

PARTICLEBOARD AND MEDIUM-DENSITY FIBERBOARD

Since U.S. production of particleboard began after World War II, this practical and inexpensive alternative to solid wood has become one of the nation's leading building materials. The floor you walk on, your workstation at the office, your household cabinets, and the walls and doors of your home may well contain particleboard (PB) or medium-density fiberboard (MDF), a similar product whose manufacture began in the United States in the mid-1960s.

Production and use of PB and MDF have grown dramatically in the past decade, replacing more and more solid wood lumber and plywood products. In fact, the combined production of PB and MDF in North America during 1999 was approximately 10.7 million cubic meters (over 12 billion square feet of $\frac{3}{8}$ -inch thick panel).

Though easy to produce and well-suited for a host of uses, most PB and MDF, as currently manufactured, use formaldehyde-based resins, which emit formaldehyde gas from factories, into the workplace, and into the home. Formaldehyde is considered a probable human carcinogen, and inhalation of even small amounts of the gas can increase risks of cancer. Some manufacturers are now turning to more benign resins to bind the wood products.

Meanwhile, though PB and MDF are currently manufactured primarily from wood residues from production of lumber and plywood, there is the opportunity to utilize post-consumer waste wood and



waste paper and agricultural residues as raw materials. Use of these materials can divert wastes from landfilling or burning. These alternative materials include straw residue, which is the stem of a grain crop, such as rice or wheat, and

bagasse, the residue from sugar cane processing. The amount of agricultural waste fiber far exceeds present and future fiber requirements for production of PB and MDF. Most residual straw and bagasse is now burned, which contributes to air pollution and global warming.

From an environmental standpoint it is also important to

make sure that the recycled content of wood-fiber-based PB and MDF is as high as possible and that little, if any, virgin wood is used. Recycled content saves trees.

This report evaluates various methods of producing PB and MDF and the associated environmental and health impacts. It also makes recommendations that will inform consumers and guide them to environmentally preferable—and safer—PB and MDF products.

PB and MDF: Hard-Pressed and Bonded for Life

Particleboard (PB) is a panel product made of sawdust and wood shavings bonded together by urea formaldehyde or other synthetic resin and pressed into sheets. Used primarily as core material for doors, furniture, and cabinets, particleboard often is covered on one or both sides with

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WHAT'S WHAT: SOME KEY DEFINITIONS

Post-consumer Materials: Materials or finished products that have served their intended use, been diverted or recovered from waste destined for disposal, and formed into useful consumer items. Post-consumer materials are part of the broader category of *recovered materials*.

Pre-consumer Materials: Materials generated by manufacturing and converting processes, such as manufacturing scrap and trimmings/cuttings. Also called post-industrial materials.

Recovered Materials: Waste materials and byproducts that have been recovered or diverted from solid-waste streams; this category does not include materials and byproducts generated from, and commonly reused within, an original manufacturing process.

Resin: The chemical material that binds the fibers together to produce particleboard or medium density fiberboard. Also called "binder."

veneer or another surface finish. In housing construction, particleboard is used under carpet or other finished surfaces as floor underlayment and stair treads; it is also used as floor decking in mobile homes.

Medium-density fiberboard (MDF), a composite board made of wood fibers bonded with urea formaldehyde or other synthetic resin, has a smooth surface and good machinability. MDF is used as a replacement for wood boards in furniture, cabinets, moldings, and picture frames. Like PB, the wood residues used to manufacture MDF come from sawdust and shavings from lumber and plywood manufacturing processes.

The manufacture of PB in the United States began on a large scale after World War II as a low-cost replacement for lumber and plywood in furniture and cabinetry. Some twenty years later, in 1966, the first North American MDF plant began production in New York. Demand for PB and MDF has grown dramatically in the past decade, replacing more and more solid wood lumber and plywood products.

While demand for PB and MDF is increasing, there are concerns that the availability of wood residues is not keeping pace with this demand and that the price is increasing. This has led some producers to look toward alternative sources of fiber, such as agricultural waste products and wood and paper waste. Aside from any economic advantage, these alternatives also present environmental benefits such as diversion of waste from landfills or burning.



If These Walls Could Talk

Environmental Impacts of PB and MDF

A portion of the trees cut for lumber and plywood production become sawdust and trimmings that are used in PB and MDF. If trees are harvested for direct use in these products, then the impacts from growing and harvesting these trees must be considered as part of the environmental profile of PB and MDF. Information obtained from industry sources shows that approximately 25% of the production capacity in the U.S. and Canada uses some virgin wood in their products, ranging from 1 to 80% virgin content, averaging 34%.

