

## 10.6.2 Particleboard Manufacturing

### 10.6.2.1 General<sup>1,2</sup> -

Particleboard is defined as a panel product manufactured from lignocellulosic materials, primarily in the form of discrete particles, combined with a synthetic resin or other suitable binder and bonded together under heat and pressure. The primary difference between particleboard and other reconstituted wood products, such as waferboard, oriented strandboard, medium density fiberboard, and hardboard, is the material or particles used in its production. The major types of particles used to manufacture particleboard include wood shavings, flakes, wafers, chips, sawdust, strands, slivers, and wood wool. The term particleboard sometimes is used generically to include waferboard and oriented strandboard, which are manufactured primarily with wood flakes and wafers. However, for the purposes of this report, particleboard pertains only to panels manufactured from a mixture of wood particles or otherwise from wood particles other than wafers and flakes. Particleboard manufacturing falls under Standard Industrial Classification (SIC) Code 2493, reconstituted wood products, which includes hardboard, insulation board, medium density fiberboard, waferboard and oriented strandboard in addition to particleboard. The six-digit Source Classification Code (SCC) for particleboard manufacturing is 3-07-006.

### 10.6.2.2 Process Description<sup>1,2</sup> -

Particleboard is produced in densities ranging from around 590 kilograms per cubic meter ( $\text{kg/m}^3$ ) (37 pounds per cubic foot [ $\text{lb/ft}^3$ ]) to greater than 800  $\text{kg/m}^3$  (50  $\text{lb/ft}^3$ ). Most particleboard is formed into panels. However, molded particleboard products such as furniture parts, door skins, or molded pallets are also produced.

Although some single-layer particleboard is produced, particleboard generally is manufactured in three or five layers. The outer layers are referred to as the surface or face layers, and the inner layers are termed the core layers. Face material generally is finer than core material. By altering the relative properties of the face and core layers, the bending strength and stiffness of the board can be increased.

The general steps used to produce particleboard include raw material procurement or generation, classifying by size, drying, blending with resin and sometimes wax, forming the resinated material into a mat, hot pressing, and finishing. Figure 10.6.2-1 presents a process flow diagram for a typical particleboard plant.

The furnish or raw material for particleboard normally consists of wood particles, primarily wood chips, sawdust, and planer shavings. This material may be shipped to the facility or generated onsite and stored until needed. In mills where chips are generated onsite, logs are debarked, sawn to proper length, and chipped. After shipping to the site or generation onsite, the furnish may be further reduced in size by means of hammermills, flakers, or refiners. After milling, the material is either screened using vibrating or gyratory screens, or the particles are air-classified. The purpose of this step is to remove the fines and to separate the core material from the surface material. The screened or classified material then is transported to storage bins.

From the storage bins, the core and surface material are conveyed to dryers. Rotary dryers are the most commonly used dryer type in the particleboard industry. Both single and triple-pass dryers are used. In addition, some facilities use tube dryers to dry the furnish. Wood-fired dryers are used at most facilities. However, gas- and oil-fired dryers also are used. The moisture content of the particles entering the dryers may be as high as 50 percent on a wet basis. Drying reduces the moisture content to 2 to 8 percent. Dryer inlet temperatures may be as high as 871EC (1600EF) if the furnish is wet; for dry furnish, inlet temperatures generally are no higher than 260EC (500EF). Dryers with an inlet furnish

moisture content of greater than 50 percent on a dry basis are labeled “green” dryers. A predryer may be used for initial drying of relatively wet furnish. Following predrying, the drying process is completed in a final dryer (which may be either a rotary dryer or a tube dryer). The dryer inlet temperature is adjusted based on the desired furnish moisture content at the dryer outlet. Core dryers generally operate at higher temperatures than surface dryers due to differences in core and surface particle characteristics and because a lower moisture content is more desirable for core material.

After drying, the particles pass through a primary cyclone for product recovery and then are transferred to holding bins. Face material sometimes is screened to remove the fines, which tend to absorb too much of the resin, prior to storage in the holding bins. From the holding bins, the core and surface materials are transferred to blenders, in which the particles are mixed with resin, wax, and other additives by means of spray nozzles, tubes, or atomizers. Urea-formaldehyde is the resin most commonly used for particleboard manufacture. However, phenol-formaldehyde resin may be used for particleboard produced for exterior applications.

Waxes are added to impart water resistance, increase the stability of the finished product under wet conditions, and to reduce the tendency for equipment plugging. For furnishes that are low in acidity, catalysts also may be blended with the particles to accelerate the resin cure and to reduce the press time. Formaldehyde scavengers also may be added in the blending step to reduce formaldehyde emissions from the process.

Blenders generally are designed to discharge the resinated particles into a plenum over a belt conveyor that feeds the blended material to the forming machine, which deposits the resinated material in the form of a continuous mat. Formers use air to convey the material, which is dropped or thrown into an air chamber above a moving caul, belt, or screen and floats down into position. To produce multilayer particleboard, several forming heads can be used in series, or air currents can produce a gradation of particle sizes from face to core.

As it leaves the former, the mat may be prepressed prior to trimming and pressing. The mats then are cut into desired lengths and conveyed to the press. The press applies heat and pressure to activate the resin and bond the fibers into a solid panel. Although some single-opening presses are used, most domestic particleboard plants are equipped with multi-opening batch presses. Total press time is generally 2.5 minutes (min) for single-opening presses and up to 6 min for multi-opening presses. Continuous presses may also be used to produce particleboard. Presses generally are heated using steam generated by an onsite boiler that burns wood residue. However, hot oil and hot water also are used to heat the press. The operating temperature for particleboard presses generally ranges from 149E to 182EC (300E to 360EF).

The presses used to manufacture molded particleboard products are not platen presses, but are press molds equipped with a heated die that shapes the resinated wood particles into the finished product. Press temperatures can range from 132E to 288EC (270E to 550EF). Press temperature and time vary according to the molded product being produced.

After pressing, the boards generally are cooled prior to stacking. The particleboard panels then are sanded and trimmed to final dimensions, any other finishing operations (including laminate or veneer application) are done, and the finished product is packaged for shipment.

