cavities and the cell walls.

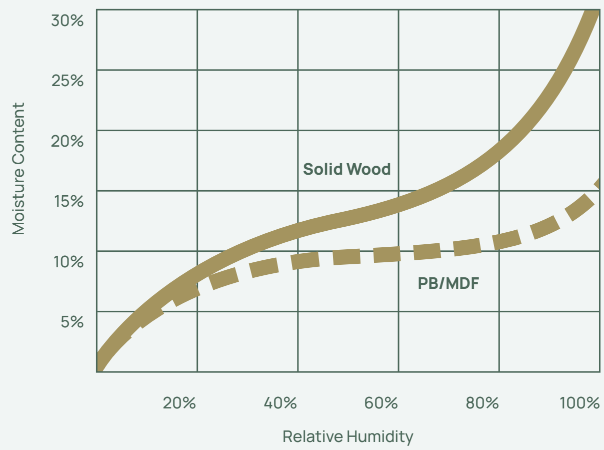
The water in the cell cavities is called “free water” and the water in the cell walls is called “bound water.” Normally, free water is removed completely during the drying process. Some bound water remains, however, and is in equilibrium with the relative humidity of the air.

Residing in the cell wall, bound water affects the wood’s bulk. As a general rule, wood swells and shrinks in proportion to the amount of bound water in the cell walls. Swelling does not occur above a limit known as the fiber saturation point (generally accepted to be 28% moisture content based on the oven dry weight of wood). Conversely, shrinking does not occur until the moisture content is below the fiber saturation point. This in turn affects the gross dimensions of the wood. For solid wood, swelling and shrinking is quite different in longitudinal vs. tangential or radial directions. These differences are significant and could result in practical problems.

As the relative humidity of the air changes, all wood products gain or lose water, including wood-based laminating materials like resin impregnated papers or high pressure laminates (HPL). **Expansion or contraction in wood products is directly related to moisture content changes. The degree of movement depends on the expansion/shrinkage coefficient of the product.**

All wood species more or less follow the curve shown in Figure 1. Particleboard (PB) and medium density fiberboard (MDF) follow a somewhat modified curve as indicated by the dashed line.

FIGURE 1



Unlike solid wood, particleboard and MDF exhibit swelling of the wood particles and fibers, as well as the tendency of collapsed wood cells (due to densification during the manufacturing process) to measurably swell and expand when exposed to high humidity or water. When particleboard or MDF swells and expands beyond its original dimensions due to exposure to high humidity, it is not reversible (i.e. not fully recovered upon re-drying to the initial equilibrium moisture content).

Thus, thickness swell and linear expansion in particleboard and MDF will be greater than those properties in solid wood. This can lead to practical problems where solid wood is attached to particleboard or MDF—for example, in solid edge banding of furniture panel cores.

How to Control Dimensional Changes

The following examples are some of the construction methods that can reduce dimensional change in particleboard and MDF products.

Cross-Lamination

One important method for reducing dimensional changes is cross lamination, a key characteristic of plywood, particleboard, and MDF products. Cross lamination is accomplished in plywood by alternating the grain direction of the veneer layers in the panel, or in the case of particleboard and MDF, by using randomly placed particles and fibers.

To see how cross lamination controls dimensional changes, let's use the example of a veneered lumber panel. When there is an increase in moisture, an edge-glued lumber panel freely expands. Edge gluing alone does not reduce the lateral expansion or shrinkage of the panel.

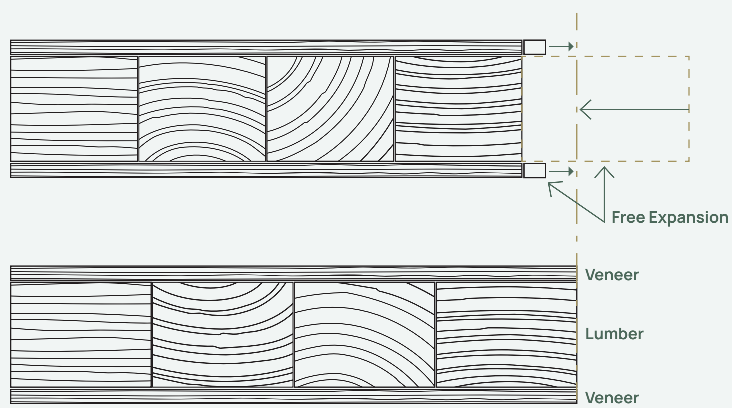
When restraining members such as cross veneers, are applied to both the top and the bottom panel prior to moisture gain, they act like steel straps nailed to the panel. They are strong enough to greatly reduce, if not totally eliminate, the expansion of the panel (see Figure 2). As the moisture content of the lumber panel increases, the restraining members will be stressed in tension, the lumber panel in compression. Although significant stress occurs, the panel will stay flat as long as the forces in the restraining members are exactly equal or balanced.

