10.6.4 Hardboard and Fiberboard Manufacturing

10.6.4.1 General[1] -

Fiberboard is a low-density insulation board used for housing, roofing, and office furnishings. Hardboard is similar to fiberboard, except that hardboard is more dense than fiberboard. Hardboard is used for applications in housing (e.g., exterior siding, garage doors, and interior door facings), furniture, store fixtures, automotive interiors, and toys. The most frequently used raw material for production of fiberboard products is wood chips which are first softened in a pressurized steam vessel (digester) and then refined or pulped into wood fibers. The fibers may then be mixed with resin, formed into mats, and pressed and/or dried to form panel products. Other materials may be added during manufacture to improve certain properties such as stiffness, hardness, finishing properties, resistance to abrasion and moisture, as well as to increase strength, durability and utility.

Hardboard/fiberboard manufacturing falls under the Standard Industrial Classification (SIC) Code 2493, for "Reconstituted Wood Products", which also includes oriented strandboard, medium density fiberboard, and particleboard. The North American Industrial Classification System (NAICS) Code for hardboard/fiberboard is 321219, for "Reconstituted Wood Product Manufacturing".

10.6.4.2 Process Description[1] -

Hardboard products are manufactured through dry processing, wet processing, or wet/dry processing. Fiberboard products are manufactured by wet processing. Dry processing involves dry mat forming and pressing, while wet processing involves wet forming and wet pressing. Wet/dry processing involves wet forming followed by dry pressing. Resin is used in wet hardboard and dry hardboard processing. Resin is not used in wet/dry hardboard or wet fiberboard processing.

The following sections summarize dry process hardboard manufacturing, fiberboard and wet process hardboard manufacturing, and the wet/dry hardboard manufacturing process.

