10.6.3 Medium Density Fiberboard Manufacturing

10.6.3.1 General[1-2,7] -

The Composite Panel Association defines medium density fiberboard (MDF) as a dry-formed panel product manufactured from lignocellulosic fibers combined with a synthetic resin or other suitable binder. The panels are compressed to a density of from 496 to 801 kilograms per cubic meter (kg/m^3) (31 to 50 pounds per cubic foot [lb/ft^3]) in a hot press. The entire interfiber bond is formed by a synthetic resin or other suitable organic binder.

In contrast to particleboard, MDF has more uniform density throughout the board and has smooth, tight edges that can be machined. It can be finished to a smooth surface and grain printed, eliminating the need for veneers and laminates. Most of the thicker MDF panels (1.27 to 1.91 centimeters [cm]) (1/2 to 3/4 inch [in.]) are used as core material in furniture panels. Medium density fiberboard panels thinner than 1.27 cm (1/2 in.) typically are used for siding.

10.6.3.2 Process Description[2-7]

The general steps used to produce MDF include mechanical pulping of wood chips to fibers (refining), drying, blending fibers with resin and sometimes wax, forming the resinated material into a mat, and hot pressing. Figure 10.6.3-1 presents a process flow diagram for a typical MDF plant.

The furnish for MDF normally consists of wood chips. Wood chips typically are delivered by truck or rail from offsite locations such as sawmills, plywood plants, furniture manufacturing facilities, satellite chip mills, and whole tree chipping operations. If wood chips are prepared onsite, logs are debarked, cut to more manageable lengths, and then sent to chippers. If necessary, the chips are washed to remove dirt and other debris.

Clean chips are softened in a steam-pressurized digester, then transported into a pressurized refiner chamber. In the refiner chamber, single or double revolving disks are used to mechanically pulp the softened chips into fibers suitable for making the board.

From the refiners, the fibers move to the drying and blending area. A rotary predryer may be used for initial drying of relatively wet furnish. Regardless of whether or not a predryer is used, tube dryers typically are used to reduce the moisture content of the fibers to desired levels. Single-stage or multiple-stage tube drying systems are commonly used in MDF manufacture. Most of the multiple-stage tube drying systems incorporate two stages. In multiple-stage tube dryers, there is a primary tube dryer and a second stage tube dryer in series separated by an emission point such as a cyclonic collector. Heat is usually provided to tube dryers by the direct firing of propane, natural gas, or distillate oil or by indirect heating.

The sequence of the drying and blending operations depends on the method by which resins and other additives are blended with the fibers. Urea-formaldehyde (UF) resins are the most common resins used in the manufacture of MDF. Phenolic resins, melamine resins, and isocyanates are also used. Some plants inject resins into a short-retention blender, while most facilities inject resin formulations into a blowline system. If resin is added in a separate blender, the fibers are first dried and separated from the gas stream by a fiber recovery cyclone, then conveyed to the blender. The fibers then are blended with resin, wax, and any other additives and conveyed to a dry fiber storage bin.

If a blowline system is used, the fibers are first blended with resin, wax, and other additives in a blowline, which is a duct that discharges the resinated fibers to the dryer. After drying, the fibers are separated from the gas stream by a fiber recovery cyclone and then conveyed to a dry fiber storage bin.