The problem with cross lamination is that sometimes it can be difficult to maintain balance. For exact balance, the two restraining members must be identical in:

- Thickness.
- Resistance to deformation, or the modulus of elasticity (MOE).
- Expansion characteristics.

FIGURE 2

Veneered Furniture Panel



Even minor imbalances in the characteristics of the restraining members can cause significant warping. The greater the potential expansion of the lumber panel, the greater the warp when a restraint is removed on one side.

How to Control Dimensional Changes

Alternating Grain Direction

Veneer layers can serve the same function as steel straps, except that they gain moisture and expand (see Figure 3).

By design, the veneer grain is arranged at 90 degrees relative to the grain of the lumber core, pairing the minimum expansion of the veneer along its grain with maximum expansion of the core across its grain. The veneer layers effectively restrain the lumber core because of:

- Very high resistance to stretching (MOE) of the veneer along the grain.
- Relatively low resistance to compression (also MOE) of the lumber core across the grain.

Balance is vital. If the top veneer was only half as thick as the bottom veneer, it would not restrain the core as effectively and the panel would warp concavely downwards (see Figure 3). Relative expansion and direction of stresses are reversed when considering the other principal direction of the panel, but the mechanism is the same.

Using Randomly Placed Particles or Fibers

Particleboard and MDF also benefit from cross lamination because of the random orientation of their elements. Expansion of the particles or fibers in the plane of the board is greatly reduced and is substantially the same in both directions. These properties make particleboard and MDF core materials with equal expansion characteristics in the machine direction and cross machine direction (see Figure 4).

FIGURE 3

Expansion of Veneered Panels

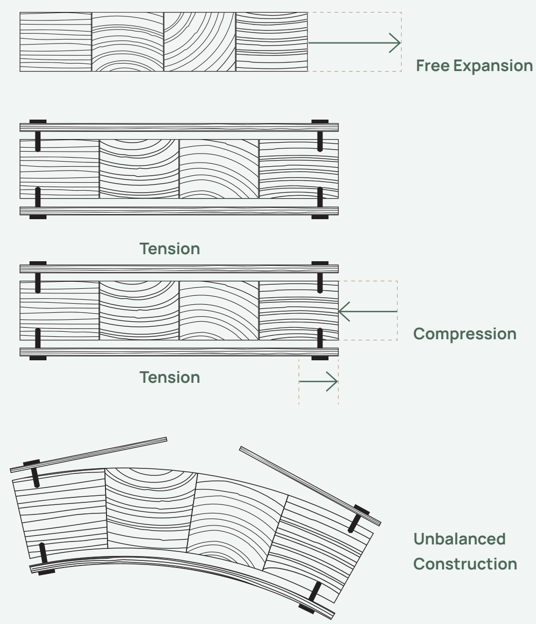
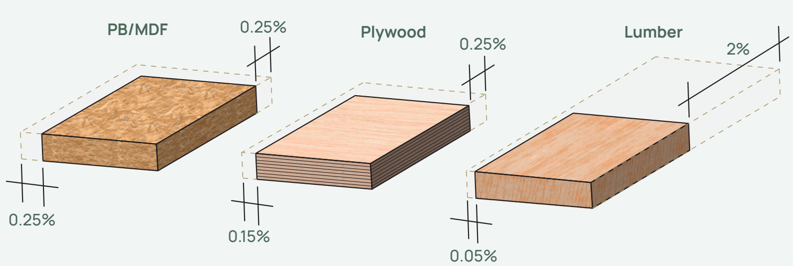


FIGURE 4

Expansion Comparison

Showing change in relative humidity from 40% to 85%.



