Environmental, Health, and Safety Guidelines for Board and Particle-Based Products

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are reference documents designed to provide project developers, financiers, facility managers, and other decision makers with relevant industry background and technical information. This information supports actions aimed at avoiding, minimizing, and controlling EHS impacts during the construction, operation, and decommissioning phases of a project or facility. [*]

How to Use This Document

The EHS Guidelines for Board and Particle-Based products provide information that is specific to facilities in this industry sector. They are organized according to the following sections.

They are designed to be jointly used with the **General EHS Guidelines** document, which provides the user with guidance on common EHS issues potentially applicable to all industry sectors. On complex projects, multiple industry-sector guidelines may be useful. A complete list of industry-sector guidelines can be found at

www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology, at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines may need to be established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

Applicability

The EHS Guidelines for Board and Particle-based Products apply to the manufacture of board and particle-based products such as particle-board, oriented stand board (OSB), medium density fiberboard (MDF), and plywood. They also apply to plants that make board from other raw materials such as sugar cane bagasse, straw, and linen. Sawmilling and the manufacture of wood-based products such as furniture are addressed in the EHS Guidelines for Sawmilling and Manufactured Wood Products. Growing, harvesting, and transport of timber used in this sector is discussed in the **EHS Guidelines on Forest Management**. Annex A provides a description of industry activities.

[*] **Note:** Attribution of all references, including verification for completeness and accuracy, to be completed for final draft.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with manufacture of board and particle-based products along with recommendations for their management.

Recommendations for the management of EHS issues common to most large industrial facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues associated with board and particle-based product manufacturing include:

- Sustainable forestry practices
- Emissions to air
- Water consumption and wastewater effluents
- Hazardous materials
- Solid wastes
- Noise

Sustainable forestry practices

Where round logs rather than wood waste are used as the source of fiber (in particular for plywood and OSB), the major environmental impact of manufacturing concerns the management of forest resources. Issues related to sustainable forestry practices are addressed in the **EHS Guidelines for Forest Management**. These impacts can be reduced through the use of more recycled or recovered fiber in board manufacturing.

Emissions to air

Board and particle-based product processes can give rise to a wide variety of emissions to air according to the different processes employed. Combustion pollutants including particulate matter (PM), nitrogen oxides (NO_x), carbon monoxide (CO) and sulfur oxides (SO_x) may arise from utility boilers, hot gas generators and thermal fluid heaters. Aldehydes (including formaldehyde) and other volatile organic compounds (VOCs) are released where wood is heated in particle dryers, veneer dryers and presses, and when pressed board cools. VOCs are also released in the manufacture and application of decorative coatings for boards. Wood dust arises from mechanical operations such as chipping, chip grading, and from cutting and sanding of pressed board. Board manufacture is very energy intensive and if energy systems are based upon fossil fuel rather than wood waste, these plants can be significant emitters of greenhouse gases.

Recommendations to prevent, minimize, and control emissions to air are discussed below.

Combustion products

Emissions to air from standalone utility heating systems, such as thermal fluid heaters or steam boilers, should be controlled as described in the **General EHS Guidelines.** When the thermal needs of the manufacturing facility are based upon a (usually waste wood fired) hot gas generator which provides thermal fluid heating for the press and hot gases for the particle dryer, then control of emissions of combustion products should be combined with control of VOCs and aldehydes as described below.

Fiber, Particle, and Veneer Dryers

Air emissions from dryers contain moisture and VOCs evaporated from the wood. Dryers are typically directly heated by hot gases arising from a wood-products and / or fossil-fuel fired hot gas generator and contain pollutants from wood combustion. Control of these emissions in OSB and particle board manufacture may be achieved by passing the dryer exhaust gases through a wet electrostatic precipitator (WESP). Cyclone separators, however, are more widely used in MDF manufacturing. Stacks should be designed according to Good Engineering Practice (GEP) as described in the **General EHS Guidelines.**

Presses

Board presses should be hooded. Air collected from around the presses, which will normally contain formaldehyde since this is a component of many of the resins used in board formation, should be routed to the utility plant for use as combustion air, thus destroying the formaldehyde, or to control devices such as dry or wet ESPs or wet scrubbers. Formaldehyde emissions should be reduced at source by limiting the press temperature to the minimum feasible level, and formulating resins to minimize excess formaldehyde. Board cooler emissions are typically vented to atmosphere without secondary controls.

