Technical Bulletin

VOC Emission Barrier Effects of Laminates, Overlays and Coatings for Particleboard, Medium Density Fiberboard (MDF) and Hardboard

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COMPOSITE PANEL ASSOCIATION

Introduction

The Role of Laminates and Coatings as VOC Emission Barriers in Composite Wood Panels

Packaging

A principal goal for designers and architects is to enhance the aesthetic and functional qualities of the products they use and specify. Concerns about indoor air quality in homes and offices have added another laudable goal: to reduce volatile organic compound (VOC) emissions.

Composite wood panels are a family of wood products that have expanded the design and performance envelope while offering substantial cost savings over alternative products, particularly when combined with decorative surface finishes. In addition to the significant increase in design flexibility, many of the laminate and coating options available to designers today reduce VOC emissions dramatically.

This technical bulletin addresses the different surfacing options used with composite wood panels with a focus on their capabilities as emission barriers.

Finished Composite Panel Components

The three major components of finished composite panel products - including particleboard, medium density fiberboard (MDF) and hardboard - are wood fiber, adhesive binder, and surface finish.

Primary Wood-Base Component

The foundation for particleboard, MDF and hardboard are wood particles and fiber. These raw materials are generally by-products of other woodworking operations (lumber shavings, sawdust, trimmings, etc.), and are often called residual wood or residues. In recent years, post consumer or urban wood has become an important resource. Wood fiber from all these sources that was previously landfilled or burned has now become a valuable and useful product ingredient in the manufacture of composite wood products.

Essential Adhesive Product Component

Nearly equal in importance to wood fiber is the adhesive used to bond the wood fiber or particles. Because of their versatility, relatively low cost, and outstanding ability as adhesives for interior applications, urea-formaldehyde (UF) adhesives contributed to the rapid worldwide growth of both the particleboard and MDF industries during the last half of the 20th century. UFs have been improved in recent years and remain the most widely used adhesives for manufacturing composite wood products around the world.

Important Finish Component

Finished composite wood panels are the principal components of household and office furniture, kitchen and bath cabinetry, millwork and fixtures. These products consist of a core material such as particleboard, MDF, or hardboard that is finished or laminated to achieve the desired aesthetic and functional properties. Designers should select a surfacing option that meets functional and aesthetic requirements, and acts as an effective emission barrier. Additionally, designers can specify a core material certified to meet low emission standards. The Composite Panel Association certifies both particleboard and MDF to low emission ANSI standards for those products.

Formaldehyde, VOCs and Indoor Air

Many familiar odors in everyday life are actually volatile organic compounds (VOCs). They include the smell of baking bread, flowers and perfumes as well as decomposing vegetables and skunks. VOCs, including formaldehyde, are also naturally emitted from wood. VOCs comprise thousands of compounds, many of which may be at higher concentrations indoors than outdoors. Well-designed scientific experiments can help determine what VOCs are present and if the

concentrations exceed levels that may affect health or comfort. However, measuring and understanding VOCs presents some important challenges because of multiple definitions for VOCs, the lack of a standardized test methodology, and the absence of a uniform procedure for calculating VOCs.

The VOC formaldehyde is a simple hydrocarbon (HCHO) that is produced by plants, animals and humans during normal metabolic processes. Most people produce 1 1/2 ounces daily. It is also a by-product of combustion and is a commonly used compound in many practical applications, for example in adhesives, paints, and personal hygiene products. Its use has been prevalent in a variety of industrial products for 100 years. Because of its widespread application in adhesives, it is found in many building products such as particleboard and MDF. The long-standing knowledge of this VOC has led to the development of testing procedures for assessing formaldehyde product emissions, which has contributed to the significant reduction of formaldehyde emissions from particleboard and MDF of 80% or greater since the late 1970s and early 1980s.

Emission Standards and the Importance of Finishes

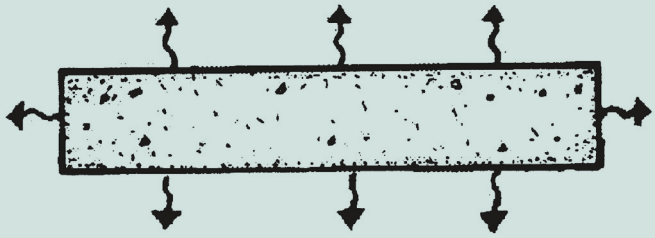
American National Standards Institute (ANSI) A208.1 (Particleboard) and A208.2 (MDF) are the North American industry standards for physical properties and formaldehyde emissions. There are no ANSI standards for other VOC emissions from either product, whether unfinished or finished. Neither do the ANSI product emission standards address characteristics of finishes and laminates, in part due to the continually increasing variety of finishes available. There are, however, increasing numbers of governmental and non-governmental organizations, and commercial purchasing specifications that limit both formaldehyde and VOC emissions from finished products such as office and household furniture.