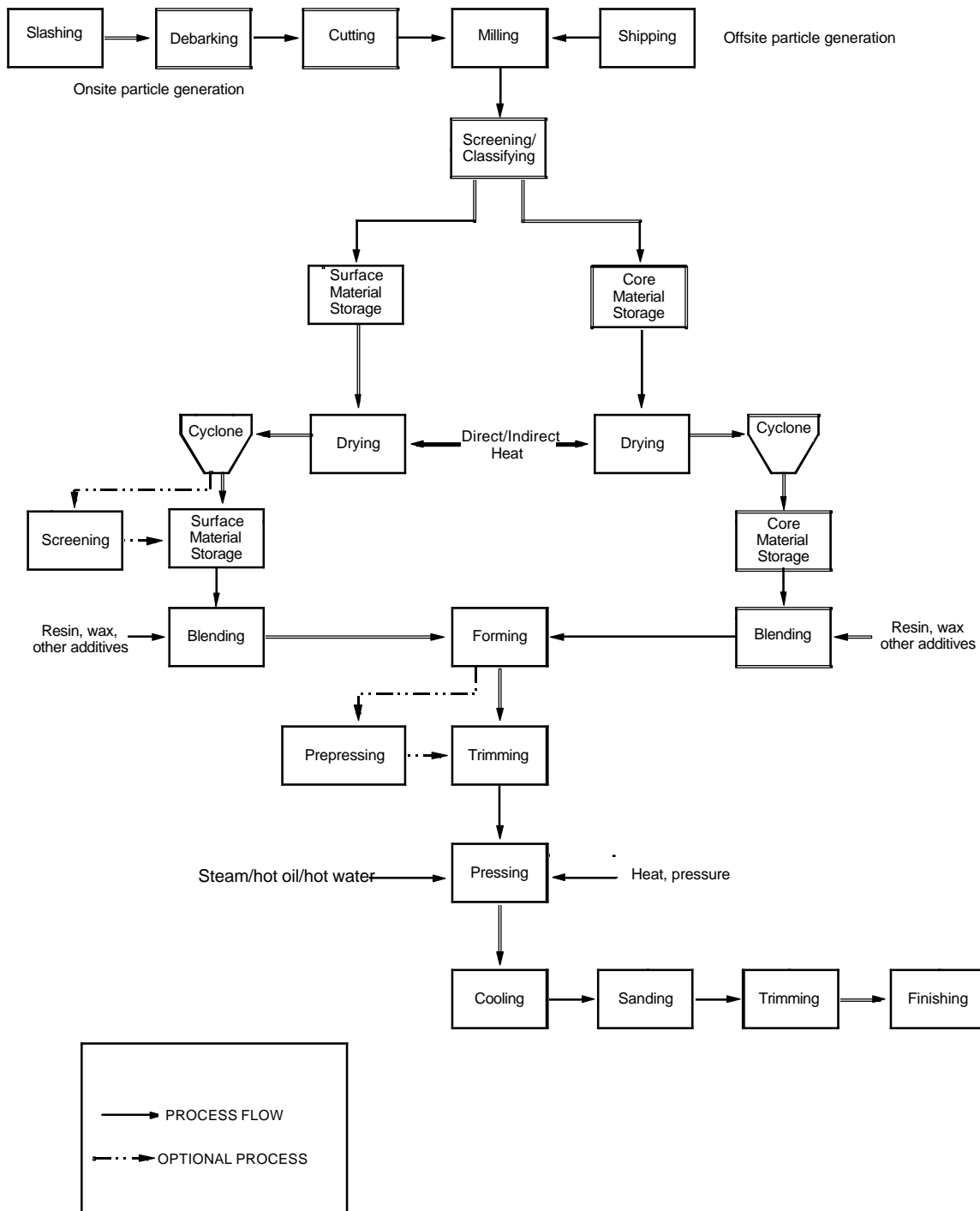


Figure 10.6.2-1. Process flow diagram for particleboard manufacturing.

### 10.6.2.3 Emissions And Controls<sup>1-35</sup> -

The primary emission sources at particleboard mills are particle dryers and hot press vents. Other emission sources may include boilers, particle generation, blending, forming, board cooling, and finishing operations such as sanding, trimming, and laminate or veneer application. Other potential emissions sources ancillary to the manufacturing process may include wood chip storage piles and bins (including wood fuel), chip handling systems, and resin storage and handling systems.

Although most particleboard mills have chips delivered from offsite locations, in mills where chips are generated onsite, operations such as log debarking and sawing, in addition to particle mills, screens, and classifiers generate particulate matter (PM) and PM less than 10 micrometers in aerodynamic diameter (PM-10) emissions in the form of sawdust and wood particles. In addition, these processes may be sources of PM less than 2.5 micrometers in aerodynamic diameter (PM-2.5) emissions.

Emissions from dryers that are exhausted from the primary recovery cyclone include wood dust and other solid PM, volatile organic compounds (VOCs), condensible PM, and products of combustion such as carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>), if direct-fired units are used. The condensible PM and a portion of the VOCs leave the dryer stack as vapor but condense at normal atmospheric temperatures to form liquid particles or mist that creates a visible blue haze. Both the VOCs and condensible PM are primarily compounds evaporated from the wood, with a minor constituent being combustion products. Quantities emitted are dependent on wood species, dryer temperature, fuel used, and other factors including season of the year, time between logging and processing, and chip storage time.

Emissions from board hot presses are dependent on the type and amount of resin used to bind the wood fibers together, as well as wood species, wood moisture content, wax and catalyst application rates, and press conditions. When the press opens, vapors that may include resin ingredients such as formaldehyde and other VOCs are released. The rate at which formaldehyde is emitted during pressing and board cooling operations is a function of the amount of excess formaldehyde in the resin, board thickness, press temperature, press cycle time, and catalyst application rates.

Emissions from finishing operations for particleboard are dependent on the type of products being finished. For most particleboard products, finishing involves trimming to size and sanding. Some products may require application of laminate surfaces or veneers with adhesives. Trimming and sanding operations are sources of PM and PM-10 emissions. In addition, these processes may be sources of PM less than 2.5 micrometers in aerodynamic diameter (PM-2.5) emissions. No data specific to particleboard trimming and sawing are available. However, emissions factors for plywood or medium density fiberboard (MDF) sawing operations may provide an order of magnitude estimate for similar particleboard sawing and trimming operations.

In particleboard mills where particles are generated onsite, PM, PM-10, and PM-2.5 emissions from log debarking, sawing, and grinding operations can be controlled through capture in an exhaust system connected to a sized cyclone and/or fabric filter collection system. Emissions of PM, PM-10, and PM-2.5 from sanding and final trimming operations can be controlled using similar methods. These wood dust capture and collection systems are used not only to control atmospheric emissions, but also to recover the dust as a by-product fuel for a boiler or dryer.

Methods of controlling PM emissions from the particleboard sources include multiclones, absorption systems (wet scrubbers), fabric filters, sand filter scrubbers, electrified filter beds (EFBs), wet electrostatic precipitators (WESPs), and oxidation systems (discussed below). The sand filter scrubber incorporates a wet scrubbing section followed by a wet-sand filter and mist eliminator. The EFB uses

electrostatic forces to attract pollutants to an electrically charged gravel bed. The WESP uses electrostatic forces to attract pollutants to either a charged metal plate or a charged metal tube. The collecting surfaces are continually rinsed with water to wash away the pollutants. Wet PM control systems such as wet scrubbers and WESP's may achieve short-term reductions in emissions of some water-soluble organic compounds (such as formaldehyde). However, the ability of these wet systems to absorb water-soluble compounds diminishes as the recirculating scrubbing liquid becomes saturated with these compounds.

A VOC control technology commonly used in the wood products industry for controlling both dryer and press exhaust gases is regenerative thermal oxidation. Thermal oxidizers destroy VOCs and condensible organics by burning them at high temperatures. Thermal oxidizers also reduce CO emissions in direct-fired dryer exhausts by oxidizing the CO in the exhaust to CO<sub>2</sub> (a product of complete combustion). Regenerative thermal oxidizers (RTOs) are designed to preheat the inlet emission stream with heat recovered from the incineration exhaust gases. Up to 98 percent heat recovery is possible, although 95 percent is typically specified. Gases entering an RTO are heated by passing through pre-heated beds packed with a ceramic media. A gas burner brings the preheated emissions up to an incineration temperature between 788E and 871EC (1450E and 1600EF) in a combustion chamber with sufficient gas residence time to complete the combustion. Combustion gases then pass through a cooled ceramic bed where heat is extracted. By reversing the flow through the beds, the heat transferred from the combustion exhaust air preheats the gases to be treated, thereby reducing auxiliary fuel requirements.

Biofiltration systems are also used effectively for control of a variety of pollutants including organic compounds, NO<sub>x</sub>, CO, and PM from press exhaust streams. Biofiltration uses microorganisms immobilized in a biofilm layer on a porous packing such as bark, wood chips, or synthetic media. Typical biofilter design consists of a three- to six-foot deep bed of media suspended over an air distribution plenum. Exhaust gases entering the plenum are evenly distributed through the moist biofilter media. As the contaminated vapor stream passes through the biofilter media, pollutants are transferred from the vapor to the biofilm and, through microbiological degradation, are converted to CO<sub>2</sub>, water, and salts. The microorganisms cannot easily attack pollutants in the gas phase; therefore, less water soluble compounds (such as pinenes) are generally more difficult to control using a biofilter than are the more water-soluble compounds (such as formaldehyde).

Fugitive PM emissions from road dust and uncovered bark and dust storage piles may be controlled in a number of different ways. These methods include enclosure, wet suppression systems, and chemical stabilization. Control techniques for these sources are discussed more fully in AP-42 Chapter 13, Miscellaneous Sources.