Dust

Many of the processes in board manufacture have the potential to create dust, be it nuisance dust, wood dust or contaminants from the wood surface. Dust can be created throughout the process including in the log yard, and during activities such as log handling, log and recycled material chipping, chip screening, veneer trimming and laying out the particulate mat to be pressed. After pressing, dust arises from cutting to length of continuously-pressed board, end trimming, edge trimming, cutting to size and sanding.

The recommended measures to prevent, minimize, and control dust emissions include:

- Where outdoor stockpiles are unavoidable, measures such as windbreaks, spraying, or binders should be used to minimize dust emissions;
- Where possible, handling of chips and particles should be by pneumatic means rather than by open conveyor or by bulk transport. Where conveyors are used they should be fully enclosed, especially at height changes;
- Chips storage areas should be enclosed;
- Areas identified above with high potential for dust generation (chip grading, mat layout and sawing and sanding areas) should have dust extraction equipment. Extraction systems should lead to bag filter or cyclone separator systems as required to meet site specific requirements, and should be regularly inspected to identify and eliminate blockages preventing effective removal of dust.

Greenhouse Gases

Board mills are energy intensive, using mechanical power for material breakdown, grading and transport, and with a high heat demand particularly in fiber particle and veneer drying, but also in presses. The following opportunities to improve energy efficiency should be considered:

- In utility plants (boilers and thermal fluid heaters), the general energy efficiency techniques described in the **General EHS Guidelines** should be adopted where appropriate;
- Electricity use can be reduced at source by designing new plants to minimize transfer distances between process stages, specification of fans used in chip grading and transfer, and by adjusting fan output through variable speed inverter drives rather than damper control when air flow rates need to be adjusted (e.g. in chip graders, particle transfer and combustion air fans);

- Energy used in drying can be reduced through use of relatively dry raw materials, including recycled wood matter in particle board manufacturing, by maximizing the contact between drying air and particles in dryers through use of a three-pass dryer or partial recirculation of hot and dry dryer exhaust air and minimizing dryer temperature to the extent possible;
- Board mills have high heat and power demand and operate for extended periods, often without great variation in heat or power demand. These operating conditions can favor successful co-generation (combined heat and power) projects. MDF manufacturing is particularly well suited to gas-turbine based cogeneration, with the turbine's electrical output substantially meeting process demands if the turbine is sized such that its heat output satisfies the fiber drying load;
- All wood waste produced in the process should be burnt on site to meet process heat (and power) demands. Such waste will include bark, (when a debarking stage is included), saw dust and sanding dust, while some sites buy wood waste for use as carbon-neutral fuel. In an MDF plant with cogeneration, wood waste burning can generally meet the heating needs of the board press and lamination areas.

Water consumption and wastewater effluents

Water consumption and reuse

Board and particle-based product mills may include water-intensive operations, including chip washing, chip steaming and softening in MDF production, and water used within the WESP.

Particularly but not exclusively in manufacture of MDF, wood chips may be washed before downstream processing, primarily to remove soil residues that cause premature wear of machining equipment. This wash water can contain high quantities of sediments and leachate from wood chips and should be treated by settling and, if necessary, filtration, and then recycled within the process.

Also in MDF manufacture, effluents arising from chip steaming and softening before the refining stage can be reused in the process after treatment using membrane filtration systems.

WESP cleaning water is typically cleaned in a decanting system before re-use in the WESP.

Effluents

The quantity of effluent arising from chip washing, MDF manufacture and WESPs should be minimized by the recycling techniques described above. Remaining effluent generation from board processes is small, with water being carried from the wet processes with wood chips or fibers and ultimately leaving the site through evaporation in the dryer.