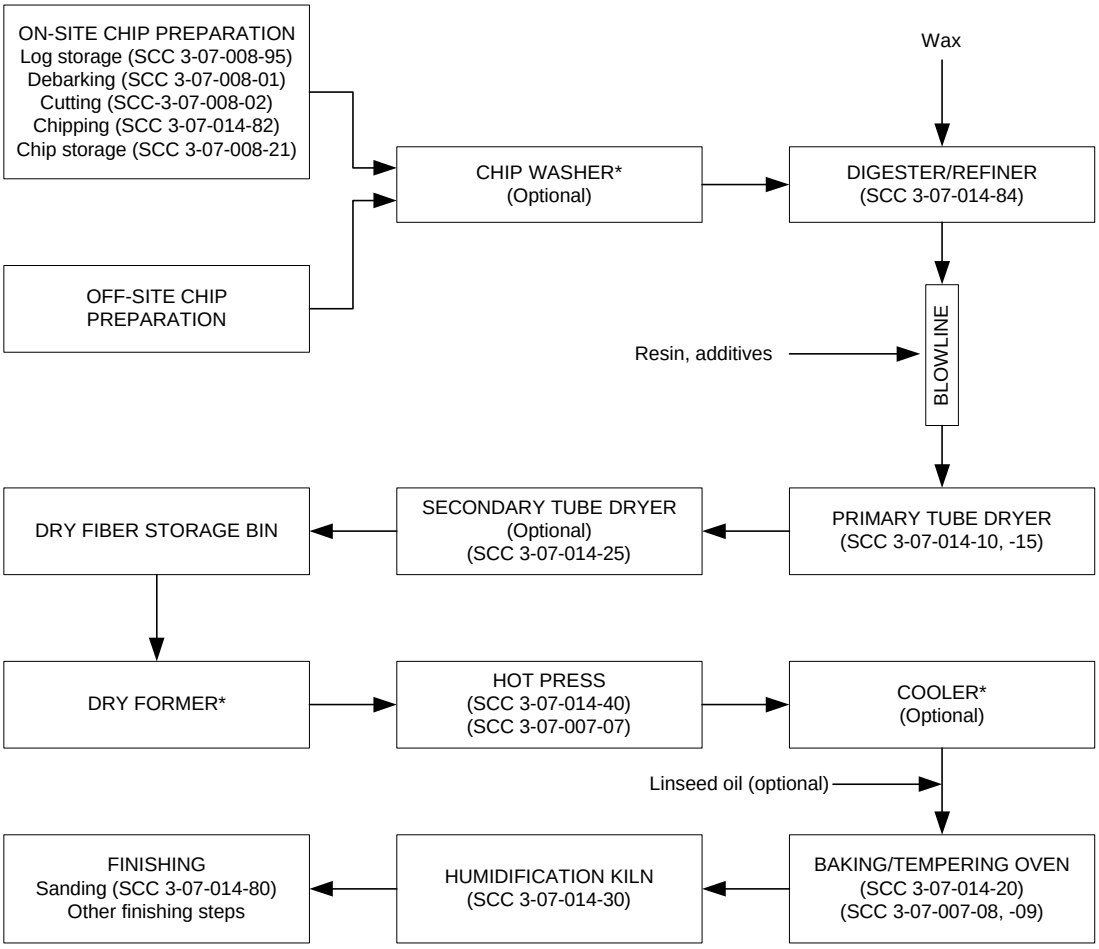
Dry Process Hardboard -

The general steps used to manufacture dry process hardboard include mechanical pulping of wood chips to fibers (digesting and refining), blending of fibers with resin and wax, drying, forming the resinated material into a mat, hot pressing, heat treatment of the pressed boards, and humidification. Figure 10.6.4-1 presents a flow diagram for dry process hardboard manufacturing.

The primary raw material used in hardboard is hardwood or softwood chips. In addition to wood chips, shavings or sawdust may be used as a raw material. If wood chips are prepared onsite, logs are debarked, cut to manageable lengths, and then sent to chippers. If necessary, the chips are washed to remove dirt and other debris.

Clean chips are either processed in pressurized refiners or are softened by steam in a digester and sent to atmospheric refiners. Pressurized refiners consist of a steaming vessel (digester) and of single or double revolving disks to mechanically pulp (refine) the chips into fibers suitable for making the board. The wood chips are discharged under pressure from the digester section of the pressurized refiner into the refiner section. The steam pressure is maintained throughout the entire refining process. Atmospheric refiners also use revolving disks to pulp the chips into fibers, but steam pressure is not maintained in atmospheric refiners.

Wax may be added to the wood chips in the digester. Phenol-formaldehyde (PF) resin and other additives (if used) are added to the wood fiber during or immediately following refining. Most dry process hardboard plants inject PF resin into a blowline that discharges the resinated fibers to a tube



** This process is a potential emission source; however, no emissions data specific to this process are available.*

Figure 10.6.4-1. Dry hardboard manufacturing processes.

dryer. The turbulent conditions in the tube dryer facilitate mixing between the wood fibers and resin droplets. After drying, the resinated fibers are conveyed to a dry fiber storage bin where they await forming.

Single-stage or multiple-stage tube drying systems are most commonly used in dry process hardboard manufacture. Most of the multiple-staged tube drying systems incorporate two stages. In multiple-stage tube dryers, there is a primary tube dryer and a secondary tube dryer in series separated by an emission point such as a cyclonic collector. Single-stage and double-stage tube dryers are shown in Figures 10.6.4-2a and 10.6.4-2b. Hardboard primary tube dryers dry wood fibers from about 51 percent moisture (dry basis) to around 20 percent moisture (dry basis) with dryer inlet temperatures ranging up to 246°C (475°F). Secondary tube dryers further dry the wood furnish to around 6 percent moisture (dry basis). Heat is provided to the hardboard tube dryers by either direct-firing with wood residuals, gas, or oil or by indirect-heating. Although less common than tube dryers, rotary dryers may also be used to dry wood material for hardboard manufacture.

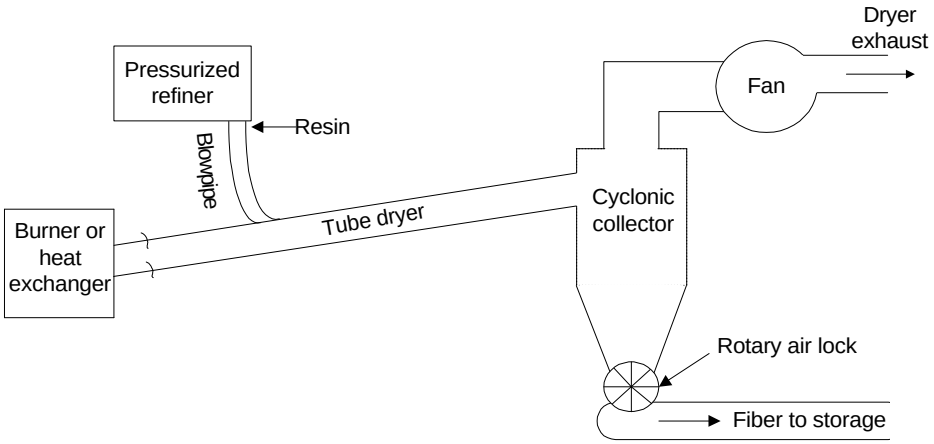


Figure 10.6.4-2a. Single-stage tube dryer.