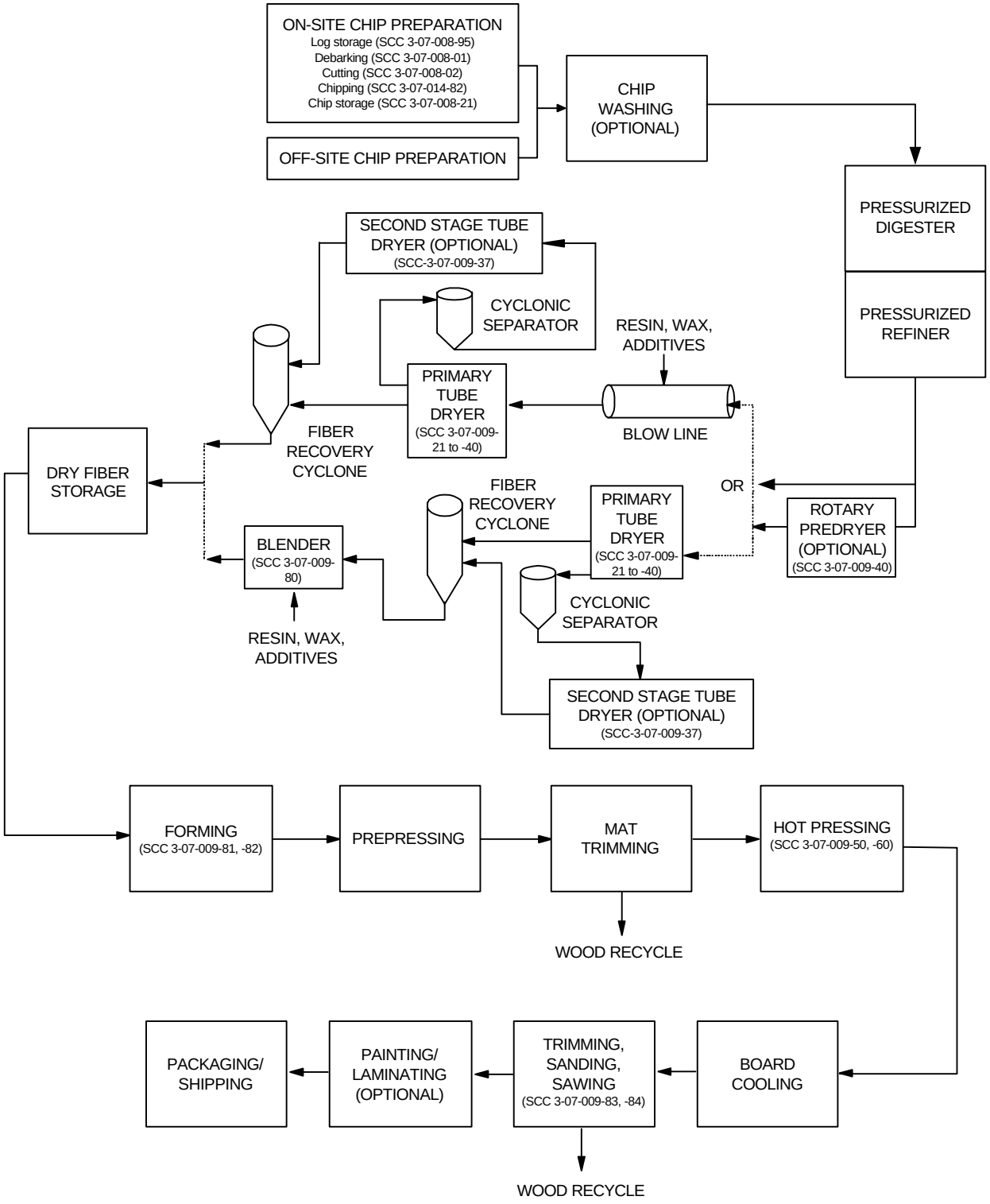

Figure 10.6.3-3. Typical process flow diagram for a medium density fiberboard (MDF) plant.

Air conveys the resinated fibers from the dry storage bin to the forming machine, where they are deposited on a continuously moving screen system. The continuously formed mat must be prepressed before being loaded into the hot press. After prepressing, some pretrimming is done. The trimmed material is collected and recycled to the forming machine.

The prepressed and trimmed mats then are transferred to the hot press. The press applies heat and pressure to activate the resin and bond the fibers into a solid panel. The mat may be pressed in a continuous hot press, or the precompressed mat may be cut by a flying cutoff saw into individual mats that are then loaded into a multi-opening, batch-type hot press. Steam or hot oil heating of the press platens is common in domestic MDF plants. After pressing, the boards are cooled, sanded, trimmed, and sawed to final dimensions. The boards may also be painted or laminated. Finally, the finished product is packaged for shipment.