In plywood manufacturing, logs are soaked in warm water before peeling. Such soaking ponds are often steam heated, and heating is often by direct injection to the pond. Toxic chemicals contained in wood (such as tannins, phenols, resins, and fatty acids) will leach from wood in these ponds. The leachate typically has a high BOD (150 -5000 mg/l) and COD (750 – 7500 mg/l). The same chemicals are also prone to leach from round wood and wood chip storage areas. Such areas are exposed to rain water and may be irrigated to control dust.

Recommended techniques to prevent and control leaching include:

- Log soaking ponds used in plywood manufacture should be lined to prevent loss of leachate to ground water;
- Log and chip storage areas should have impermeable surfaces, spill containment curbs, and run off from these areas should be directed to the waste water treatment facility;

- Log yard irrigation water should be recycled.

Effluent water should be treated to remove wood fines (dissolved air flotation (DAF) is effective in this application) and then to reduce BOD and COD. Since this water should not contain pathogens, treatment can be achieved in most cases by passing the water through constructed wetlands or aerated treatment ponds with a retention time of at least 14 days or until an acceptable BOD and COD is achieved.

Hazardous Materials

Board and particle-based products may use large volumes of resins in the manufacturing process. These resins may contain a variety of toxic compounds. Formaldehyde is a common component of these resins but other toxic agents such as pesticides and fungicides may be included in the final product. These chemicals represent a potential hazard if spilled, and also can represent an occupational health and safety hazard if not handled appropriately. Recommendations for the safe use, handling and storage of hazardous materials are addressed in the **General EHS Guidelines**.

Solid Waste

Solid waste in this sector includes wood waste (e.g. board off cuts), waste from water treatment processes, and ash[1] from combustion of wood waste.

Recommended measures to prevent, minimize and control waste include:

- Ash should be stored in a contained wind resistant area until it has fully cooled. Ash should be returned to the forest or to some other site for inclusion in the soil as a fertilizer and soil improver;
- Board off-cuts should be minimized by control of the pressed-board dimensions and gradual minimization of trimming margins. Remaining offcuts can be recycled as furnish in particleboard manufacture, used as the core of blockboard, or burnt in the wood waste-burning utility system;
- Solid wastes arising from water treatment processes, including the sludge captured by the WESP, should be burnt, providing appropriate air pollution control is adopted or disposed of as hazardous waste, as discussed in the **General EHS Guidelines**.

Noise

Board and particle-based product plants generate significant noise primarily from debarking drums and chipping machinery (which produce the most noise), mechanical breakdown processes used for the raw timber, and sanding and cutting machinery.

Recommended measures to prevent, minimize and control noise include:

- Debarking and chipping should be carried out in enclosed buildings;
- Noise generating machinery should be regularly maintained according to manufacturer specifications;
- Log handling facilities should be sited to minimize noise;
- Sound reducing earth banks or sound reflecting screens should be installed as necessary.

1.2 Occupational Health and Safety

Occupational health and safety impacts during the construction of board and particle-based products plants are common to

[1] Combustion of wood waste in a large board mill will give rise to large volumes of ash. This ash, if not properly stored immediately after removal from incinerators and furnaces, can be a serious fire hazard since it is light and the embers can easily be blown by the wind.

those of most large industrial facilities and their prevention and control is discussed in the **General EHS Guidelines**.

Occupational health and safety hazards in board and particle-based manufacturing operations primarily include the following:

- Physical hazards
- Exposure to noise
- Dust inhalation
- Chemical exposure
- Explosion / fire

Physical Hazards

The most severe injuries in this sector are usually attributable to the failure of Lockout -Tagout systems. Robust Lockout - Tagout procedures as described in the **General EHS Guidelines** should be devised and practiced regularly.

Machine Safety

Almost all board and particle board processing plants have some kind of cutting equipment, such as chippers, mills, flakers, saws and sanding equipment. In addition, process machinery such as multi-opening presses and drive systems can present risk of trapping. Injuries from this type of machinery often lead to loss of limbs and digits. Accidents often happen when machines are inadvertently switched on during maintenance and cleaning.