Calculating PM-10 emissions from wood products industry emission sources is problematic due to the relationship between PM-10 (or PM) emissions and VOC emissions from these processes. Because the Method 201A train (PM-10) operates with an in-stack cyclone and filter, organic materials that are volatile at stack gas temperatures but that are condensed at back half impinger temperatures (-20EC [-68EF]) are collected as condensible PM-10. However, these materials will also be measured as VOC via Methods 25 and 25A, which operate with a heated or an in-stack filter. Hence, if PM-10 is calculated as the sum of filterable and condensible material, some pollutants will be measured as both PM-10 and VOC emissions. However, if only filterable material is considered to be PM-10, the PM-10 emission factors will be highly dependent on stack gas temperature. In this AP-42 section, PM-10 is reported as front half catch only (Method 201A results only; not including Method 202 results). However, condensible PM results are also reported, and these results can be combined with the PM-10 results as appropriate for a specific application. Measured VOC emissions may be affected by the

sampling method and by the quantity of formaldehyde and other aldehydes and ketones in the exhaust; formaldehyde is not quantified using Method 25A. Other low molecular weight oxygenated compounds have reduced responses to Method 25A. Therefore, when VOC emissions are measured using Method 25A, the emission rates will be biased low if low molecular weight oxygenated compounds are present in significant concentrations in the exhaust stream. A more extensive discussion of these sampling and analysis issues is provided in the Background Report for this section.

Guidance from EPA's Emission Factor and Inventory Group (EFIG) indicates that when it is possible, VOC emission factors should be reported in terms of the actual weight of the emitted compound. However, when an actual molecular weight (MW) of the emitted stream is not feasible (as is the case with the mixed streams emitted from wood products industry sources), the VOC should be reported using an assumed MW of 44, and reported "as propane." Each VOC-as-propane emission factor is estimated by first converting the THC from a carbon basis to a propane basis. Propane (MW = 44) includes 3 carbon atoms (total MW of 36) and 8 hydrogen atoms (total MW of 8). Every 36 pounds of carbon measured corresponds to 44 pounds of propane. The ratio of the MW of propane to the MW of carbon in propane is 44/36, or 1.22. The conversion is expressed by the following equation:

$$\text{THC as pounds carbon} \times \frac{44 \text{ pounds propane}}{36 \text{ pounds carbon}} = \text{THC as pounds propane}$$

or

$$\text{THC as pounds carbon} \times 1.22 = \text{THC as pounds propane}$$

After the THC emission factor has been converted from a carbon to a propane basis, the formaldehyde emission factor is added (where available), then the available emission factors for non-VOC compounds, including acetone, methane, and methylene chloride, are subtracted. This procedure is expressed simply by the following equation:

$$\text{VOC as propane} = (1.22 \times \text{THC as carbon}) + \text{formaldehyde} - (\text{acetone} + \text{methane} + \text{methylene chloride})$$

In cases where no emission factor is available (or the emission factor is reported only as below the test method detection limit, or "BDL") for one or more of the compounds used to estimate the VOC-as-propane value, adjustments to the converted THC value are made only for those compounds for which emission factors are available. That is, a value of zero is inserted in the above equation for the specified compounds where no emission factor is available, or where the emission factor is reported only as BDL. For example, if no methane emission factor is available, the THC-as-carbon emission factor is converted to THC-as-propane, formaldehyde is added, and only acetone and methylene chloride are subtracted.

Table 10.6.2-1 presents emission factors for dryer emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.2-2 presents emissions factors for dryer emissions of NO<sub>x</sub>, CO, and CO<sub>2</sub>. Table 10.6.2-3 presents emission factors for dryer emissions of organic pollutants. The emission factors for dryer emissions are presented in units of pounds of pollutant per oven-dried ton of wood material out of the dryer (lb/ODT). Table 10.6.2-4 presents emission factors for press and board cooler emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.2-5 presents emission factors for press and board cooler emissions of NO<sub>x</sub> and CO. Table 10.6.2-6 presents emission factors for press and board cooler emissions of organic pollutants. The units for the press and board cooler emission factors are pounds of pollutant per thousand square feet of 3/4-inch thick panel produced (lb/MSF 3/4). Table 10.6.2-7 presents emission factors for miscellaneous sources of organic pollutants.

Emission factors for every possible mix of hardwood and softwood species cannot be reported in this section. Emission factors for specific mixes of wood species may be calculated by combining

emission factors for individual wood species in the ratio specific to a given application, as emission data for those species become available. For example, a THC as carbon emission factor for a direct wood-fired rotary dryer processing 60 percent softwood and 40 percent hardwood may be calculated using the THC as carbon emission factors for softwood (1.0 lb/ODT) and hardwood (0.20 lb/ODT), and the ratio of 60 percent to 40 percent. The resultant emission factor, rounded to two significant figures, would be 0.68 lb/ODT.

Table 10.6.2-1. EMISSION FACTORS FOR PARTICLEBOARD DRYERS--  
PARTICULATE MATTER<sup>a</sup>

Source	Emission control device <sup>c</sup>	Filterable <sup>b</sup>				Condensible <sup>d</sup>	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
Rotary dryer, direct wood-fired, hardwood	Uncontrolled MCLO SCBR EFB	2.5 <sup>e</sup>	D	ND		0.13 <sup>e</sup>	E
		2.7 <sup>e</sup>	D	ND		0.23 <sup>e</sup>	D
		0.93 <sup>e</sup>	D	ND		0.024 <sup>e</sup>	D
		0.19 <sup>e</sup>	D	ND		0.087 <sup>e</sup>	D
Rotary dryer, direct wood-fired, softwood	Uncontrolled MCLO	3.4 <sup>e</sup>	D	0.69 <sup>e</sup>	D	0.20 <sup>e</sup>	D
		0.93 <sup>f</sup>	D	ND		ND	
Rotary dryer, direct wood-fired, mixed species (35-60% softwood, 40-65% hardwood)	Uncontrolled EFB	2.2 <sup>g</sup>	D	ND		0.58 <sup>g</sup>	D
		0.28 <sup>h</sup>	D	ND		0.20 <sup>h</sup>	D
Rotary dryer, green, direct wood-fired (inlet moisture content >50%, dry basis), softwood	Uncontrolled MCLO BH EFB EFB/BH	1.9 <sup>j</sup>	E	ND		0.83 <sup>j</sup>	E
		2.5 <sup>e</sup>	E	ND		ND	
		1.4 <sup>j</sup>	E	ND		0.97 <sup>j</sup>	E
		1.5 <sup>e</sup>	E	0.64 <sup>e</sup>	E	1.8 <sup>e</sup>	E
		0.20 <sup>j</sup>	E	ND		0.84 <sup>j</sup>	E
Rotary dryer, green, direct wood-fired (inlet moisture content >50%, dry basis), mixed species (40-60% softwood, 40-60% hardwood)	MCLO BH EFB EFB/BH	2.0 <sup>e</sup>	E	ND		ND	
		1.3 <sup>j</sup>	E	ND		0.43 <sup>j</sup>	E
		0.27 <sup>e</sup>	E	0.11 <sup>e</sup>	D	0.66 <sup>e</sup>	E
		0.15 <sup>k</sup>	E	ND		0.72 <sup>k</sup>	E
Rotary dryer, direct natural gas-fired, hardwood	Uncontrolled MCLO EFB	10.4 <sup>m</sup>	E	ND		0.12 <sup>m</sup>	E
		6.4 <sup>m</sup>	E	ND		0.39 <sup>m</sup>	E
		0.31 <sup>n</sup>	E	ND		0.10 <sup>n</sup>	E
Rotary dryer, direct natural gas-fired, softwood	Uncontrolled MCLO	0.30 <sup>p</sup>	E	ND		0.16 <sup>p</sup>	E
		0.47 <sup>q</sup>	D	ND		0.10 <sup>r</sup>	D

<sup>a</sup> Emission factor units are pounds of pollutant per oven-dried ton of wood material out of dryer (lb/ODT). One lb/ODT = 0.5 kg/Mg (oven-dried). Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available.

<sup>b</sup> Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. Filterable PM-10 is that PM collected on the filter, or in the sample line between the cyclone and filter of an EPA Method 201 or 201A sampling train.

<sup>c</sup> Emission control device: MCLO = multiclone; SCBR = wet scrubber; EFB = electrified filter bed; BH = baghouse (fabric filter).

<sup>d</sup> Condensible PM is that PM collected in the impinger portion of a PM sampling train (EPA Method 202).