The importance of finishes and laminates in acting as barriers to limit formaldehyde emissions from unfinished products is widely recognized. For example, in the German E1 guidelines, uncoated wood panels must not exceed a specific formaldehyde limit when the product is evaluated in a Large Test Chamber. However, when unfinished composite wood panels are destined to be finished with a very specific list of coatings or laminates, the substrate can meet a substantially higher emission limit. All of the laminates and finishes recognized as effective barriers in the German guidelines are also discussed as barriers in this bulletin.

Mechanisms and Factors of Barriers

The effectiveness of an emission barrier is determined by its basic permeability or porosity. Other factors affecting a barrier's effectiveness include holes, cuts and the integrity of the laminate or coating (see diagram).

UNBOUND VOCS ESCAPE THROUGH THE SURFACE OF THE RAW BOARD DURING THE AGING PROCESS



LAMINATES OR SURFACE COATINGS RESTRICT VOC EMISSIONS

Emission barriers work by retarding the evaporation and diffusion rates of VOCs. Evaporation and diffusion are believed to be the primary release mechanisms for VOCs that are not chemically bound in the panel, such as solvents, adhesive residues, and natural VOCs. For chemically bound VOCs the mechanisms and factors are complex and can involve sorption, mechanical/chemical/physical processes, and decomposition related to hydrolysis or heat, oxidation and chain breakdown resulting in smaller and more volatile molecules.

It is generally well known that formaldehyde and other VOC emissions from uncoated or unlaminated products are dependent upon product properties, indoor temperature and relative humidity. Actual concentrations of VOCs in indoor air, however, are functions of source loading ratio, air exchange rate and finished product emission rates, among others.

The decrease in VOC emissions from wood composite panel products over time is called "decay." Published literature shows that the average half-life of formaldehyde decay from newly manufactured unfinished products, for example, is about 7 months. Available data indicate that the same general principles probably apply to at least some, if not many other VOCs.

Surfacing Materials

Applying barriers, which consist of coatings or laminates, on panel surfaces is one of the approaches used to inhibit the release of VOCs from particleboard and MDF products. Effective barriers can reduce emissions by up to 95%.

Thick and Thin Laminates

Laminates are generally very effective as barriers to emissions, thick laminates generally being more effective than thin laminates. Thick laminates can be either rigid or flexible and include the following materials:

- High pressure laminates (HPL)
- Phenolic impregnated backer sheets (20 mils+)
- Vinyls (6 mils+)

When properly applied, thin laminates can be effective barriers. Thin laminates include:

- Low pressure laminates (LPL)/Resin saturated papers
- Thin vinyls (2-5 mils)
- Low basis weight papers
- Foils

Coatings

It is not the intention of this technical bulletin to give comprehensive information on coatings as emission barriers. When properly applied, however, coatings of adequate thickness can be effective barriers. Emission barrier effectiveness of coatings may vary due to application; the type of coating; environmental factors such as indoor relative humidity and temperature; and substrate characteristics. As well, cured coatings must exhibit sufficient flexibility to retain integrity of the surface during dimensional changes related to normal humidity cycling.

Liquid applied coatings emit various VOCs and some can emit formaldehyde. It should be noted that concentrations are greater immediately following application. Emissions from coatings generally reach very low levels in a few hours or days and can be less than 5% of the initial level in a few days or weeks.

Two thin coats are generally much more effective as an emission barrier than one thick coat and often provide a more aesthetically pleasing surface. High porosity areas on the surface of composite wood panels can absorb enough of the initial coating to cause breaks in the initial film. Subsequent coats can mask and repair these breaks, reducing or eliminating diffusion through the coating barrier and improving its effectiveness.

The use of an integrated coating system for reducing emissions in composite wood panel products has achieved some success in arriving at functional properties while reducing emissions. For example, a system of polyurethane or alkyd as a base coat minimizes grain raise and provides an emission barrier. When combined with a compatible latex topcoat, the VOC release potential of the coating system is further reduced.

Liquid coatings applied in factory settings are more effective than on-site finishing in the control of emissions because hoods and air currents typically carry finishing solvents and other curing finish residues away. When the factory-coated product is installed, the finish is essentially cured and most VOC emissions have already been released. On site finishing usually depends on air-drying under uncontrolled conditions that can result in greater emission exposures and increased coating variability.

Powder coatings are a relatively recent addition to factory wood product finishing options. Powder coatings are applied as electrostatic solids and have demonstrated their efficacy as a formaldehyde emission barrier. As the use of these and other new coating systems are commercialized, emission barrier information on other VOCs will be evaluated for addition to this technical bulletin.