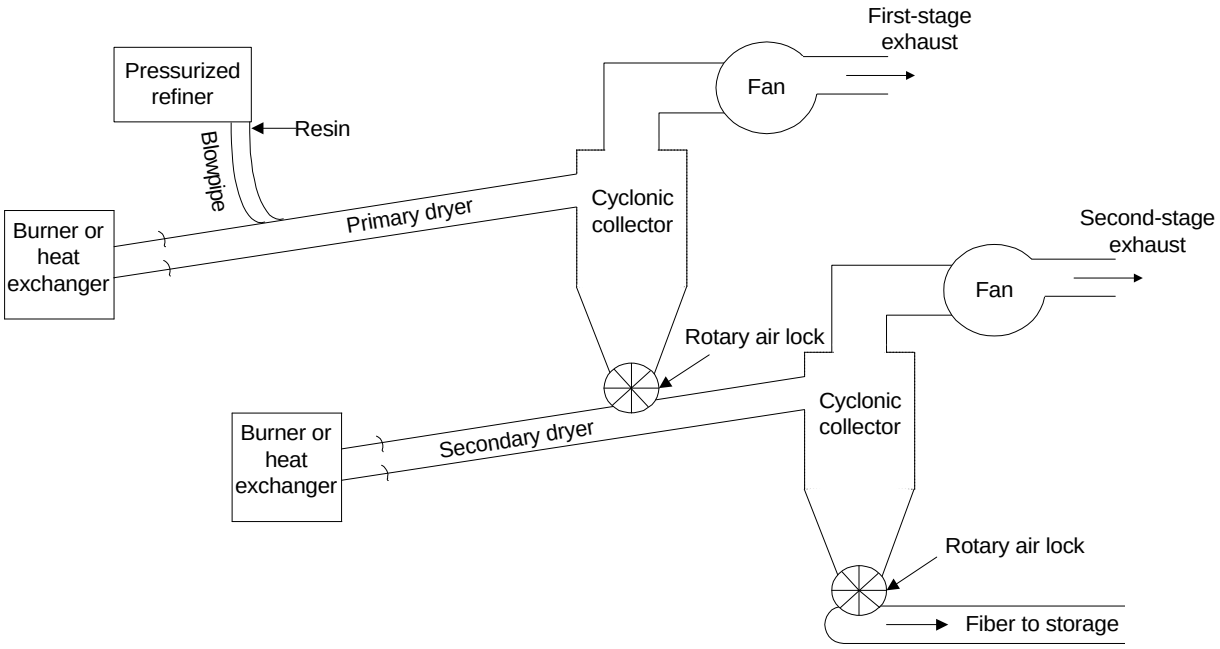


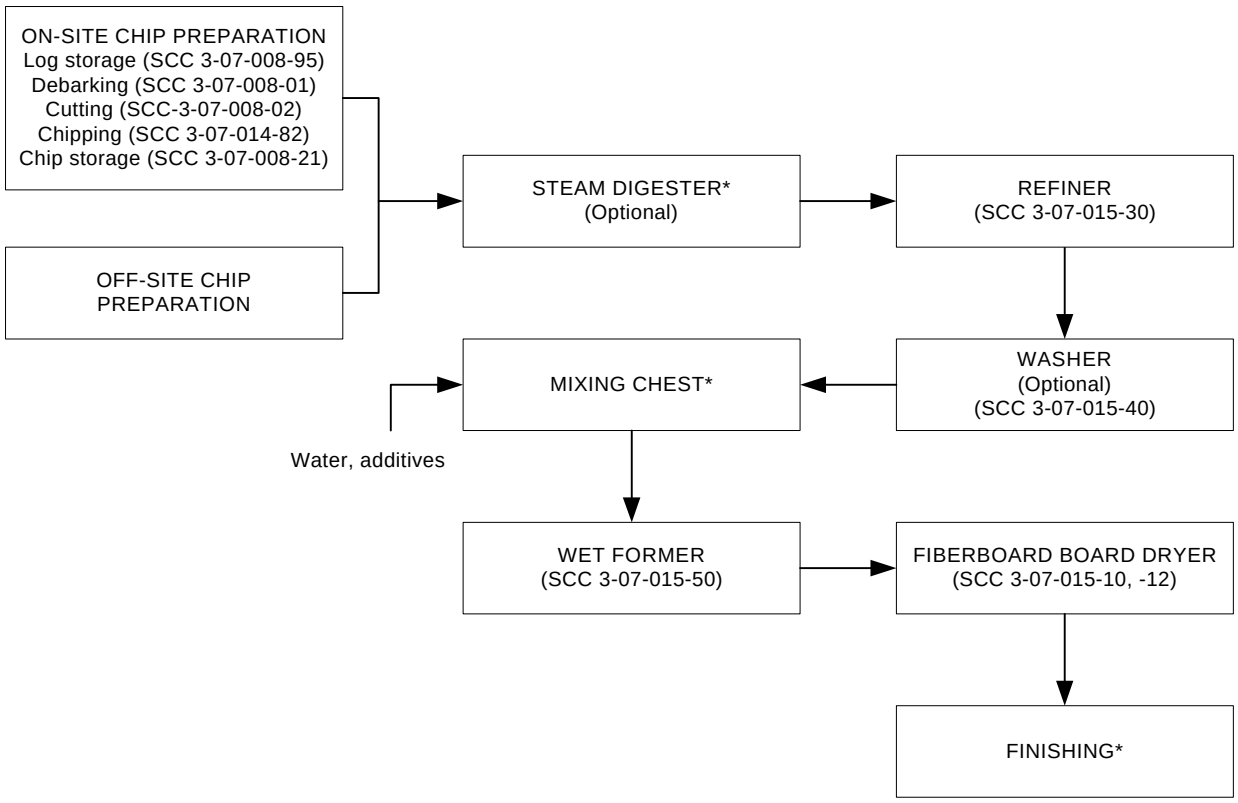
Figure 10.6.4-2b. Double-stage tube dryer.

Resinated fibers exiting the drying system enter a forming machine where they are deposited on a continuously moving conveyor. The mat is prepressed and trimmed before being loaded into the hot press. The press applies heat and pressure to activate the PF resin and bond the fibers into a solid board. Dry process hardboard plants use a multi-opening batch press. The typical press cycle is about 4 minutes. The hardboard presses are heated by steam to a temperature of around 210°C (410°F). Following pressing, boards are routed through a board cooler at some plants. However, most plants do not operate board coolers.

Hardboard plants typically heat treat the pressed hardboard in a bake or tempering oven. The purpose of heat treatment is to lower the moisture content of pressed hardboard to bone dry levels to improve dimensional stability and enhance board mechanical properties. Linseed oil is sometimes applied to the hardboard prior to heat treatment. Hardboard ovens are either indirect-heated or direct-fired and operate at temperatures up to 170°C (340°F). Humidification of boards is done immediately following heat treatment to bring the board moisture content back into equilibrium with ambient air conditions. Humidification kilns are often integrated with hardboard ovens (i.e., the boards coming out of the hardboard oven go straight into the humidification kiln). Following humidification, the hardboard is finished and packaged for shipment. Dry process hardboard densities range from 625 to 1,100 kilograms per cubic meter (kg/m^3) (39 to 69 pounds per cubic foot [lb/ft^3]).

Wet Process Fiberboard -

The general steps in production of fiberboard manufacture include pulping of hardwood or softwood wood chips, wet forming, drying, and finishing. Fiberboard may be manufactured with bagasse or other agricultural fiber instead of wood fiber. The bagasse fiberboard manufacturing process is generally the same as the wood fiberboard manufacturing process. Figure 10.6.4-3 presents a flow diagram for wet process fiberboard manufacturing. The discussion below focuses on the wood fiberboard manufacturing process.



** This process is a potential emission source; however, no emissions data specific to this process are available.*

Figure 10.6.4-3. Process flow diagram for wet process fiberboard manufacturing.

Wood chips for fiberboard may either be steamed in digesters or soaked in hot process water before being ground into fiber in atmospheric refiners. From the refiners, fibers are sometimes washed to remove wood sugars that might reduce the quality of the finished product. The refined and/or washed fibers are sent to stock chests to await further processing. The fibers from the stock chests are mixed with water and additives such as alum, starch, asphalt, and wax. Resins are not used in fiberboard production. The wood fibers are bonded together by additives and substances naturally contained in the wood. Alum aids in the precipitation of wax, asphalt, and rosin onto wood fibers. Bonds between these substances and the wood fibers assist in holding the fiber mat together.