10.6.3.3 Emissions And Controls[2-18] -

The primary emission sources at MDF mills are fiber dryers and press vents. Other emission sources may include boilers, chip production operations, and finishing operations such as sanding, trimming, and laminate application. Wood storage piles are sources of fugitive PM and VOC emissions.

Most MDF mills have chips delivered from offsite locations. However, in mills where chips are generated onsite, operations such as log debarking, sawing, chipping, and grinding, in addition to panel trimming, sanding, and sawing generate particulate matter (PM) and PM less than 10 micrometers (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.

The exhaust from dryers first is ducted to a fiber recovery cyclone before being emitted. Emissions can include wood dust and other solid PM, volatile organic compounds (VOCs), and condensible PM. If direct-fired units are used, products of combustion such as carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxides (NO_x), are also emitted. 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 MDF are dependent on the type of products being finished. For most MDF products, finishing involves trimming to size, sanding, and in some cases application of laminates. Other products may require sanding or the application of laminate surfaces with spray adhesives. Trimming and sanding operations are sources of PM and PM-10 emissions. In addition, these processes may be sources of PM-2.5 emissions. Limited data are available for MDF sanding and sawing operations. Emission factors for plywood sanding and sawing operations may provide an order of magnitude estimate for similar MDF sanding and sawing operations. Emissions from adhesives used in the application of laminate surfaces are likely to include VOCs.

In MDF mills where wood chips 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 MDF sources include absorption systems (wet scrubbers), fabric filters, wet electrostatic precipitators (WESPs), and oxidation systems (discussed below). 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 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_2 (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 788° and 871°C (1450° and 1600°F) 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.

Regenerative catalytic oxidizers (RCOs) are also used to control VOCs from wood products dryers and presses. Regenerative catalytic oxidizers function similar to RTOs, except that the heat recovery beds in RCOs contain catalytic media. The catalyst accelerates the rate of VOC oxidation and allows for VOC destruction at lower temperatures than in an RTO, typically 316° to 538°C (600° to 1000°F), which reduces auxiliary fuel usage.

Thermal catalytic oxidizers (TCOs), which are a combination of an RTO and RCO, are also used in the wood products industry. The TCO operates at a temperature of around 480°C (900°F) and contains catalytic media. However, the heat recovery canisters and fans on the TCO are sized large enough so that the TCO can be operated like an RTO (with non-catalytic ceramic media) if catalyst replacement costs become overly expensive.

In addition to add-on thermal or catalytic oxidizers, exhaust gases from dryers and presses may be routed to the combustion chamber of an onsite boiler or process heater. The VOC and CO emissions in the process exhaust may be incinerated in the combustion chamber provided that the system is designed to allow for sufficient mixing and residence time.

Fugitive PM emissions from road dust and uncovered bark and dust storage piles may be controlled in a number of different ways. Some of these methods include enclosure, wet suppression systems, and chemical stabilization.

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 (~20°C [~68°F]) 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:

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

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 10.6.3-1 presents emission factors for dryer emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.3-2 presents emission factors for dryer emissions of NO_x, CO, and CO_2. Table 10.6.3-3 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 10.6.3-4 presents emission factors for press and board cooler emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.3-5 presents emission factors for press emissions of NO_x and CO. Table 10.6.3-6 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 10.6.3-7 presents emission factors for miscellaneous source emissions of organic pollutants.

To the extent possible, separate emission factors for MDF dryers are presented in Tables 10.6.3-1 to -3 for hardwoods and softwoods. Hardwoods generally correspond to deciduous species. For MDF, plywood, and other composite wood products, commonly used hardwoods include aspen, oak, poplar, maple, cherry, alder, hickory, gum, beech, birch, larch, and basswood. The emission factors for hardwood MDF dryers presented in this section are based largely on the drying of gum, alder, and hickory furnish. Softwoods generally correspond to coniferous species. For MDF, plywood, and other composite wood products, commonly used softwoods include pines, firs, and spruce. Pines and firs are the most commonly used softwood species for MDF manufacturing.