Recommended measures to prevent and control injuries from cutting equipment include:

- All cutting equipment should be fitted with safety guards capable of preventing access to moving cutting blades;
- All workers should be trained in the safe use of cutting equipment;
- Chippers should be fitted with safety guards which prevent the insertion of body parts;
- All cutting equipment should be adequately contained to prevent the expulsion of blade fragments in case of blade breakage;
- Moving gears, chains, belts and rollers should be fully enclosed.

Log Handling Activities

Logs are generally unloaded from railroad cars or heavy trucks and stacked by machines before being moved to log conveyors for transport to the debarker and chipper. Injuries due to vehicle movement in log yards are common, in addition to injuries from logs that roll off or are dropped by handling equipment or are dislodged from log stacks.

Recommendations to prevent, minimize, and control injury in log yards include[2]:

- Complete mechanization of log yard activities should be considered to reduce human contact with logs during handling and stacking activities;
- Transport routes within log yards should be clearly demarcated and vehicle movement should be closely controlled;
- Log stacks should be no higher than a safe height defined by risk assessment which should take account of site-specific circumstances including stacking methodology;
- Access to log yards should be restricted to authorized personnel;
- Log decks should have stops, chains, or other guards to prevent logs from rolling down and off the deck;

[2] Specific techniques for log receiving and handling can be found at US OSHA (2003), available at: http://www.osha-slc.gov/SLTC/etools/sawmills/receive.html and http://www.osha-slc.gov/SLTC/etools/sawmills/convey.html

- Workers should be trained in safe working procedures in log stack and deck areas, including avoidance of falling logs and planning of escape routes;
- Workers should be provided with protective steel capped boots, hardhats, high visibility jackets, eye protection and gloves;
- All mobile equipment should have audible reversing alarms.

Burns

Severe injuries from steam, hot oil, or hot machinery are a risk in many board mills and may occur through accidental contact with hot surfaces and by accidental release of hot substances to the workplace. Recommended measures to prevent and control injury from steam pipelines and other hot materials include:

- All steam and thermal fluid pipelines should be insulated, marked, and regularly inspected;
- Steam vents and pressure release valves should be directed away from areas where workers have access;
- Handling of hot liquors or resins should not be done manually;
- All high temperature areas of presses should be screened to prevent ingress of body parts.

Noise

The machinery responsible for most milling and sawing operations emits levels of noise that are damaging to hearing. In many cases even relatively short term exposure will lead to permanent loss of hearing acuity. Noise reduction methodologies described in the 'Environment' section of this document should be employed, with hearing protection equipment also provided if such measures fail to reduce noise levels below 85 dB(A). Ear protection is likely to be necessary around the chipper, mills and chip grading areas and in utility plant rooms.

Dust

Wood dust inhalation, especially of PM_{10}, may cause irritation, asthma, allergic reaction, and nasopharyngeal cancer amongst wood processing workers. The dust produced from some alternative fibers used for board processing has specific health effects leading to specific occupational diseases. For example, bagassosis is caused by allergy to actinomycete fungal spores found on moldy sugarcane while byssinosis is caused by cotton or flax particles. Both these conditions may lead to permanent incapacity or death. Melamine powder which may be used for lamination may be a carcinogen and may have irritant effects to the eyes skin and respiratory tract. Dust exposure should be prevented and controlled through the adoption and maintenance of effective extraction and filtration systems[3] as described in the "Environment" section above supplemented by the use of Personal Protective Equipment (PPE) such as the use of masks and respirators, as necessary.

Chemicals

Where formaldehyde based resins and glues are used as a binding agent there may be an elevated exposure to formaldehyde vapor. Where wood is dried or pressed at elevated temperatures wood volatile compounds are commonly released. Exposure to these chemicals should be controlled by the measures described above in the 'Environmental' section of this document, in addition to guidance provided in the **General EHS Guidelines**.

Methylene diphenyl diisocyanate (MDI) adhesive is often used in OSB manufacture. This compound can cause severe respiratory

[3] Specific local exhaust ventilation controls for various machines and equipment can be found at US OSHA 2003. Available at: http://www.osha-slc.gov/SLTC/etools/sawmills/dust.html

damage if inhaled and demands special precautions in use which will be specified by responsible suppliers of this material.