The wood residues are either ground into particles (for PB) or steam heated to break down the residues into fibers (for MDF), then dried to lower moisture content. Many dryers are directly heated by combustion of a portion of the wood residues; others are heated by burning oil or natural gas. Dryers release wood dust, carbon monoxide, carbon dioxide, nitrogen oxides, fly ash, volatile organic compounds—such as terpenes, resin, and fatty acids—that evaporate from the wood, and combustion and pyrolysis products, such as methanol, acetic acid, ethanol, formaldehyde, and furfural.

After the fiber is dried, it is blended with wax, a synthetic resin such as urea formaldehyde, and other additives and formed into mats. The mats are processed in large presses that use heat and pressure to cure the resin and form the product into sheets or boards. Presses are usually heated by steam, which is generated by a boiler that burns wood residues.

The type of resin used to bind the wood fibers determines the type of air emissions released during the pressing process; typically these emissions include formaldehyde compounds, such as urea formaldehyde. Primary finishing steps for PB and MDF include cooling or hot stacking, grading, trimming/cutting, and sanding. Secondary finishing steps include filling, painting, laminating, and edge finishing.

When used in the home in furniture, subflooring, or stair treads, PB and MDF made with formaldehyde-based resins

Because no threshold has been determined below which exposures do not increase the risk of cancer, formaldehyde remains a health concern even at lower levels.

continue to release small amounts of formaldehyde gas. Producers have generally met industry standards and have reduced formaldehyde emissions from PB an average of 80 percent below 1980 levels, primarily by reducing the ratio of formaldehyde to urea in resin formulations.

FORMALDEHYDE TOXICITY

According to the EPA, formaldehyde is a probable human carcinogen when inhaled or ingested. In fact:

- Breathing even small amounts of formaldehyde may increase the risk of contracting lung and nasal cancer.
- Chronic formaldehyde exposure can cause menstrual disorders and pregnancy problems in women workers exposed to higher levels.
- Short-term inhalation exposure can result in eye, nose, and throat irritation and respiratory symptoms.

Standards have been set by industry for formaldehyde emissions from all wood products and by the U.S. Department of Housing and Urban Development for wood products in manufactured homes.

American National Standards Institute (ANSI) standards for particleboard flooring products restrict formaldehyde gas emissions to 0.2 parts per million (ppm) as measured in the American Society for Testing and Materials (ASTM) large chamber test. All other materials must emit less than 0.3 ppm to meet the ANSI standard. HUD regulations for materials used in mobile homes limit emissions to 0.3 ppm. According to EPA's Integrated Risk Information System, if these levels were to occur in indoor air, and an individual had lifetime exposure, the risk of cancer would be higher than generally considered acceptable.



However, because formaldehyde is believed to cause cancer, and because no threshold has been determined below which exposures do not increase the risk of cancer, formaldehyde remains a health concern even at these lower levels.

Greener Choices

Alternative Fiber Sources

Clear the Air, Clear the Fields by Using Agricultural Waste Fiber

Straw is the stem of a small-grain cereal plant, such as wheat or rice, or the shaft left after the growing of grass for grass seed. While some straw is left to condition the soil, in many places it is cleared from fields after grain harvest by burning, which has caused serious air pollution problems. For example, some 500,000 acres of rice fields in California's Sacramento Valley produce about 1.5 million tons of rice straw that traditionally was burned in the field each year. Such

burning was creating 56,000 tons of carbon monoxide annually in California alone, along with particulate matter, carbon dioxide, and other air pollutants.

Because of adverse health effects associated with such pollution, California is phasing out straw burning and is requiring rice growers to find alternative means of straw disposal. Meanwhile, wheat production in the Midwest and the cultivation of bluegrass for

Some 500,000 acres of rice fields in California's Sacramento Valley produce about 1.5 million tons of rice straw that traditionally was burned in the field each year.

grass seed in the Northwest are producing large amounts of straw. For PB and MDF manufacturers, this is a case of one industry's trash being another industry's treasure. In fact, the amount of residual straw generated by U.S. agriculture (estimated at over 100 million metric tons) far exceeds present and future fiber requirements for PB and MDF manufacture.

Bagasse, another source of fiber for PB and MDF, is the residue from the processing of sugar cane for sugar production. This waste product is currently disposed of in large quantities in Louisiana, Florida, and Hawaii. In fact, more than 4.5 million tons of bagasse generated each year in the United States is typically burned in steam boilers, which creates more air emissions than other energy sources, such as natural gas.

Using straw or bagasse as the fiber for PB and MDF provides an alternative to burning straw in fields or disposing of bagasse by burning it in steam boilers. Although processing straw into PB and MDF is similar to processing wood residues, breaking straw into fibers requires less processing and less drying, therefore less energy use.

In addition, the properties of strawboard, such as internal bond strength, resistance to rupture, moisture resistance, and screw-holding strength (as measured by tests developed by the American National Standards Institute or the American Society for Testing and Materials), are equal to or better than wood-based PB and MDF. And, because formaldehyde-based resins are not used with board made from straw and bagasse, the resulting product does not carry the health risks associated with formaldehyde.