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, an uncontrolled THC as carbon emission factor for an indirect-heated tube dryer, blowline blending UF resin and processing 60 percent softwood and 40 percent hardwood may be calculated using the THC as carbon emission factors for softwood (4.4 lb/ODT) and hardwood (3.7 lb/ODT), and the ratio of 60 percent to 40 percent. The resultant emission factor, rounded to two significant figures, would be 4.1 lb/ODT.

Table 10.6.3-1. EMISSION FACTORS FOR MDF DRYERS--PARTICULATE MATTER[a]

Source[c]	Emission Control Device[d]	Filterable[b] PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Condensible[e]	EMISSION FACTOR RATING
Tube dryer, indirect-heated, blowline blend, UF resin, softwood (SCC 3-07-009-32)	Uncontrolled	ND		0.60[f]	D	0.53[g]	D
	BH	ND		0.011[h]	D	0.14[h]	D
	BH/WESP	ND		0.013[f]	D	0.13[f]	D
Tube dryer, direct wood-fired, blowline blend, UF resin, softwood (SCC 3-07-009-23)	Uncontrolled	10.4[j]	D	1.6[j]	D	0.59[j]	D

[a] 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. See Table 10.6.3-8 for the hardwood and softwood species commonly used in the production of MDF and other composite wood products. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.**

[b] 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.

[c] UF = urea formaldehyde.

[d] Emission control device: BH = baghouse (fabric filter); WESP = wet electrostatic precipitator.

[e] Condensible PM is that PM collected in the impinger portion of a PM sampling train (EPA Method 202).

[f] Reference 8.

[g] References 8 and 9.

[h] Reference 9.

[j] Reference 10.

Table 10.6.3-2. EMISSION FACTORS FOR MDF DRYERS--NO_x, CO, AND CO_2 [a]

Source[b]	Emission Control Device	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2	EMISSION FACTOR RATING
Tube dryer, indirect-heated, non-blowline blend, softwood (SCC 3-07-009-33)	Uncontrolled	ND		0.11[c]	D	ND	
Tube dryer, indirect-heated, blowline blend, UF resin, softwood (SCC 3-07-009-32)	Uncontrolled Thermal oxidizer	ND 0.38[d]	 E	0.068[c] 1.6[d]	D E	ND ND	
Tube dryer, direct natural gas-fired, non-blowline blend, hardwood (SCC 3-07-009-27)	Uncontrolled	ND		0.20[c]	D	ND	
Tube dryer, direct wood-fired, blowline blend, UF resin, softwood (SCC 3-07-009-23)	Uncontrolled	ND		4.0[e]	D	ND	
Rotary predryer, direct natural gas-fired, softwood (SCC 3-07-009-40)	Uncontrolled	ND		0.24[c]	D	ND	

[a] 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. See Table 10.6.3-8 for the hardwood and softwood species commonly used in the production of MDF and other composite wood products. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.**

[b] UF = urea formaldehyde

[c] Reference 11.

[d] Reference 12.

[e] Reference 10.

Table 10.6.3-3. EMISSION FACTORS FOR MDF DRYERS--ORGANICS[a]

Source[b]	Emission Control Device	CASRN[c]	Pollutant	Emission factor	EMISSION FACTOR RATING
Tube dryer, indirect-heated, non-blowline blend, softwood (SCC 3-07-009-33)	Uncontrolled		THC as carbon[d]	1.7	D
			VOC as propane[e]	2.1	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	BDL	
		67-64-1	Acetone	0.055	D
			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	
		50-00-0	Formaldehyde *	0.085	D
			Limonene	BDL	
		67-56-1	Methanol *	0.74	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	
			Phenol *	BDL	
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	

Table 10.6.3-3 (cont.).