Once mixed with additives, the fiber slurry is sent to the forming machine. In the wet forming process, the water-fiber mixture is metered onto a wire screen. Water is drained away by gravity and with the aid of suction applied to the underside of the wire. The fiber mat along with the supporting wire is moved to a room-temperature pre-press where excess water is squeezed out. Once pre-pressed, the fiber mat may be cut to length and trimmed on the edges with high-pressure water jets.

The fiber mats, which are around 60 percent moisture (dry basis), are passed through a conveyor-type board dryer where their moisture content is reduced to about 4 percent. Fiberboard board dryers operate with inlet temperatures of around 230°C (450°F) and outlet temperatures of around 160°C (320°F). Finished fiberboard density ranges from 190 to 380 kg/m^3 (12 to 24 lb/ft^3). Once dried, the fiberboard is finished, trimmed, and may be painted or roll-coated with asphalt. Finally, the fiberboard is packaged for shipment.

Wet Process Hardboard -

Production of wet process hardboard includes pulping of wood chips, wet forming, pressing, heat treatment, humidification, and finishing. Phenol-formaldehyde resin, wax, and alum are used in wet process hardboard manufacturing. Figure 10.6.4-4 presents a flow diagram for wet process hardboard manufacturing.

Hardwood or softwood chips may either be purchased from outside or generated onsite from logs. The chips are washed to remove dirt and debris. The chips are then steam cooked under pressure in digesters to soften the chips and liberate the wood sugars. After cooking, the softened chips are refined in a single or double disc atmospheric refiner (referred to as the primary refiner), which grinds the chips into fiber form. The fibers from the primary refiner are subsequently fed into stock washers, which use water and pressure to wash out the wood sugars. After washing, the wood material is further refined in a secondary refiner. Some plants may omit secondary refining.

Once refined, the wood fiber is mixed with water, alum, PF resin, and wax in stock or mix chests. The alum is added to the fiber slurry to control pH and help precipitate the resin and wax onto the fibers. The dilute slurry of fiber, additives, and water is routed to a wet forming machine. At some plants, the forming machine may have separate header boxes where separate slurries may be used to make layers in the hardboard mat. The top layer of the fiber mat is called an “overlay” and the bottom layer is called a “substrate”. The wood fiber used to make the overlay undergoes additional refining prior to chemical addition and dilution so that the top layer of the hardboard will have a smoother finish. The fiber slurry from the substrate head box and the overlay head box are fed onto a moving wire screen (forming machine) where they immediately begin to form a continuous fiber mat. Water drains through the wire screen first by gravity and then by suction. The fiber mat is compressed with press rolls and further dewatered. The edges of the fiber mat may be trimmed with water jets prior to hot pressing.