Currently, six plants in the United States produce PB and MDF from straw and bagasse. These include strawboard plants in North Dakota (Primeboard, Inc.), Minnesota (Isoboard Enterprises), California (Fiber Tech), and Idaho (Pacific Northwest Fiber) and sugar cane bagasse plants in Louisiana (Acadia Board) and Hawaii (Hawaiian DuraGreen). Another strawboard plant, which will use rice straw, is under construction in California. These plants are located near the sources of the straw or bagasse to keep transportation to a minimum.

Reduce the Waste Stream through Use of Post-Consumer Wood and Paper

The solid-waste stream in the United States contains approximately 16 million tons of recoverable solid wood waste from the municipal, construction, and demolition solid-waste streams. In addition, 79 million tons of waste paper disposed of each year could provide another source of fiber for PB and MDF. Using post-consumer wood and paper waste for PB and MDF could potentially divert some 95 million tons from landfills and decrease the harvesting of trees. Locating PB and MDF plants near urban areas would provide access to wood and paper wastes and



place the finished product in proximity to users.

One company, Homasote, produces an MDF-like board from post-consumer recycled waste paper, recycling approximately 80,000 tons per year. Homasote uses a formaldehyde-free wax emulsion as the binder and a closed-loop manufacturing process that recycles all water used.

Unfortunately, while there are PB products available that are made from recycled wood products, such as waste pallets, they use formaldehyde-based resins.

Reduce the Waste Stream by Using Pre-consumer Recycled and Recovered Wood Residues

Most PB and MDF contains wood residues from lumber and plywood production. The PB and MDF industries, along with other panel industries, consume approximately 10 million metric tons of these wood residues per year. Depending on the plant and the process, these raw materials may be considered pre-consumer recycled content or recovered materials.

Pre-consumer and recovered materials are those that otherwise would end up in the solid waste stream. PB and MDF with high content of pre-consumer and recovered materials divert wood waste from disposal and is an indication that little or no wood fiber was produced and harvested for direct use in the product. Some manufacturers have had the pre-consumer and recovered material content of their PB and MDF

certified by independent certification organizations. Most producers of PB and MDF with pre-consumer recycled wood content, however, use formaldehyde resins in the board.

Promote Sustainable Forest Practices by Using Sustainably Managed Wood Sources

Even if the wood fiber for PB and MDF is pre-consumer recycled and recovered material, by demanding that this wood fiber be from trees grown and harvested in a sustainable manner, builders can reduce the overall impacts of forestry practices for lumber and plywood products. There are organizations that certify wood products that have

been produced with wood from sustainably managed forests. For instance, the Forest Stewardship Council and its independent certifiers apply criteria to certify that the source of wood for products is a “well-managed” forest: one that maintains the essential characteristics of a natural forest before and after a timber harvest. FSC standards of



well-managed forestry carefully balance ecosystem health with the amount of timber harvested from the forest. Invasive management techniques, like clear-cutting and biocide use are minimized. Non-invasive management practices such as riparian buffer zones, balanced-age distribution, and integrated pest management are always preferred over invasive techniques. PB is available containing wood fiber derived from sustainable forestry, but these products currently use formaldehyde-based resins.

Alternative Resins

Methylenediphenyl Isocyanate (MDI)

The most widely used alternative to urea formaldehyde for PB and MDF is methylenediphenyl isocyanate (MDI). Unlike most wood-based PB and MDF products that are made with formaldehyde-based adhesives, products made with MDI do not emit a toxic gas during use. While MDI has other advantages, such as the ability to bond to wood particles with higher moisture content and requiring less dryer energy and lower press temperatures (which may lower air emissions), there are concerns about MDI toxicity for workers exposed during PB and MDF manufacturing. MDI can be used

MDI TOXICITY

MDI is a hazard for workers in PB and MDF plants, although controls to prevent exposure are generally in place. MDI can cause dermatitis and respiratory diseases in workers and may alter the immune system, resulting in sensitization of the respiratory system and asthma-like reactions. It is not considered a carcinogen in humans, but there is limited evidence of tumors in animals. While OSHA's Permissible Exposure Limit for MDI in the workplace is less than that for formaldehyde (0.02 ppm versus 0.75 ppm), MDI does not present an exposure risk in the finished PB and MDF products.

for wood-based PB and MDF and for products made with agricultural residues, for which formaldehyde-based adhesives are generally not suitable.

Naturally Derived Adhesives

Environmental and human health concerns have prompted researchers to develop naturally derived adhesives and resins for wood products. While alternatives, such as resins manufactured from furfuryl alcohol or lignin chemicals, have been demonstrated in the laboratory, they have not been embraced by

manufacturers of PB and MDF. A strawboard, available in the United Kingdom under the name Stramit, uses the natural lignin in straw, together with high temperatures and pressures, to bind the straw fiber; this type of strawboard is not currently manufactured in the United States.