Source[b]	Emission Control Device	CASRN[c]	Pollutant	Emission factor	EMISSION FACTOR RATING
Tube dryer, indirect-heated, blowline blend, UF resin, softwood (SCC 3-07-009-32)	Uncontrolled		THC as carbon[d]	4.4	D
			VOC as propane[e]	5.6	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL[f]	
		75-07-0	Acetaldehyde *	0.020	D
		67-64-1	Acetone	0.025	D
			Acrolein *	BDL	
		80-56-8	Alpha-pinene	2.1	D
			Benzene *	BDL	
		127-91-3	Beta-pinene	0.43	D
			Bromomethane *	BDL	
		79-92-5	Camphene	0.12	D
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.22[g]	C
			Limonene	0.11	D
		67-56-1	Methanol *	0.87	D
			Methyl ethyl ketone *	BDL	
		108-10-1	Methyl isobutyl ketone *	0.0049	D
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
			o-Xylene *	BDL	
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
		108-95-2	Phenol *	0.023	D
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	
Tube dryer, indirect-heated, blowline blend, UF resin, softwood (SCC 3-07-009-32)	Thermal oxidizer	75-07-0	Acetaldehyde *	0.0051[h]	E
		50-00-0	Formaldehyde *	0.15[h]	E
Tube dryer, indirect-heated, blowline blend, UF resin, hardwood (SCC 3-07-009-36)	Uncontrolled		THC as carbon[d]	3.7[j]	D
			VOC as propane[e]	4.8	E
		75-07-0	Acetaldehyde *	0.013[j]	D
		50-00-0	Formaldehyde *	0.26[j]	D

Table 10.6.3-3 (cont.).

Source[b]	Emission Control Device	CASRN[c]	Pollutant	Emission factor	EMISSION FACTOR RATING
Tube dryer, direct natural gas-fired, non-blowline blend, hardwood (SCC 3-07-009-27)	Uncontrolled		THC as carbon[d]	1.0	D
			VOC as propane[e]	1.2	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	BDL	
		67-64-1	Acetone	0.016	D
			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	
		50-00-0	Formaldehyde *	0.0085	D
			Limonene	BDL	
		67-56-1	Methanol *	0.96	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	
			Phenol *	BDL	
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	
Tube dryer, direct wood-fired, blowline blend, UF resin, softwood (SCC 3-07-009-23)	Uncontrolled		THC as carbon[d]	4.8[j]	D
			VOC as propane[e]	6.7	E
		50-00-0	Formaldehyde *	0.86[j]	D

Table 10.6.3-3 (cont.).

Source[b]	Emission Control Device	CASRN[c]	Pollutant	Emission factor	EMISSION FACTOR RATING
Tube dryer, second stage, blowline blend, indirect-heated, softwood (SCC 3-07-009-37)	Uncontrolled		THC as carbon[d]	0.13	D
			VOC as propane[e]	0.18	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.0035	D
		67-64-1	Acetone	0.0034	D
			Acrolein *	BDL	
		80-56-8	Alpha-pinene	0.055	D
		71-43-2	Benzene *	0.00073	D
			Beta-pinene	BDL	
			Bromomethane *	BDL	
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.021	D
			Limonene	BDL	
		67-56-1	Methanol *	0.015	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	
			Phenol *	BDL	
			Propionaldehyde *	BDL	
			Styrene *	BDL	
		108-88-3	Toluene *	0.00083	D

Table 10.6.3-3 (cont.).