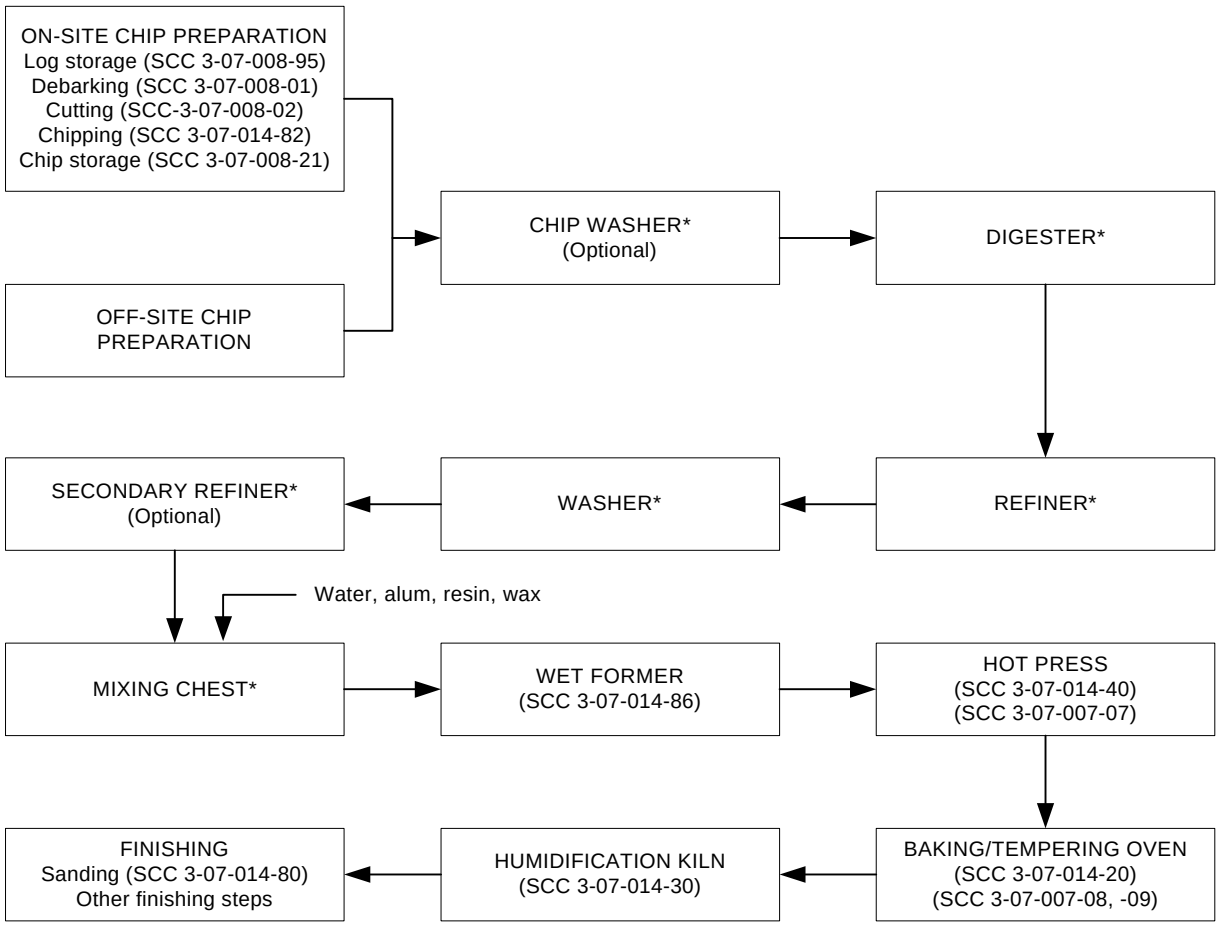


Figure 10.6.4-4. Process flow diagram for wet process hardboard manufacturing.