Fire and Explosion

Explosions may present a serious hazard in areas where large amounts of finely divided combustible dust are present. The risk is particularly high in mills which use high temperature drying of chips or flakes mixed with resins or waxes, and in dust control equipment removing dry sanding and saw dust. Ducts used to extract fumes from the press area can become coated with combustible material and also represent a fire hazard. Explosion risk should be minimized by application of the measures for prevention and control of dust accumulation as described in the 'Environment' section of this document. In addition, measures to prevent and control fire and explosion hazard related to dust must include:

- Regular housekeeping to ensure that dust is removed from the facility, including a biannual blow down or vacuuming of the entire facility (e.g. roof rafters);
- Use of explosion relief panels on all dust moving equipment, in dryers and in buildings;
- Installation and regular maintenance of spark detection and deluge dousing systems in dryer systems and dust control equipment;
- Eliminating all sources of ignition from the working environment, including:
    - Use of electrical equipment of at least IP64 rating
    - Elimination of naked flames, such as burner flames, welding or cutting torches, matches, cigarette lighters, and heaters
    - Control of hot surfaces, such as operating internal combustion engines, frictional sparks, heated wires, glowing metals, and overheated bearings
    - Control of portable, battery powered equipment e.g. radios, mobile phones etc.
    - Safe use of certain chemicals, for example peroxide hardening products which can be self-heating or result in spontaneous combustion
    - Electrical grounding of conveyors and dust control systems to prevent discharge of static electricity
- Workers should be trained in emergency evacuation procedures and first line of attack fire fighting techniques.

1.3 Community Health and Safety

Community health and safety impacts during the construction of board and particle-based product manufacturing plants are common to those of most large industrial facilities, and are discussed in the **General EHS Guideline**. Community health and safety issues associated with board mills primarily include exposure dust and other air emissions and noise. Operators should ensure that the techniques to mitigate impacts described in the 'Environment' section ensure that local communities are not adversely affected.

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Tables 1 and 2 present emission and effluent guidelines for the board sector. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guidelines**.

Emissions guidelines are applicable to process emissions. Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a heat input capacity equal to or lower than 50 MW are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the Thermal Power EHS Guidelines. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Resource Use

Table 3 provides examples of resource consumption indicators for energy, water, materials, and waste in this sector. Industry benchmark values are provided for comparative purposes only and individual projects should target continual improvement in these areas.

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

Table 1: Air Emission Guidelines for Board and Particle Based Products

Pollutants	Units	Guideline Value
Particulate Matter	mg/Nm³	20 (MDF) 20 (Wood Dryers) 50 (Other Sources)
Condensable VOCs	mg/Nm³ (as carbon)	130
Formaldehyde	mg/Nm³	20 (Wood Dryers) 5 (Other Sources)

Table 2: Effluent Guidelines for Board and Particle Based Products

Pollutants	Units	Guideline Value
BOD	mg/l	50
COD	mg/l	150
TSS	mg/l	50
Formaldehyde	mg/l	10

Table 3: Resource and Energy Consumption

Inputs per unit of product	Mass Load Unit	Industry Benchmark
Conversion efficiency (plywood) **Conversion efficiency (MDF)** **Conversion efficiency (other)**	m³ product / m³ wood	55% 90% 95%
Electricity use (MDF) **Electricity use (Plywood)** **Electricity use (Other)**	kWh/m³	260 280 150
Heat use (MDF) **Heat use (Plywood)** **Heat use (Other)**	MJ/m³	1000 TBD. 630
Water use (MDF **Water use (Plywood)** **Water use (Other)**	m³ water/m³ product	300 TBD. 100

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[4] the United States National Institute for Occupational Health and Safety (NIOSH),[5] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[6] Indicative Occupational Exposure Limit Values published by European Union member states,[7] or other similar sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[8].

Occupational Health and Safety Monitoring

The working environment should be occupational hazards relevant to the specific project. Monitoring should be designed and implemented by credentialed professionals[9] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**..