Source[b]	Emission Control Device	CASRN[c]	Pollutant	Emission factor	EMISSION FACTOR RATING
Rotary predryer, direct natural gas-fired, softwood (SCC 3-07-009-40)	Uncontrolled		THC as carbon[d]	0.79	D
			VOC as propane[e]	0.95	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	BDL	
		67-64-1	Acetone	0.019	D
			Acrolein *	BDL	
		80-56-8	Alpha-pinene	0.28	D
			Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.0076	D
			Limonene	BDL	
		67-56-1	Methanol *	0.025	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	
			Phenol *	BDL	
			Propionaldehyde *	BDL	
			Styrene *	BDL	
			Toluene *	BDL	

[a] 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 11 unless otherwise noted. See Table 10.6.3-8 for the hardwood and softwood species commonly used in the production of MDF and other composite wood products. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.**

[b] UF = urea formaldehyde.

[c] CASRN = Chemical Abstracts Service Registry Number.

[d] THC as carbon = total hydrocarbon measurements using EPA Method 25A.

[e] 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 10.6.3-3 (cont.).

[f] References 11 and 12.
[g] References 11, 12, and 13.
[h] Reference 12.
[j] Reference 10.

Table 10.6.3-4. EMISSION FACTORS FOR MDF HOT PRESSES AND BOARD COOLERS--PARTICULATE MATTER[a]

Source[c]	Emission Control Device[d]	Filterable[b] PM	EMISSION FACTOR RATING	Filterable[b] PM-10	EMISSION FACTOR RATING	Condensible[e]	EMISSION FACTOR RATING
Hot press, UF resin (SCC 3-07-009-60)	Uncontrolled	0.18[f]	D	0.15[g]	D	0.20[f]	D
	RTO	0.040[h]	E	ND		0.016[h]	E
Board cooler, UF resin (SCC 3-07-009-71)	Uncontrolled	0.054[g]	D	0.0038[g]	E	ND	

[a] 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^3. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.**

[b] 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.

[c] UF = urea formaldehyde.

[d] Emission control device: RTO = regenerative thermal oxidizer.

[e] Condensible PM is that PM collected in the impinger portion of a PM sampling train (EPA Method 202).

[f] References 10 and 14.

[g] Reference 10.

[h] Reference 14.

Table 10.6.3-5. EMISSION FACTORS FOR MDF HOT PRESSES--NO_x, CO, AND CO_2 [a]

Source[b]	Emission Control Device[c]	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2	EMISSION FACTOR RATING
Hot press, UF resin (SCC 3-07-009-60)	Uncontrolled	0.030[d]	E	0.034[d]	E	ND	
	RTO	0.51[e]	E	0.085[e]	E	ND	

[a] 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^3. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.**

[b] UF = urea formaldehyde.

[c] Emission control device: RTO = regenerative thermal oxidizer.

[d] Reference 10.

[e] Reference 14.

Table 10.6.3-6. EMISSION FACTORS FOR MDF HOT PRESSES AND BOARD COOLERS--ORGANICS[a]

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	EMISSION FACTOR RATING
Hot press, UF resin (SCC 3-07-009-60)	Uncontrolled		THC as carbon[e]	0.29[g]	D
			VOC as propane[f]	0.80	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
		5779-94-2	2,5-Dimethyl benzaldehyde	0.0025[h]	E
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.014[j]	D
		67-64-1	Acetone	0.029[k]	D
		107-02-8	Acrolein *	0.0012[h]	E
			Alpha-pinene	BDL	
		100-52-7	Benzaldehyde	0.00055[h]	E
			Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
		123-72-8	Butylaldehyde	0.0024[h]	E
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
		4170-30-3	Crotonaldehyde	0.0011[h]	E
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.48[m]	C
		66-25-1	Hexaldehyde	0.0029[h]	E
		590-86-3	Isovaleraldehyde	0.0014[h]	E
			Limonene	BDL	
		67-56-1	Methanol *	0.56[n]	D
		78-93-3	Methyl ethyl ketone *	0.00059[h]	E
		108-10-1	Methyl isobutyl ketone *	0.016[k]	D
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
		529-20-4	o-Tolualdehyde	0.00070[h]	E
			o-Xylene *	BDL	
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
		104-87-0	p-Tolualdehyde	0.0010[h]	E
		108-95-2	Phenol *	0.027[k]	D
		123-38-6	Propionaldehyde *	0.00054[h]	E
			Styrene *	BDL	
			Toluene *	BDL	
		110-62-3	Valeraldehyde	0.0024[h]	E
Hot press, UF resin (SCC 3-07-009-60)	RTO		THC as carbon[e]	0.019[p]	E
			VOC as propane[f]	0.032	E
		50-00-0	Formaldehyde *	0.0091[p]	E