<sup>e</sup> Reference 7.

<sup>f</sup> References 8, 9, and 10.

<sup>g</sup> References 11 and 12.

<sup>h</sup> References 7 and 13.

<sup>j</sup> Reference 14.

<sup>k</sup> Reference 11.



Table 10.6.2-1 (cont.).

<sup>m</sup> Reference 15.

<sup>n</sup> Reference 16.

<sup>p</sup> Reference 17.

<sup>q</sup> Reference 8 and 18.

<sup>r</sup> Reference 18.

Table 10.6.2-2. EMISSION FACTORS FOR PARTICLEBOARD DRYERS--NO<sub>x</sub>, CO, AND CO<sub>2</sub> <sup>a</sup>

Source <sup>b</sup>	Emission control device	NO <sub>x</sub>	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO <sub>2</sub>	EMISSION FACTOR RATING
Rotary dryer, direct wood-fired, hardwood	Uncontrolled	0.92 <sup>c</sup>	D	5.7 <sup>c</sup>	D	ND	
Rotary dryer, direct wood-fired, softwood	Uncontrolled	0.58 <sup>d</sup>	D	0.68 <sup>e</sup>	C	ND	
Rotary dryer, direct wood-fired, mixed species (35-60% softwood, 40-65% hardwood)	Uncontrolled	1.8 <sup>f</sup>	D	0.59 <sup>c</sup>	D	538 <sup>g</sup>	D
Rotary dryer, green, direct wood-fired (inlet moisture content >50%, dry basis), softwood	Uncontrolled	2.7 <sup>h</sup>	D	3.5 <sup>h</sup>	D	573 <sup>j</sup>	D
Rotary dryer, green, direct wood-fired (inlet moisture content >50%, dry basis), mixed species (40-60% softwood, 40-60% hardwood)	Uncontrolled	1.4 <sup>c</sup>	E	0.77 <sup>k</sup>	D	ND	
Rotary dryer, direct natural gas-fired, hardwood	Uncontrolled	0.024 <sup>m</sup>	E	1.2 <sup>m</sup>	E	311 <sup>n</sup>	E
Rotary dryer, green, direct natural gas-fired (inlet moisture content >50%, dry basis), softwood	Uncontrolled	ND		ND		237 <sup>p</sup>	D
Rotary dryer, indirect heated with auxiliary natural gas, softwood	Uncontrolled	0.31 <sup>c</sup>	D	0.12 <sup>c</sup>	D	38.2 <sup>q</sup>	D
Tube dryer, direct wood-fired, blowline blend, UF resin, hardwood	Uncontrolled	ND		ND		447 <sup>r</sup>	E

<sup>a</sup> Emission factor units are pounds of pollutant per oven-dried ton of wood material out of dryer (lb/ODT). One lb/ODT = 0.5 kg/Mg (oven-dried). Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available.

<sup>b</sup> UF = urea formaldehyde.

Table 10.6.2-2 (cont.).

- <sup>c</sup> Reference 7.
- <sup>d</sup> References 7, 9, and 10.
- <sup>e</sup> References 7, 9, 10, and 19.
- <sup>f</sup> References 7, 12, and 13.
- <sup>g</sup> References 11, 12, 13, and 14.
- <sup>h</sup> References 7, 20, and 21.
- <sup>j</sup> References 14, 20, and 21.
- <sup>k</sup> References 7 and 19.
- <sup>m</sup> Reference 15.
- <sup>n</sup> Reference 22.
- <sup>p</sup> References 21 and 23.
- <sup>q</sup> Reference 24.
- <sup>r</sup> Reference 25.

Table 10.6.2-3. EMISSION FACTORS FOR PARTICLEBOARD DRYERS--ORGANICS<sup>a</sup>

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, direct wood-fired, hardwood	Uncontrolled		THC as carbon <sup>d</sup> VOC as propane <sup>e</sup>	0.20 <sup>f</sup> 0.24	D E

Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, direct wood-fired, softwood	Uncontrolled	71-55-6	THC as carbon <sup>d</sup>	1.0 <sup>g</sup>	C
			VOC as propane <sup>e</sup>	0.90	D
			1,1,1-Trichloroethane *	0.000012 <sup>f</sup>	D
		95-63-6	1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			1,2,4-Trimethyl benzene	0.000090 <sup>f</sup>	D
		5779-94-2	2,5-Dimethyl benzaldehyde	0.000033 <sup>f,y</sup>	E
		13466-78-9	3-Carene	0.076	D
		75-07-0	Acetaldehyde *	0.013	D
		67-64-1	Acetone	0.084 <sup>h</sup>	D
		98-86-2	Acetophenone	0.000064 <sup>f</sup>	D
		107-02-8	Acrolein *	0.0045	D
		80-56-8	Alpha-pinene	0.39 <sup>f,y</sup>	D
		100-52-7	Benzaldehyde	0.0026 <sup>f,y</sup>	E
		71-43-2	Benzene *	0.00099 <sup>h</sup>	D
		127-91-3	Beta-pinene	0.12	D
		92-52-4	Biphenyl *	0.000039 <sup>f</sup>	D
		117-81-7	Bis-(2-ethylhexyl phthalate)	0.00032 <sup>f</sup>	D
		74-83-9	Bromomethane *	0.000028 <sup>f,y</sup>	D
		123-72-8	Butylaldehyde	0.0031 <sup>f,y</sup>	E
		85-68-7	Butylbenzyl phthalate	0.000014 <sup>f</sup>	E
		75-15-0	Camphene	BDL	
			Carbon disulfide *	0.000018 <sup>f</sup>	D
			Carbon tetrachloride *	0.000012 <sup>f</sup>	D
		74-87-3	Chloroethane *	BDL	
			Chloroethene *	BDL	
			Chloromethane *	0.00011 <sup>f</sup>	D
		98-82-8	Cis-1,2-dichloroethylene	BDL	
			Cumene *	0.000069 <sup>f</sup>	D
			Di-N-butyl phthalate	0.000023 <sup>f</sup>	D
		75-18-3	Dimethyl sulfide	0.000014 <sup>f</sup>	E
		74-84-0	Ethane	0.015 <sup>j</sup>	D
		100-41-4	Ethyl benzene *	0.0000038 <sup>f</sup>	E
		50-00-0	Formaldehyde *	0.025 <sup>k</sup>	C
		66-25-1	Hexaldehyde	0.016 <sup>f,y</sup>	E
		123-31-9	Hydroquinone	0.000060 <sup>f</sup>	E
		590-86-3	Isovaleraldehyde	0.00052 <sup>f,y</sup>	E
		138-86-3	Limonene	0.034	D
		1330-20-7	m-, p-Xylene *	0.00055 <sup>h</sup>	D
		620-23-5	m-Tolualdehyde	0.00045 <sup>f,y</sup>	E
		74-82-8	Methane	0.26 <sup>j</sup>	D
		67-56-1	Methanol *	0.014 <sup>m</sup>	D
		78-93-3	Methyl ethyl ketone *	0.0049 <sup>h</sup>	D
		108-10-1	Methyl isobutyl ketone *	0.0024 <sup>h</sup>	D
		75-09-2	Methylene chloride *	0.00063 <sup>h</sup>	D
		110-54-3	n-Hexane	0.000026 <sup>f</sup>	E
		95-47-6	o-Xylene *	0.000014 <sup>f</sup>	D
		108-95-2	p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
			Phenol *	0.0066	D
		123-38-6	Propionaldehyde *	0.0032 <sup>f</sup>	D
		100-42-5	Styrene *	0.00012 <sup>f</sup>	E
		108-88-3	Toluene *	0.0021 <sup>h</sup>	D
		110-62-3	Valeraldehyde	0.0016 <sup>f,y</sup>	E

Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, direct wood-fired, mixed species (35-60% softwood, 40-65% hardwood)	Uncontrolled		THC as carbon <sup>d</sup> VOC as propane <sup>e</sup>	0.048 <sup>f</sup> 0.059	E E

Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, green, direct wood-fired, softwood (inlet moisture content >50%, dry basis)	Uncontrolled		THC as carbon <sup>d</sup>	3.9 <sup>n</sup>	D
			VOC as propane <sup>e</sup>	4.7	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
		5779-94-2	2,5-Dimethyl benzaldehyde	0.0053 <sup>f,y</sup>	E
		13466-78-9	3-Carene	0.043	E
		80-56-8	Alpha-pinene	1.4 <sup>h</sup>	D
		8006-64-2	a-Terpene	0.17 <sup>f</sup>	E
		75-07-0	Acetaldehyde *	0.075 <sup>h</sup>	D
		67-64-1	Acetone	0.19 <sup>h</sup>	D
		107-02-8	Acrolein *	0.023 <sup>f,y</sup>	E
		127-91-3	Beta-pinene	0.52 <sup>h</sup>	D
		100-52-7	Benzaldehyde	0.12 <sup>f,y</sup>	E
		71-43-2	Benzene *	0.0076	D
			Bromomethane *	BDL	
		123-72-8	Butylaldehyde	0.029 <sup>f,y</sup>	E
		79-92-5	Camphene	0.043	E
			Chloroethane *	BDL	
			Chloroethene *	BDL <sup>f</sup>	
		67-66-3	Chloroform	0.00010 <sup>f</sup>	E
			Cis-1,2-dichloroethylene	BDL	
		4170-30-3	Crotonaldehyde	0.010 <sup>f,y</sup>	E
		98-82-8	Cumene *	0.0020 <sup>f</sup>	E
		50-00-0	Formaldehyde *	0.14 <sup>p</sup>	D
		66-25-1	Hexaldehyde	0.022 <sup>f,y</sup>	E
		590-86-3	Isovaleraldehyde	0.018 <sup>f,y</sup>	E
		138-86-3	Limonene	0.043	E
		67-56-1	Methanol *	0.11 <sup>q</sup>	D
		78-93-3	Methyl ethyl ketone *	BDL	
		108-10-1	Methyl isobutyl ketone *	0.0069	D
		75-09-2	Methylene chloride *	0.0018 <sup>h</sup>	D
		1330-20-7	m,p-Xylene *	0.0048 <sup>h</sup>	D
		123-72-8	n-Butyraldehyde	0.030 <sup>f,y</sup>	E
		529-20-4	o-Tolualdehyde	0.011 <sup>f,y</sup>	E
		95-47-6	o-Xylene *	0.00045 <sup>f</sup>	E
		99-87-6	p-Cymene	0.027 <sup>h</sup>	D
		99-83-2	p-Mentha-1,5-diene	0.043	E
		104-87-0	p-Tolualdehyde	0.026 <sup>f,y</sup>	E
		108-95-2	Phenol *	0.028	D
		123-38-6	Propionaldehyde *	0.013 <sup>h</sup>	D
		100-42-5	Styrene *	0.00036 <sup>f</sup>	E
		108-88-3	Toluene *	0.013 <sup>h</sup>	D
		110-62-3	Valeraldehyde	0.014 <sup>f,y</sup>	E

Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, green, direct wood-fired, mixed species (40-60% softwood, 40-60% hardwood) (inlet moisture content >50%, dry basis)	Uncontrolled		THC as carbon <sup>d</sup>	1.3 <sup>h</sup>	D
			VOC as propane <sup>e</sup>	1.6	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
		5779-94-2	2,5-Dimethyl benzaldehyde	0.0015 <sup>f,y</sup>	E
		13466-78-9	3-Carene	0.040	D
		80-56-8	Alpha-pinene	0.51 <sup>h</sup>	D
		8006-64-2	a-Terpene	0.053 <sup>f</sup>	E
		75-07-0	Acetaldehyde *	0.059 <sup>h</sup>	D
		67-64-1	Acetone	0.047 <sup>h</sup>	D
		107-02-8	Acrolein *	0.015	D
		127-91-3	Beta-pinene	0.11 <sup>h</sup>	D
		100-52-7	Benzaldehyde	0.0082 <sup>f,y</sup>	E
		71-43-2	Benzene *	0.0047	D
			Bromomethane *	BDL	
		123-72-8	Butylaldehyde	0.0019 <sup>f,y</sup>	E
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
		156-59-2	Cis-1,2-dichloroethylene	0.0012	D
		4170-30-3	Crotonaldehyde	0.00082 <sup>f,y</sup>	E
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.096 <sup>h</sup>	D
		66-25-1	Hexaldehyde	0.0062 <sup>f,y</sup>	E
		590-86-3	Isovaleraldehyde	0.0011 <sup>f,y</sup>	E
			Limonene	BDL	
		67-56-1	Methanol *	0.059	D
		78-93-3	Methyl ethyl ketone *	0.0034	D
			Methyl isobutyl ketone *	BDL	
		75-09-2	Methylene chloride *	0.0014 <sup>h</sup>	D
		1330-20-7	m,p-Xylene *	0.0058	D
		529-20-4	o-Tolualdehyde	0.00066 <sup>f,y</sup>	E
		95-47-6	o-Xylene *	0.00058	D
		99-87-6	p-Cymene	0.0016 <sup>f</sup>	D
			p-Mentha-1,5-diene	BDL	
		104-87-0	p-Tolualdehyde	0.0046 <sup>f,y</sup>	E
		108-95-2	Phenol *	0.0079	D
		123-38-6	Propionaldehyde *	0.0042 <sup>h</sup>	D
		100-42-5	Styrene *	0.00057	D
		108-88-3	Toluene *	0.0059 <sup>h</sup>	D
		110-62-3	Valeraldehyde	0.0040 <sup>f,y</sup>	E



Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, green, direct wood-fired, mixed species (40-60% softwood, 40-60% hardwood) (inlet moisture content >50%, dry basis)	RTO	67-64-1	THC as carbon <sup>d</sup>	0.013	E
			VOC as propane <sup>e</sup>	0.013	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	BDL	
		71-43-2	Acetone	0.0033	E
			Acrolein *	BDL	
			Alpha-pinene	BDL	
			Benzene *	0.00055	E
			Beta-pinene	BDL	
		50-00-0	Bromomethane *	BDL	
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
		67-56-1	Cumene *	BDL	
			Formaldehyde *	0.00055	E
			Limonene	BDL	
			Methanol *	0.0019	E
			Methyl ethyl ketone *	BDL	
			Methyl isobutyl ketone *	BDL	
		75-09-2	Methylene chloride *	0.00060	E
			m,p-Xylene *	0.00075	E
			o-Xylene *	0.00075	E
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
		1330-20-7	Phenol *	BDL	
			Propionaldehyde *	BDL	
			Styrene *	0.00074	E
			Toluene *	0.00065	E
Rotary dryer, direct natural gas-fired, hardwood	Uncontrolled	50-00-0	THC as carbon <sup>d</sup>	0.21 <sup>r</sup>	E
			VOC as propane <sup>e</sup>	0.28	E
			Formaldehyde *	0.028 <sup>s</sup>	E
Rotary dryer, direct natural gas-fired, softwood	Uncontrolled	50-00-0	THC as carbon <sup>d</sup>	1.6 <sup>t</sup>	D
			VOC as propane <sup>e</sup>	2.0	E
			Formaldehyde *	0.0086 <sup>u</sup>	E
			Methanol *	0.073 <sup>u</sup>	E
Rotary dryer, green, direct natural gas-fired, softwood (inlet moisture content >50%, dry basis)	Uncontrolled	50-00-0	THC as carbon <sup>d</sup>	0.77 <sup>v</sup>	E
			VOC as propane <sup>e</sup>	0.94	E
			Formaldehyde *	0.0042 <sup>v</sup>	E
			Methanol *	BDL	

Table 10.6.2-3 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary dryer, indirect heated with auxiliary natural gas, softwood	Uncontrolled		THC as carbon <sup>d</sup>	0.43 <sup>w</sup>	D
			VOC as propane <sup>e</sup>	0.30	E
		50-00-0	Formaldehyde *	0.047 <sup>x</sup>	D
		64-82-8	Methane	0.27 <sup>t</sup>	D
		67-56-1	Methanol *	0.027 <sup>x</sup>	D

<sup>a</sup> Emission factor units are pounds of pollutant per oven-dried ton of wood material out of dryer (lb/ODT). One lb/ODT = 0.5 kg/Mg (oven-dried). Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. \* = hazardous air pollutant. BDL = below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. Reference 19 unless otherwise noted.

