

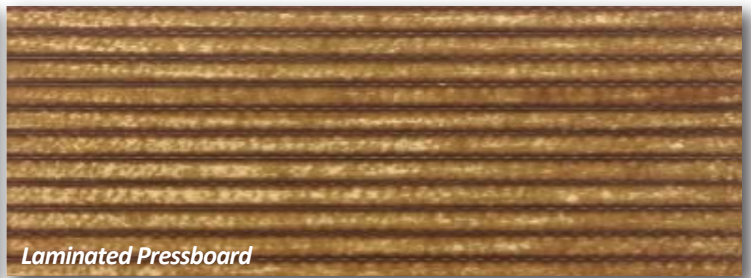


THE GUND COMPANY

TOP 5 ADVANTAGES OF LAMINATED WOOD VS. LAMINATED PRESSBOARD



Laminated Wood



Laminated Pressboard

Ranprex® laminated wood and laminated pressboard are cellulosic insulation boards used in the oil-immersed power & distribution transformer industry. The components manufactured from these materials have dual functions; provide electrical insulation and mechanical functionality. Both laminated wood and pressboard can be used interchangeably in many transformer applications such as coil supports, rings, and lead rails. However, there are many times when laminated wood has an advantage over laminated pressboard. This bulletin describes the five main benefits of laminated wood over pressboard.

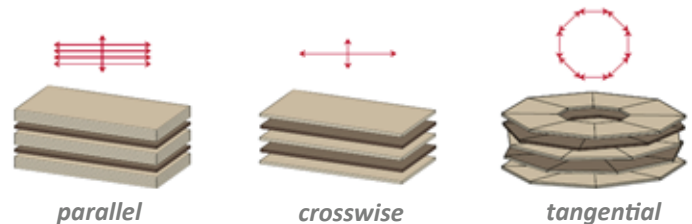
The top five advantages are:

- Mechanical Properties
- Density
- Fast Dry Out
- Lower Cost
- Oil Absorption

Mechanical Properties

Laminated wood is available with the grain of the veneers arranged in three different ways or construction style; parallel (P), crosswise (C), and tangential (T). The three arrangements allow for optimizing the mechanical properties such as flexural strength, modulus of elasticity, compressive strength, and tensile strength for each construction

style. For example, P2R parallel grade provides higher flexural strength in the length direction, making it ideal for lead structure. C2R has a balanced construction in the X and Y planes and is suitable for support blocks and small to medium-sized clamping rings. Tangential grades are specifically designed to provide uniform properties in a ring format for larger tangential rings.



Density

Laminated wood is available in four densities, while laminated pressboard is only commercially available in one density. The four densities for laminated wood; ultra-low, low, medium, and high, provide a unique range of properties and allow flexibility in design. Ultra-low density (P1R, C1R) grade is used for tooling and/or temporary fixtures. Low density (P2R, C2R, T2R) is the most common grade used in the manufacturing of many common transformer components.

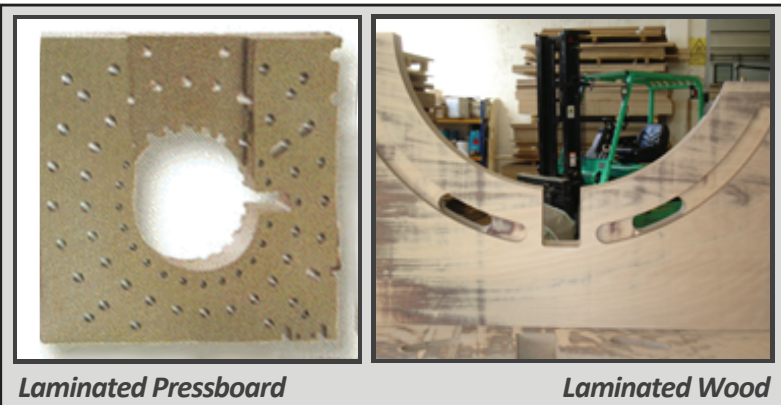
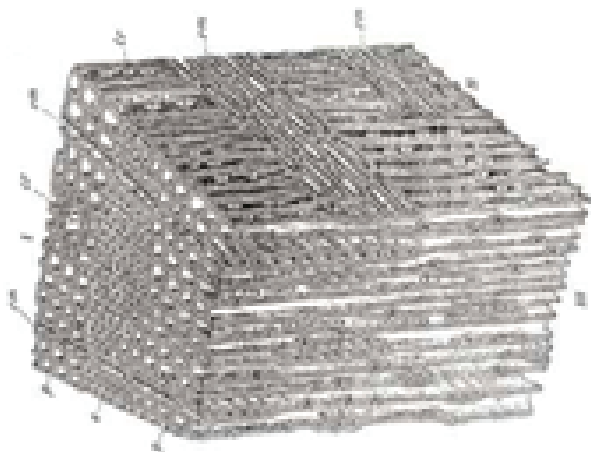
Medium-density (P4R, C4R, T4R) is used to manufacture parts for applications that require higher mechanical strength. Lastly, the high density (PFWV202) is used to manufacture components for extremely high mechanical strength applications but is typically not used in a transformer due to low oil absorption.

Ultra Low Density	IEC – P1R, C1R	0.7-0.9 g/cm3
Low Density	IEC – P2R, C2R, T2R	0.9-1.1 g/cm3
Medium Density	IEC – P4R, C4R, T4R	1.2-1.3 g/cm3
High Density	IEC – PFWV202	1.3-1.4 g/cm3

Since low-density P2R and C2R are the most common grades used for transformer components, many of the additional advantages derived hereafter are based on comparing these grades versus laminated pressboard.

Fast Dry Out

The ability to dry out quickly has a huge cost savings benefit in two ways. First, the laminated wood's veneers' fibers allow for easy removal of moisture from the material in all directions. The fast removal of moisture reduces cycle times and heating costs. On the contrary, laminated pressboard's layer arrangement mostly removes moisture parallel to the adhesive layers, impeding the removal in the transversal direction. For this reason, laminated pressboard must be opened, drilling holes perpendicular to the lamination to shorten the path for moisture to escape the board. Not only does this step create extra machining cost, but it also reduces the mechanical properties of the laminated pressboard.



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Lower Cost

As mentioned previously, low-density laminated wood at 1.0 g/cc is 25% lighter than laminated pressboard at 1.25 g/cc. When considering two parts of similar size, the savings would essentially be 25% on a weight basis. Likewise, laminated wood overall is less expensive than laminated pressboard based on kg or lb pricing.

Oil Absorption

Similar to the moisture dry-out advantage, laminated wood also provides a better oil impregnation rate due to the arrangement of the veneer's fibers. Oil absorption in laminated pressboard cannot pass through the adhesive layers making the only path parallel to the layers. Again, there is a saving in processing times due to faster oil absorption and shorter vapor phase cycles. Secondly, with improved vapor phase processing, partial discharge can be less problematic with laminated wood.