Table 10.6.3-6 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	EMISSION FACTOR RATING
Board cooler, UF resin (SCC 3-07-009-71)	Uncontrolled		THC as carbon[e]	0.077[j]	D
			VOC as propane[f]	0.13	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
		5779-94-2	2,5-Dimethyl benzaldehyde	0.00019[h]	E
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.0010[h]	E
		67-64-1	Acetone	0.0092[k]	E
		107-02-8	Acrolein *	0.00022[h]	E
			Alpha-pinene	BDL	
		100-52-7	Benzaldehyde	0.000099[h]	E
			Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
		123-72-8	Butylaldehyde	0.0014[h]	E
			Camphene	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Crotonaldehyde	0.00026[h]	
		4170-30-3	Cumene *	BDL	E
			Formaldehyde *	0.042[q]	
		50-00-0	Hexaldehyde	0.00065[h]	D
		66-25-1	Isovaleraldehyde	0.00025[h]	E
		590-86-3	Limonene	BDL	E
			Methanol *	0.025[k]	
		67-56-1	Methyl ethyl ketone *	0.00011[h]	E
		78-93-3	Methyl isobutyl ketone *	BDL	E
			Methylene chloride *	BDL	
			m,p-Xylene *	BDL	
			o-Tolualdehyde	0.000065[h]	
		529-20-4	o-Xylene *	BDL	E
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
			p-Tolualdehyde	0.00017[h]	
		104-87-0	Phenol *	BDL	E
			Propionaldehyde *	BDL	
			Stryene *	BDL	
			Toluene *	BDL	
			Valeraldehyde	0.00048[h]	
		110-62-3			E

[a] 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^3. 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 10 unless otherwise noted. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are**

Table 10.6.3-6 (cont.).

available on EPA's Technology Transfer Network (TTN) website at: http://www.epa.gov/ttn/chief/.

[b] UF = urea formaldehyde.

[c] Emission control device: RTO = regenerative thermal oxidizer.

[d] CASRN = Chemical Abstracts Service Registry Number.

[e] THC as carbon = total hydrocarbon measurements using EPA Method 25A.

[f] 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".

[g] References 10, 11, 14, 15, 16, and 17.

[h] Based on M0011 data only; suspected to be biased low due to poor collection efficiency or analytical problems.

[j] References 10 and 11.

[k] Reference 11.

[m] References 10, 11, 14, 15, 16, 17, and 18.

[n] References 11 and 17.

[p] Reference 14.

[q] References 10, 11, and 18.

Table 10.6.3-7. EMISSION FACTORS FOR MDF MISCELLANEOUS SOURCES[a]

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Log storage (SCC 3-07-008-95)	Uncontrolled		PM, THC, VOC	ND		
Log debarking (SCC 3-07-008-01)	Uncontrolled		PM, THC, VOC	ND		
Log chipper, hardwood[e] (SCC 3-07-014-82)	Uncontrolled		PM	ND		
			THC as carbon[f]	0.0041	lb/ODT	E
			VOC as propane[g]	0.0050	lb/ODT	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 *	BDL		
			Limonene	BDL		
		67-56-1	Methanol *	0.0010	lb/ODT	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 *	BDL		
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		
Chip storage (SCC 3-07-008-21)	Uncontrolled		PM, THC, VOC	ND		