<sup>b</sup> Emission control device: RTO = regenerative thermal oxidizer.

<sup>c</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>d</sup> THC as carbon = total hydrocarbon measurements using EPA Method 25A.

<sup>e</sup> VOC as propane =  $(1.22 \times \text{THC}) + \text{formaldehyde} - (\text{acetone} + \text{methane} + \text{methylene chloride})$ ; a value of zero is inserted in the equation for the specified compounds where no emission factor is available, or where the emission factor is reported only as "BDL".

<sup>f</sup> Reference 7.

<sup>g</sup> References 7, 9, 10, and 19.

<sup>h</sup> References 7 and 19.

<sup>j</sup> References 9 and 10.

<sup>k</sup> References 7, 9, 19, and 26.

<sup>m</sup> References 9, 19, and 26.

<sup>n</sup> References 7, 19, 20, and 21.

<sup>p</sup> References 7, 19, 20, 21, and 27.

<sup>q</sup> References 19 and 21.

<sup>r</sup> Reference 15.

<sup>s</sup> Reference 22.

<sup>t</sup> References 17 and 18.

<sup>u</sup> Reference 17.

<sup>v</sup> Reference 23.

<sup>w</sup> References 7 and 24.

<sup>x</sup> Reference 24.

<sup>y</sup> Based on M0011 data only; suspected to be biased low due to poor collection efficiency or analytical problems.

Table 10.6.2-4. EMISSION FACTORS FOR PARTICLEBOARD PRESSES AND BOARD COOLERS--PARTICULATE MATTER<sup>a</sup>

Source <sup>c</sup>	Emission control device	Filterable <sup>b</sup>				Condensible <sup>d</sup>	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
Hot press, UF resin	Uncontrolled	0.20 <sup>e</sup>	D	0.016 <sup>f</sup>	E	0.23 <sup>g</sup>	D
Board cooler, UF resin	Uncontrolled	0.15 <sup>g</sup>	D	ND		0.077 <sup>g</sup>	D

<sup>a</sup> Emission factor units are pounds of pollutant per thousand square feet of 3/4-inch thick panel (lb/MSF 3/4). One lb/MSF 3/4 = 0.26 kg/m<sup>3</sup>. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available.

<sup>b</sup> Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train. Filterable PM-10 is that PM collected on the filter, or in the sample line between the cyclone and filter of an EPA Method 201 or 201A sampling train.

<sup>c</sup> UF = urea formaldehyde.

<sup>d</sup> Condensible PM is that PM collected in the impinger portion of a PM sampling train (EPA Method 202).

<sup>e</sup> References 7, 26, 28, and 29.

<sup>f</sup> Reference 7.

<sup>g</sup> References 28 and 29.

Table 10.6.2-5. EMISSION FACTORS FOR PARTICLEBOARD PRESSES AND BOARD COOLERS--NO<sub>x</sub>, CO, AND CO<sub>2</sub> <sup>a</sup>

Source <sup>b</sup>	Emission control device <sup>c</sup>	NO <sub>x</sub>	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO <sub>2</sub>	EMISSION FACTOR RATING
Hot press, UF resin	Uncontrolled	0.017 <sup>d</sup>	E	0.22 <sup>e</sup>	D	ND	
	RTO	0.092 <sup>d</sup>	E	0.090 <sup>f</sup>	D	ND	
Board cooler, UF resin	Uncontrolled	ND		0.15 <sup>g</sup>	D	ND	

<sup>a</sup> Emission factor units are pounds of pollutant per thousand square feet of 3/4-inch thick panel (lb/MSF 3/4). One lb/MSF 3/4 = 0.26 kg/m<sup>3</sup>. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available.

<sup>b</sup> UF = urea formaldehyde.

<sup>c</sup> Emission control device: RTO = regenerative thermal oxidizer.

<sup>d</sup> Reference 26.

<sup>e</sup> References 7, 15, 19, 26, 28, and 29.

<sup>f</sup> References 19 and 26.

<sup>g</sup> References 28 and 29.

Table 10.6.2-6. EMISSION FACTORS FOR PARTICLEBOARD PRESSES AND BOARD COOLERS--ORGANICS<sup>a</sup>

Source <sup>b</sup>	Emission control device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Hot press, UF resin	Uncontrolled		THC as carbon <sup>e</sup>	0.79 <sup>g</sup>	C
			VOC as propane <sup>f</sup>	1.1	D
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL <sup>h,j</sup>	
		5779-94-2	2,5-Dimethyl benzaldehyde	0.00032 <sup>h,j</sup>	E
		13466-78-9	3-Carene	0.036	D
		75-07-0	Acetaldehyde *	0.011 <sup>k</sup>	D
		67-64-1	Acetone	0.029 <sup>m</sup>	D
		107-02-8	Acrolein *	0.0054 <sup>m</sup>	D
		80-56-8	Alpha-pinene	0.40	D
		100-52-7	Benzaldehyde	0.0018 <sup>j,n</sup>	E
		71-43-2	Benzene *	0.0030	D
		127-91-3	Beta-pinene	0.11	D
			Bromomethane *	BDL	
		123-72-8	Butylaldehyde	0.0019 <sup>j,n</sup>	E
		79-92-5	Camphene	0.044	D
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL <sup>h,j</sup>	
		4170-30-3	Crotonaldehyde	0.00050 <sup>h,j</sup>	E
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.23 <sup>p</sup>	C
		66-25-1	Hexaldehyde	0.010 <sup>j,n</sup>	E
		590-86-3	Isovaleraldehyde	0.0011 <sup>h,j</sup>	E
		138-86-3	Limonene	0.036	D
		74-82-8	Methane	0.011 <sup>q</sup>	E
		67-56-1	Methanol *	0.59 <sup>r</sup>	D
		78-93-3	Methyl ethyl ketone *	0.0052 <sup>m</sup>	D
		108-10-1	Methyl isobutyl ketone *	0.0099	D
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
			o-Xylene *	BDL	
		99-87-6	p-Cymene	0.035	D
		99-83-2	p-Mentha-1,5-diene	0.036	D
		108-95-2	Phenol *	0.011	D
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL <sup>h,j</sup>	
		110-62-3	Valeraldehyde	0.0039 <sup>h,j</sup>	E

Table 10.6.2-6 (cont.).

Source <sup>b</sup>	Emission control device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Hot press, UF resin	RTO	50-00-0	THC as carbon <sup>e</sup>	0.018	E
			VOC as propane <sup>f</sup>	0.027	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	BDL	
			Acetone	BDL	
			Acrolein *	BDL	
			Alpha-pinene	BDL	
			Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Cumene *	BDL	
			Formaldehyde *	0.0054 <sup>f</sup>	D
			Limonene	BDL	
			Methanol *	BDL	
			Methyl ethyl ketone *	BDL	
			Methyl isobutyl ketone *	BDL	
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
			o-Xylene *	BDL	
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
		108-95-2	Phenol *	0.0082	E
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	

Table 10.6.2-6 (cont.).

Source <sup>b</sup>	Emission control device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission factor	EMISSION FACTOR RATING
Board cooler, UF resin	Uncontrolled		THC as carbon <sup>e</sup>	0.069 <sup>s</sup>	D
			VOC as propane <sup>f</sup>	0.091	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.0036 <sup>t</sup>	D
		67-64-1	Acetone	0.0083 <sup>m</sup>	D
		107-02-8	Acrolein *	0.00036 <sup>h,j</sup>	E
		80-56-8	Alpha-pinene	0.050	D
		100-52-7	Benzaldehyde	0.00042 <sup>h,j</sup>	E
		123-72-8	Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
			Butylaldehyde	0.00060 <sup>h,j</sup>	E
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Crotonaldehyde	0.00029 <sup>h,j</sup>	E
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.015 <sup>u</sup>	D
		66-25-1	Hexaldehyde	0.0011 <sup>h,j</sup>	E
		590-86-3	Isovaleraldehyde	0.00040 <sup>h,j</sup>	E
		67-56-1	Limonene	BDL	
			Methanol *	0.081	D
			Methyl ethyl ketone *	0.00011 <sup>h,j</sup>	E
			Methyl isobutyl ketone *	0.0032	E
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
			o-Xylene *	BDL	
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
			Phenol *	0.0066	D
		108-95-2	Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	
			Valeraldehyde	0.0015 <sup>h,j</sup>	E

<sup>a</sup> Emission factor units are pounds of pollutant per thousand square feet of 3/4-inch thick panel (lb/MSF 3/4). One lb/MSF 3/4 = 0.26 kg/m<sup>3</sup>. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. \* = hazardous air pollutant. BDL = below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. Reference 19 unless otherwise noted.