Wood Veneers

Veneers have been shown to be effective barriers for some VOCs but only low to moderately effective for formaldehyde. Non-porous woods such as maple and birch are more effective diffusion barriers than porous woods such as ash and oak. Low permeability, high solids coatings applied to veneers on standard wood composite substrates have the potential for very low emissions of both formaldehyde and other VOCs.

Wood veneers are frequently applied to particleboard and MDF using UF adhesives. These veneer adhesives create the potential for another source of emissions and must be considered when evaluating the overall VOC and formaldehyde emission potential from such a system.

Emission Barrier Performance

Materials or combinations of materials are listed in Table A under barrier effectiveness categories for formaldehyde. Their evaluations are based on laboratory studies and industry experience. Category placement can be influenced by the nature of the specific wood composite product to which they are applied; the thickness of the laminate, film or coating; the type of impregnating resin if applicable; the indoor environment; and other factors. Due to these factors, comparative technical data demonstrating the effectiveness of the finish is essential. Small-scale laboratory testing, such as ASTM's Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions From Indoor Materials/ Products, ASTM D5116-97, can be used to quantify the effectiveness of the system in reducing formaldehyde emission potential from the specific product of interest. Emission barrier information on other VOCs for the various decorative surface finishes will be evaluated for addition to this technical bulletin as they become available.

FORMALDEHYDE EMISSION BARRIER EFFECTIVENESS CATEGORIES		
EFFECTIVENESS	**MATERIAL DESIGNATION**	**TYPE**
Range - 80 thru 95+ %	Acrylate, UV cured	Coating
	Acrylic, electronic cured	Coating
	Alcohol sealer	Coating
	Alkyd	Coating
	Alkyd and latex	Coating
	High pressure laminates	Thick Laminate
	Thermally Fused Laminate (TFL)	Thin Laminate
	Phenol backer sheets	Thick Laminate
	Polyester low pressure laminates (Polyester saturated paper)	Thin Laminate
	Polyurethane, two component (water-based)	Coating
	Polyvinyl acetate	Coating
	Powder Coatings	Coating
	Vinyl laminates	Thin Laminate
Range - 70 thru 90+ %	Alkyd primer sealer	Coating
	Polyurethane	Coating
	Vinyl coated papers	Thin Laminate
Range - Above 50 %	Polyethylene films	Thin Laminate
	Foils	Thin Laminate
Laminates that can achieve 80% and greater effectiveness when used in combination with coatings	Paper laminates	Thin Laminate
	Paper, low basis weight	Thin Laminate
	Veneers	Wood Veneer
Materials that are effective in reducing emissions of VOCs or are low in VOC content *(see note below)	High pressure laminates	Thick Laminate
	High solids liquid coatings	Coating
	Thermally Fused Laminate (TFL)	Thin Laminate
	Vinyl, certain films	Thick/Thin Laminate
	Veneers	Wood Veneer

**There is limited information on the effectiveness of certain emission barriers. Those listed include barriers for which there is technical documentation of their effectiveness. This does not necessarily mean that non-listed types are not effective emission barriers.*

Glossary

BACKER SHEET: A layer of Kraft paper impregnated with phenolic or other resins, generally 1/50 inch and thicker.

COATING: A liquid finish generally applied by secondary or tertiary manufacturers or at the end-use site. Liquid applied finishes are described by the major defining chemical ingredient.

FOIL *(sometimes referred to as decorative or finished foil)*: Cellulose paper composite that ranges in weight from approximately 40 to 200 grams per square meter. Foils may be impregnated with melamine resins.

HIGH PRESSURE LAMINATE *(HPL)*: Decorative rigid sheet up to 3/8 inch in thickness consisting of paper, fabrics or other materials formed at pressures between 1,000 and 1,400 psi. HPLs can be smooth or embossed and made in a multitude of solid colors and printed patterns.

LOW BASIS WEIGHT PAPER (*sometimes referred to as micro-paper or rice-paper)*: A sheet that ranges in weight from approximately 23 to 35 grams per square meter, can be impregnated with resins, printed and generally coated with polyurethane, polyester, acrylic, melamine or other resins.

LOW PRESSURE LAMINATE *(sometimes referred to as saturated paper or TFL)*: Decorative paper composite similar to a high pressure laminate that generally ranges in weight from approximately 60 to 130 grams per square meter. Low pressure laminates are usually saturated with melamine or polyester resins and pressed at 175 to 400 psi.

VINYL: A laminate or film made of polyvinyl chloride (PVC). Vinyl can be clear or a solid color, and can be provided with a print design or pattern.

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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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