[4] http://www.acgih.org/TLV/
[5] http://www.cdc.gov/niosh/npg/
[6] http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
[7] http://europe.osha.eu.int/good_practice/risks/ds/oel/
[8] http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm
[9] Credential professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

The board and particle-based products sector involves the manufacture of wood- and plant-based materials bonded together using adhesives or binding material and heat / pressure. This Guideline includes information relevant to the manufacture of board and particle-based products such as particle-board, oriented stand board (OSB), medium density fiberboard (MDF), and plywood. It also includes plants that make board from other raw materials such as sugar cane bagasse, straw, and linen.

Manufacturing Activities

Figure A1 depicts typical board manufacturing processes.

The raw material inputs to the process vary by product. Round wood (i.e. logs) is required for OSB and plywood. MDF and particleboard can use logs, but also sawmill waste and increasingly post-consumer wood is processed as a raw material input to particle board manufacturing. The majority of the inputs to these industries are softwoods, however hardwood veneers are used in decorative plywoods and products intended for use in marine environments.

Material Preparation

Input materials are prepared by debarking and chipping, flaking, peeling or slicing, according to product needs. Chipping may occur off site where the inputs are a waste product from other timber processing operations. Especially in MDF manufacture, chips may be washed before downstream processing.

Following initial size reduction, particles (particle board) or flakes (OSB) are graded by size before passing to the dryer. In MDF production, chips are softened by cooking in water and then fed to a refiner where they are reduced to individual fibers.

For the production of veneers for plywood the most common process is rotary peeling and, depending on the species, this is preceded by steaming of the logs to increase moisture content and the ensuing stability of the peeled sheets.

Drying

In OSB and particle board, chips / flakes will then be dried, in multiple-pass rotary dryers. Fibers used for MDF are dried in hot air in a long tube, while veneer used for making plywood is dried in sheet form in an oven-like veneer dryer. Drying involves significant energy use and opportunities for energy efficiency, and gives rise to considerable emissions to air.

Binding and Adhesives

Products are formed through the addition of adhesives and binders to the fiber, chip, flake or slice mat. Board properties and thickness are generally determined at this point which may involve the use of different layers of chips of different size, material, and orientation.

Pressing / Curing

Boards are then pressed and cured through heating and pressing of the board at medium to high temperatures depending on the product. A variety of press types are available, including multi-opening presses which produce stacks of small boards, single opening presses that make large boards which are then cut to size, and continuous roller presses.

Value Added

Value-added processing to the basic board or ply products may include decorative veneers, or water resistant and mechanically durable coatings such as melamine, or specialty products, such as window frames.

Following manufacture of the raw board there may be further finishing processes such as sanding as well as final handling and packaging for transport to point of sale.

Product types

Veneer Plywood, Laminaboard and Blockboard

Veneer plywood is constructed from multiple layers of veneer laid out in the same direction but perpendicular to adjacent layers, while laminaboard and blockboard are formed of a core faced with a single veneer layer on the outside. The various layers are glued together with adhesives. Boards formation occurs in a press and depending on the glues used this may be either a hot press or more rarely a cold press.

Particle boards

These boards are typically composed of softwood chips that are bound together with either a resin based adhesive or a cement. The board is formed by being pressed between heated platens.

Oriented strandboards (OSB)

Oriented strandboards were originally developed for making use of timber from small diameter trees. Wood strands are cut along the grain and oriented in different directions, and strands are covered in a resinous binder and pressed between heated platens to make the boards.

Dry process fibreboards

Steamed wood is reduced to fibers and these are then dried. The fibers are mixed with an adhesive, formed into a mat and pressed between heated platens. This results in products known commonly as MDF (medium density fiberboard). MDF is often made into decorative moldings for architectural use and may be coated with a variety of finishes.

Other fibers used for board manufacture

A variety of raw materials other than wood, and binders other than resin, have been used to manufacture board products. These include bagasseboard made from sugar cane straw, strawboard from wheatstraw, and flaxboard made from linen. The major logistical factor in the production of these products is the cost of storing large volumes of input materials during the non harvest season which for many inputs may be nine months. Cement is the most common alternative binder used to make these alternative boards.

Figure A.1: Simplified Board and Particle-Based Products Manufacturing Processes