<sup>b</sup> UF = urea formaldehyde.

<sup>c</sup> Emission control device: RTO = regenerative thermal oxidizer.

<sup>d</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>e</sup> THC as carbon = total hydrocarbon measurements using EPA Method 25A.

Table 10.6.2-6 (cont.).

- <sup>f</sup> VOC as propane =  $(1.22 \times \text{THC}) + \text{formaldehyde} - (\text{acetone} + \text{methane} + \text{methylene chloride})$ ; a value of zero is inserted in the equation for the specified compounds where no emission factor is available, or where the emission factor is reported only as “BDL”.
- <sup>g</sup> References 7, 15, 19, 26, 28, 29, and 30.
- <sup>h</sup> Reference 7.
- <sup>j</sup> Based on M0011 data only; suspected to be biased low due to poor collection efficiency or analytical problems.
- <sup>k</sup> References 7, 15, and 19.
- <sup>m</sup> Reference 19.
- <sup>n</sup> References 7 and 15.
- <sup>p</sup> References 7, 15, 19, 26, 28, 29, 31, 32, 33, and 34.
- <sup>q</sup> Reference 26.
- <sup>r</sup> References 19 and 26.
- <sup>s</sup> References 7, 28, 29, and 30.
- <sup>t</sup> References 7 and 19.
- <sup>u</sup> References 19, 28, and 29.

Table 10.6.2-7. EMISSION FACTORS FOR PARTICLEBOARD MISCELLANEOUS SOURCES--  
ORGANICS<sup>a</sup>

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	Emission factor units <sup>d</sup>	EMISSION FACTOR RATING
Flaker/ refiner/ hammermill	Uncontrolled	67-64-1	THC as carbon <sup>e</sup>	0.94	lb/ODT	D
			VOC as propane <sup>f</sup>	1.1	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
			Acetone	0.0064	lb/ODT	D
			Acrolein *	BDL		
			Alpha-pinene	0.49	lb/ODT	D
			Benzene *	BDL		
		127-91-3	Beta-pinene	0.15	lb/ODT	D
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
			Formaldehyde *	BDL		
			Limonene	BDL		
		67-56-1	Methanol *	0.0073	lb/ODT	D
			Methyl ethyl ketone *	BDL		
			Methyl isobutyl ketone *	BDL		
			Methylene chloride *	BDL		
			m,p-Xylene *	BDL		
			o-Xylene *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
		108-95-2	Phenol *	0.0045	lb/ODT	E
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		



Table 10.6.2-7 (cont.).

Source	Emission control device <sup>b</sup>	CASRN <sup>c</sup>	Pollutant	Emission factor	Emission factor units <sup>d</sup>	EMISSION FACTOR RATING
Sander	Uncontrolled	67-64-1	THC as carbon <sup>e</sup> VOC as propane <sup>f</sup>	0.069 0.079	lb/MSF lb/MSF	E E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
			Acetone	0.0051	lb/MSF	E
			Acrolein *	BDL		
		80-56-8	Alpha-pinene	0.048	lb/MSF	E
			Benzene *	BDL		
			Beta-pinene	BDL		
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
			Formaldehyde *	BDL		
		67-56-1	Limonene	BDL		
			Methanol *	0.013	lb/MSF	E
			Methyl ethyl ketone *	BDL		
			Methyl isobutyl ketone *	BDL		
			Methylene chloride *	BDL		
			m,p-Xylene *	BDL		
			o-Xylene *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
			Phenol *	0.015	lb/MSF	E
		108-95-2	Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		
Veneer press, UF resin  (gluing veneer to particle- board substrate)	Uncontrolled	71-55-6	1,1,1-Trichloroethane *	0.00022 <sup>g</sup>	lb/MSF 3/4	E
		80-56-8	Alpha-pinene	0.00054 <sup>g</sup>	lb/MSF 3/4	E
		75-07-0	Acetaldehyde *	0.000099 <sup>g</sup>	lb/MSF 3/4	E
		127-91-3	Beta-pinene	0.00011 <sup>g</sup>	lb/MSF 3/4	E
		50-00-0	Formaldehyde *	0.0062 <sup>g</sup>	lb/MSF 3/4	E
		66-25-1	Hexaldehyde	0.00017 <sup>g,h</sup>	lb/MSF 3/4	E
		78-93-3	Methyl ethyl ketone *	0.00020 <sup>g</sup>	lb/MSF 3/4	E
		123-72-8	n-Butylaldehyde	0.00014 <sup>g,h</sup>	lb/MSF 3/4	E
		108-88-3	Toluene *	0.00047 <sup>g</sup>	lb/MSF 3/4	E

<sup>a</sup> Emission factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code.  
\* = hazardous air pollutant. BDL = below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. Reference 19 unless otherwise noted.

<sup>b</sup> Emission control devices (baghouses) are considered no control for organic pollutants.

<sup>c</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>d</sup> Emission factor units: Pounds of pollutant per oven-dried ton of wood material (lb/ODT). One lb/ODT = 0.5 kg/Mg (oven-dried). Pounds of pollutant per thousand square feet of panel (lb/MSF). One lb/MSF = 0.0049 kg/m<sup>2</sup>. Pounds of pollutant per thousand square feet of 3/4-inch thick panel (lb/MSF 3/4). One lb/MSF 3/4 = 0.26 kg/m<sup>3</sup>.

<sup>e</sup> THC as carbon = total hydrocarbon measurements using EPA Method 25A.

<sup>f</sup> VOC as propane = (1.22 × THC) + formaldehyde - (acetone + methane + methylene chloride); a value of zero is inserted in the equation for the specified compounds where no emission factor is available, or where the emission factor is reported only as "BDL".

Table 10.6.2-7 (cont.).

<sup>g</sup> Reference 15.

<sup>h</sup> Based on M0011 data only; suspected to be biased low due to poor collection efficiency or analytical problems.

## References For Section 10.6.2

1. T. M. Maloney, *Modern Particleboard And Dry-Process Fiberboard Manufacturing*, Miller Freeman Publications, Inc., San Francisco, CA, 1977.
2. J. G. Haygreen and J. L. Bowyer, *Forest Products And Wood Science: An Introduction*, Second Edition, Iowa State University Press, Ames, IA, 1989.
3. Written communication and attachments from T. A. Crabtree, Smith Engineering Company, Broomall, PA, to P. E. Lassiter, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 26, 1996.
4. Technical Memorandum, Minutes of the October 12-13, 1993 BACT Technologies Workshop, Raleigh, NC, sponsored by the American Forest and Paper Association, K. D. Bullock, Midwest Research Institute, Cary, NC, October 1993.
5. A. E. Cavadeas, *RTO Experience In The Wood Products Industry*, presented at Environmental Challenges: What's New in the Wood Products Industry?, workshop sponsored by the American Forest and Paper Association, Research Triangle Park, NC, February 4-5, 1997.
6. *Emission Factor Documentation For AP-42 Chapter 10, Wood Products Industry*, prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute, Cary, NC, September 2000. (ESD memo)
7. *Particleboard And Medium Density Fiberboard Air Emission Databases, Technical Bulletin No. 693*, National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY, April 1995. (Memo 8)
8. *Engineering Emissions Testing For Particulate Performed On The #1 & 3 Dryer Cyclone Exhausts And Engineering Emissions Testing For Methanol Performed On The Press Vents At Temple Inland Corporation, Monroeville, Alabama, Test Dates February 10-14, 1997*, prepared for Temple Inland, by Air Techniques, Inc., ATI Job No. 97TO4908, 1997. (Memo 53)
9. *In-House Air Emissions Testing Of Primary Dryer Outlet, Hope Particleboard Plant, Hope, Arkansas, Test Dates January 29-31, 1997*, prepared for Temple-Inland Forest Products Corporation, by Maxim Technologies, Inc., Project No. 1411700875A, March 14, 1997. (Memo 54)
10. *In-House Air Emissions Testing of Primary Dryer Outlet And RTO Press Vent Inlet, Hope Particleboard Plant, Hope, Arkansas, Test Dates February 12-14, 1997*, prepared for Temple-Inland Forest Products Corporation, by Maxim Technologies, Inc., Project No. 1411700875B, March 17, 1997. (Memo 55)
11. *Stationary Source Sampling Report, Reference No. 6041A, Weyerhaeuser Company, Moncure, North Carolina, Particulate Emissions And Plume Opacity Testing, Surface Line Electrified Filter Bed Inlet And Stack, October 20, 1988*, Entropy Environmentalists, Inc., Research Triangle Park, North Carolina, November 8, 1988. (Memo 4, PB BR 5)