Table 10.6.3-7 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Blender, UF resin (SCC 3-07-009-80)	Uncontrolled		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		
		50-00-0	Formaldehyde *	0.010	lb/ODT	E
			Limonene	BDL		
		67-56-1	Methanol *	0.48	lb/ODT	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 *	BDL		
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.3-7 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Former without blowline blending, UF resin (includes blender emissions) (SCC 3-07-009-81)	Uncontrolled		1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
		67-64-1	Acetone	0.053	lb/ODT	E
			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		
		50-00-0	Formaldehyde *	0.060	lb/ODT	E
			Limonene	BDL		
		67-56-1	Methanol *	0.41	lb/ODT	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 *	BDL		
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.3-7 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Former with blowline blend, UF resin (SCC 3-07-009-82)	Uncontrolled		THC as carbon[f]	0.056	lb/ODT	E
			VOC as propane[g]	0.067	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
		67-64-1	Acetone	0.0064	lb/ODT	D
			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		
		50-00-0	Formaldehyde *	0.0051	lb/ODT	D
			Limonene	BDL		
		67-56-1	Methanol *	0.017	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		
			Phenol *	BDL		
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.3-7 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Sander[h] (SCC 3-07-009-83)	Uncontrolled		THC as carbon[f]	0.0074	lb/MSF	E
			VOC as propane[g]	0.0066	lb/MSF	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene*	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
		67-64-1	Acetone	0.0051	lb/MSF	D
			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		
		50-00-0	Formaldehyde *	0.0027	lb/MSF	D
			Limonene	BDL		
		67-56-1	Methanol *	0.0043	lb/MSF	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 *	0.0069	lb/MSF	D
			Propionaldehyde *	BDL		
		100-42-5	Styrene *	0.0014	lb/MSF	D
			Toluene *	BDL		

Table 10.6.3-7 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Saw and hogger[j] (SCC 3-07-009-84)	Uncontrolled		THC as carbon[f]	0.11	lb/MSF[k]	E
			VOC as propane[g]	0.13	lb/MSF[k]	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 *	BDL		
			Limonene	BDL		
		67-56-1	Methanol *	0.38	lb/MSF[k]	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		
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

[a] 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^2. Factors represent uncontrolled emissions unless otherwise noted. ND = No data available. 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 11. **Note: emission factors in table represent averages of data sets. The data spreadsheets, which may be more useful for specific applications, are available on EPA's TTN website at: http://www.epa.gov/ttn/chief/.**

[b] UF = urea formaldehyde.

[c] Emission control devices (baghouses) are considered no control for organic pollutants.

[d] CASRN = Chemical Abstracts Service Registry Number.

[e] Reference 20; based on data for hardboard log chipping operation (See Section 10.6.4).

[f] THC as carbon = total hydrocarbon measurements using EPA Method 25A.

Table 10.6.3-7 (cont.).

[g] 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".

[h] Emission factors for MDF sanders in units of pounds per thousand square feet of panel produced (surface area of one side, even though both sides sanded).

[j] Board trim saw and hogger for processing wood residue for recycle. Hoggers reduce the size of wood residue by slicing or chopping.

[k] References 11 and 19; emission factors for MDF saw in units of pounds per thousand square feet of reclaimed (trimmed) material; approximate MSF reclaimed (trimmed) = MSF from press × 3%.

Table 10.6.3-8. WOOD SPECIES COMMONLY USED IN COMPOSITE WOOD PRODUCTS MANUFACTURING [a]

Wood product	AP-42 section	Hardwood species	Softwood species
Plywood	10.5	Oak, cherry, poplar, maple, larch	Firs, pines
Oriented strandboard	10.6-1	Aspen	Pines, firs, spruce
Particleboard	10.6-2	Aspen, oak	Pines, firs
Medium density fiberboard	10.6-3	Gum, alder, hickory	Pines, firs
Hardboard/fiberboard	10.6-4	Aspen, birch, beech, oak, maple	Pines
Engineered wood products	10.9	Aspen, birch, poplar	Pines, firs, hemlock

[a] Reference 7.

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