Market Survey: What's Available

There are three categories of greener PB and MDF available on the market:

1. Agricultural Waste Fiber, Formaldehyde-Free: agricultural residues that would have been burned, bonded with a formaldehyde-free resin;

2. Post-Consumer Waste Fiber, Formaldehyde-Free: post-consumer paper waste, bonded with a formaldehyde-free resin;

3. Recovered Wood Fiber and Formaldehyde-Free: pre-consumer wood residues, bonded with a formaldehyde-free resin.

Recommended Particleboard and Fiberboard Products

AGRICULTURAL WASTE FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
Isoboard (Isoboard, StorageBord, ShelfBord and IsoUnderlay)	Strawboard	Wheat Straw	Annually renewable	Home Depot, Lowe's, Isobord's Global Sales Office	Meets ANSI-M3 (particleboard) standards at Guaranteed Property Performance Levels
PrimeBoard	Strawboard	Wheat Straw	Annually renewable	Multiple distributors	Meets ANSI-M3 standards
Pacific Northwest Fiber (PacificBoard)	Strawboard	Bluegrass Straw	Annually renewable	Available for immediate shipment	Moisture-resistant; laboratory tests conducted by company show superior strength, compared to wood-based particleboard
FiberTech	Agrifiber composite panel (Mainly door cores; also some industrial board and underlayment)	Rice Straw	Annually renewable	Door cores sold to door manufacturers	Meets ANSI standards for particleboard and fiberboard
Acadia (DuraCane)	Particleboard	Bagasse	Annually renewable	Available directly from the company	Excellent moisture resistance, high hardness and moduli of rupture (MOR) and elasticity (MOE); exceeds MDF standards
Hawaiian DuraGreen	Particleboard	Bagasse	Annually renewable	Panel Source International is the exclusive sales agent	Highly moisture-resistant; internal bond values greater than 200 psi; tight screw holding (contact company for details)

Recommended Particleboard and Fiberboard Products

POST-CONSUMER WASTE FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
Homasote	Fiberboard	100% post-consumer recycled newsprint	Post-consumer newsprint supply exceeds current demand	Most lumber and home center locations; network of dealers	Products comply with building codes for various applications (contact company for details)

RECOVERED WOOD FIBER, FORMALDEHYDE-FREE

MANUFACTURER (BRAND)	PRODUCT DESCRIPTION	FIBER SOURCE	RENEWABLE/ SUSTAINABLY HARVESTED	PRODUCT AVAILABILITY	PERFORMANCE STANDARDS
SierraPine (Medex, Medite II and Medite-FR)	Medium-density Fiberboard	100% recovered and preconsumer recycled wood fiber	N.A.	Multiple distributors	Meets ANSI 208.2-1994 standards for MDF

MANUFACTURER CONTACT INFORMATION

Isoboard <http://www.isoboardenterprises.com> 503-242-7345

Primeboard <http://www.primeboard.com> 701-642-1152

PacificBoard <http://www.pacificfiber.com> 208-686-6800

FiberTech 530-458-4547

Acadia 727-393-9668

Hawaiian DuraGreen <http://www.hawaiianduragreen.com> 808-877-2942

Homasote <http://www.homasote.com> 800-257-9491

SierraPine <http://www.sierrapine.com> 800-334-2250



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Guidelines and Standards

EPA Comprehensive Procurement Guideline for Fiberboard

EPA has adopted a Comprehensive Procurement Guideline for Structural Fiberboard containing recovered materials (80–100% recovered material required). Structural fiberboard is a panel made from wood, cane, or paper fibers matted together which is used for sheathing, structural, and insulating purposes. Examples of these products include building board, insulating formboard, and sheathing. Any Federal agency, or any state agency that is using appropriated Federal funds for procurement, is required to

purchase products meeting this guideline. See <http://www.epa.gov/cpg/products/fiberbrd.htm>.

U.S. Department of Agriculture Biobased Products List

A 1998 Executive Order directs the U.S. Department of Agriculture to develop a list of biobased products that can guide agencies in their purchasing policies. Once the list is published, it may also be a useful reference. See <http://www.usda-biobasedproducts.net>.

Performance Standards

The American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) have adopted

several performance standards for PB and MDF. If you are purchasing PB and MDF, you should determine the level of performance you need (a waterproof product, for example) and inquire as to whether the product meets those performance standards. For PB and MDF made from agricultural fiber, specifying the performance characteristics required may yield more eligible products than just referencing test methods, since many of the test methods for PB and MDF were developed with wood fiber products in mind. The recommended products table provides available information about performance standards met by the individual products.