How to Control Dimensional Changes

Additional Restraints

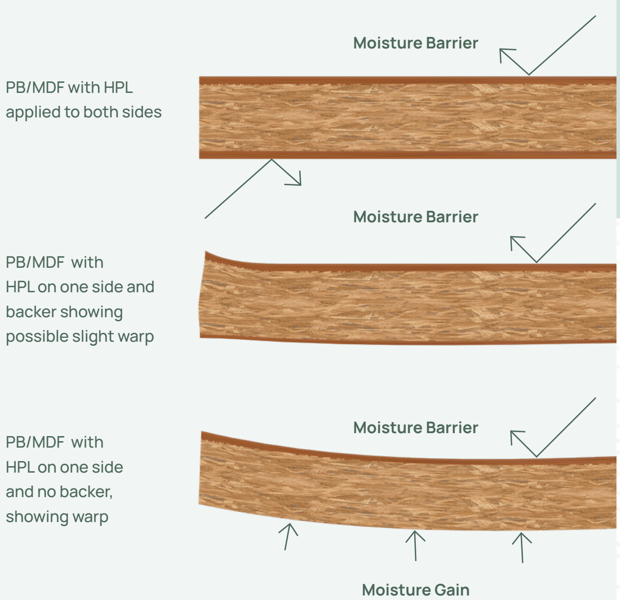
Laminating particleboard or MDF provides additional restraint, but allowances must be made for dimensional change, as potential for warping still exists. Consider particleboard or MDF overlaid with high pressure laminates (HPL), with and without backing (see Figure 5):

- Equal thickness of HPL on both sides provides maximum stability.
- Thinner backing cannot restrain the panel with the same force as the HPL, making it vulnerable.
- If the restraint is completely one-sided, it is equivalent to the snapped steel strap in the prior example.

Both unbalanced constructions would warp concavely toward the side with the thicker barrier upon moisture gain (see Figure 5).

FIGURE 5

PB/MDF Panel Construction Moisture Change Reaction



Backing Sheet

The lack of a backing sheet can also cause an imbalance. The top overlay could be a complete moisture barrier (like a vinyl overlay) or it could be a material which gains moisture at a much slower rate than the substrate. As relative humidity increases, moisture enters the particleboard or MDF from the back of the panel. A moisture content gradient develops and the back of the board swells more than the top, causing the panel to warp concavely upwards (see Figure 5). Eventually, the moisture content gradient disappears.

The panel may straighten out if the overlay applies no mechanical restraint, such as vinyl. Other more rigid one-sided overlays with expansion characteristics different from that of the substrate would still result in permanent warp.

Unbalanced, one-sided countertops can resist slight warpage pressures when mechanically fastened to base cabinets. However, warp resistance depends on cabinet construction to dissipate stress. Don't forget that backer sheets also offer resistance from splashes, spills and drips.

These examples all deal with expansion due to moisture gain. If loss of moisture occurs, panel warp may result, but in the opposite direction.

Conclusion: Balanced Construction is Key

The most certain way to minimize the degree of warp is to use balanced construction practices. Consider the moisture-related expansion and shrinkage characteristics of wood products during design and construction to help eliminate these and other potential moisture-related concerns.

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[1] *ANSI standards are available from the Composite Panel Association website www.compositepanel.org*

About CPA

The Composite Panel Association (CPA), founded in 1960, represents the North American wood-based composite panel and decorative surfacing industries on technical, public policy, quality assurance, and product acceptance issues. CPA General Members include the leading manufacturers of particleboard, medium density fiberboard (MDF), engineered wood siding, and trim and hardboard in North America, representing more than 90% of industry manufacturing capacity. CPA Associate Members include manufacturers of decorative surfaces, furniture, cabinets, mouldings, doors, and equipment, along with laminators, distributors, industry media, and adhesive suppliers committed to product advancement and industry competitiveness. CPA is a vital resource for specifiers, manufacturers, and users of industry products. The association provides leadership on federal, state, and provincial regulatory and legislative matters of interest to industry. As an internationally recognized and accredited standards developer, CPA writes, publishes, and maintains the industry's definitive ANSI product standards. CPA also operates the International Testing Center (ITC) and manages the Grademark Certification Program, the largest and most stringent testing and certification program of its kind for North American composite panel products. CPA developed the Eco-Certified Composite (ECC) Sustainability Standard and Certification Program, a voluntary industry standard for composite wood panels and finished products made with particleboard, MDF, hardboard, and engineered wood siding and trim.

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