12. *Weyerhaeuser Company, Marshfield, Wisconsin, Stack Testing Report For Total Gaseous Non-Methane Organic Compound Emissions (TGNOC), Test Date: March 19-23, 1990, Cross/Tessitore & Associates, P.A., Orlando, Florida, 1990. (Memo 4, PB BR 6)*
13. *Report To Weyerhaeuser Company, Marshfield, Wisconsin, For Particulate & NOx Emissions Testing, Door Core Dryer EFB Stack, December 20, 1991, Environmental Technology & Engineering Corporation, Elm Grove, Wisconsin, 1992. (Memo 4, PB BR 7)*
14. *Stationary Source Sampling Report, Reference No. 6393A, Weyerhaeuser Company, Moncure, North Carolina, Formaldehyde Emissions, Particulate Emissions, And Plume Opacity Testing, Core Line EFB Inlet, Core Line Stack, And Surface Line Stack, August 9 And 11, 1989, Entropy Environmentalists, Inc., Research Triangle Park, North Carolina, September 21, 1989. (Memo 4, PB BR 4)*
15. *Emission Test Report: HAP Emission Testing On Selected Sources At A Wood Furniture Production Facility—Facility A, prepared for U. S. Environmental Protection Agency, Research Triangle Park, North Carolina, by Roy F. Weston, Inc., April 1993. (Memo 4, PB BR 1)*
16. *Weyerhaeuser Company—Marshfield, Wisconsin, Door Core Dryer, Particulate Compliance 1996.4, Test Date October 19, 1996, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9640, December 12, 1996. (Memo 72)*
17. *Title V Emissions Testing On The Furnish Dryer Exhaust, Georgia Pacific Corporation, Panelboard Plant, Monticello, Georgia, February 13, 1996, prepared for CH2M Hill, by Analytical Testing Consultants, Inc., Report No. 5743, March 13, 1996. (Memo 17)*
18. *Report Of Air Emissions Tests For Louisiana-Pacific Corporation Silsbee Particleboard Facility Core And Face Dryer Cyclones, Test Date September 23, 1997, prepared for Louisiana-Pacific Corporation, by Environmental Monitoring Laboratories, Inc., October 18, 1997. (Memo 43)*
19. *Volatile Organic Compound Emissions From Wood Products Manufacturing Facilities, Part IV - Particleboard, Technical Bulletin No. 771, National Council of the Paper Industry for Air and Stream Improvement, Inc., Research Triangle Park, NC, 1999. (Memo 111)*
20. *Emissions Test Report, Boise Cascade Corporation, Island City, Oregon, Green Furnish Dryer, March 10 & 11, 1998, prepared for Boise Cascade Corporation, by BWR Associates, Inc., Project No. 98-042D, 1998. (Memo 14)*
21. *Emissions Test Report, Willamette Industries Duraflake Division, Albany, Oregon, Boiler #1, Green Dryer #1, And Green Dryer #2, Test Dates April 22-23 And 25-26, 1996, prepared for Willamette Industries, by BWR Associates, Inc., Project No. 96-048X, 1996. (Memo 96)*
22. *Weyerhaeuser Company—Marshfield, Wisconsin, Steam-Thru Door Core Dryer And Press Testing, Formaldehyde Air Emissions 1996.4, Test Dates October 19 And 21, 1996, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9640, December 30, 1996. (Memo 74)*

23. *Emissions Test Report, Willamette Industries Duraflake Division, Millersburg (Albany), Oregon, Green Dryer #3, Test Dates March 27-28, 1997*, prepared for Willamette Industries, by BWR Associates, Inc., Project No. 97-043D, 1997. (Memo 95)
24. *Emissions Test Report, Willamette Industries Duraflake Division, Albany, Oregon, Dry Dryers 1, 2, 3 And 4, Test Dates May 19-22, 1998*, prepared for Willamette Industries, by BWR Associates, Inc., Project No. 98-044D, 1998. (Memo 94)
25. *Source Emission Test Report, Dryer And Press Exhausts Allegheny MDF Limited Partnership, Mt. Jewett, Pennsylvania, Test Dates October 22-24 And December 17, 1997*, prepared for Allegheny MDF Limited Partnership, by Galson Measurements, Galson Project No. 975540, December 3, 1997. (Memo 13)
26. *In-House Air Emissions Testing Of The Diboll Particleboard Plant, Diboll, Texas, Test Dates October 8-9 And 15, 1997*, prepared for Temple-Inland Forest Products Corporation, by Maxim Technologies, Inc., Project No. 9711254A, January 12, 1998. (Memo 58)
27. *Formaldehyde Methods Comparison, NCASI Acetylacetone Method Vs. EPA Method 0011, Weyerhaeuser Company, Springfield, Oregon, MEC #3 Rotary Particle Dryer, Test Dates February 27-28, 1996*, prepared for Weyerhaeuser Company, by BWR Associates, Inc., 1996. (Memo 68)
28. *Results Of The November 14-17, 1995 Air Emission Compliance Tests At The Louisiana-Pacific Waferboard Plant In Missoula, Montana*, prepared for Louisiana-Pacific Corporation, by Interpoll Laboratories, Inc., Report No. 5-6833, December 27, 1995. (Memo 41)
29. *Results Of The May 9-12, 1994 Air Emission Compliance Tests At The Louisiana-Pacific [Particleboard] Plant In Missoula, Montana*, Report No. 4-2837, Interpoll Laboratories, Inc., Circle Pines, Minnesota, June 8, 1994. (Memo 4, PB BR 9)
30. *Weyerhaeuser Company–Marshfield, Wisconsin, Steam-Thru Door Core Plant Press Vents, VOC Compliance Testing 1998.3, Test Dates August 6-7, 1998*, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9850, September 15, 1998. (Memo 69)
31. *Weyerhaeuser Company–Marshfield, Wisconsin, Door Core Press Scavenger Trials, Press Vent Formaldehyde Air Emissions 1997.3, Test Dates July 21-24, 1997*, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9741, 1997. (Memo 76)
32. *Weyerhaeuser Company–Marshfield, Wisconsin, Formaldehyde Emissions Variability Study, Press Area Common Stack, Test Dates December 18, 1997 To March 26, 1998*, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9753, May 26, 1998. (Memo 77)
33. *Weyerhaeuser Company–Marshfield, Wisconsin, Formaldehyde Emissions Variability Study, Press Area Common Stack, Test Dates April 1, 1998 To June 30, 1998*, prepared for Weyerhaeuser Company, by Weyerhaeuser Company, Project No. 721-9753, 1998. (Memo 70)

34. *Emission Test Report Particleboard Press And No. 2 Rotary Dryer (MEC Dryer With Wood-Fired Burner) Emissions Testing, International Paper, Decorative Products Division, Stuart, Virginia, Test Dates June 8-10, 1998*, prepared for International Paper Decorative Products Division, by Roy F. Weston, Inc., Work Order No. 00157-045-002, June 1998. (Memo 32)