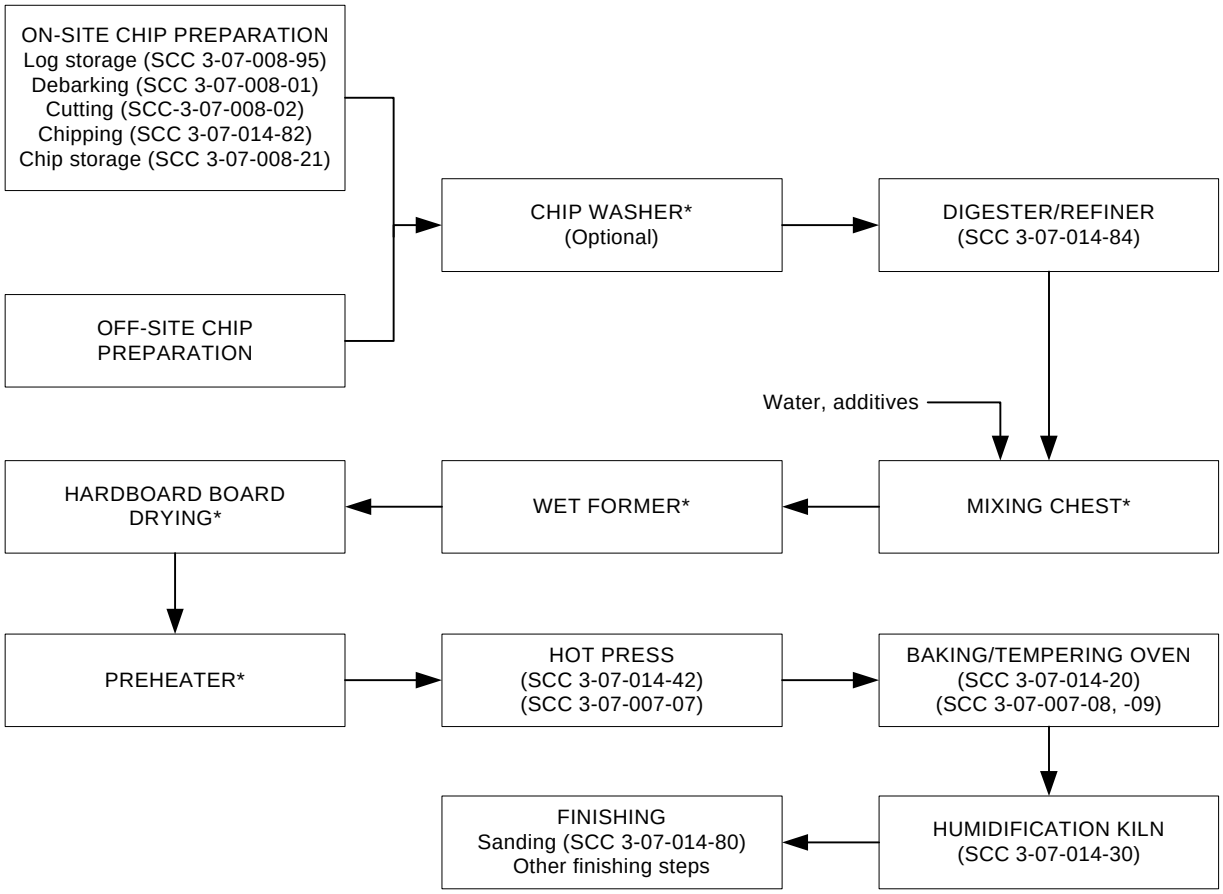
The carrying wire takes the fiber mats to a preloader to await pressing. The fiber mats are loaded into the press. Water released from the mats during pressing cascades down the sides of the press and is recycled. The fiber mats enter the press at a moisture content of about 120 percent (dry basis). Wet process hardboard presses are typically multi-opening, steam-heated, batch presses. The hardboard mats are pressed for roughly 8 minutes at around 200°C (390°F).

As with dry process hardboard, the wet process hardboard mats may be transported to baking or tempering ovens where the mats are dried to "bone-dry" levels following pressing. Further drying of the mats increases bonding and makes the hardboard more resistant to water. Once dried, the boards may be cooled and are then rehumidified to prevent buckling and to improve the overall dimensional stability of the boards. Final wet process hardboard densities range from 800 to 1,120 kg/m^3 (50 to 70 lb/ft^3).

Wet/Dry Process Hardboard -

Production of wet/dry process hardboard includes pulping of softwood or hardwood chips, wet forming, drying, pressing, heat treatment, humidification, and finishing. Wet/dry process hardboard production is similar to fiberboard production until the pressing step of the process is reached. The pressing, heat treatment, and humidification steps in wet/dry hardboard production are similar to the

same steps in wet hardboard production. Raw materials used in the production of wet/dry hardboard include wood chips and additives such as linseed oil, asphalt, and wax. No resin is used in the production of wet/dry hardboard. Figure 10.6.4-5 presents a flow diagram for wet/dry process hardboard manufacturing.



** This process is a potential emission source; however, no emissions data specific to this process are available.*

Figure 10.6.4-5. Process flow diagram for wet/dry process hardboard manufacturing.

Wood chips may either be purchased from offsite or generated onsite from logs. The chips are washed to remove dirt and debris. The chips are then steam cooked under pressure in digesters. After cooking, the chips are refined in primary and/or secondary refiners. Some plants may omit secondary refining. Some plants may use pressurized refiners in lieu of stand-alone digesters and atmospheric refiners.

Once refined the wood fiber is mixed with water and wax in stock or mix chests. The dilute slurry of fiber, additives, and water is routed to a wet forming machine. As with the manufacture of wet process hardboard, some plants may use separate substrate (bottom layer) and overlay (top layer) forming header boxes to make a layered hardboard mat. The fiber slurry from the substrate head box and the overlay head box are fed onto a moving wire screen (forming machine) where they immediately begin to form a continuous fiber mat. Water drains through the wire screen first by gravity and then by suction.

The fiber mat is compressed with press rolls which assist in further dewatering the mat. The edges of the fiber mat may be trimmed with water jets prior to drying.

The fiber mats, which are around 60 percent moisture (dry basis), are passed through a conveyor-type board dryer where their moisture content is reduced to around 4 percent. The board dryers operate with inlet temperatures of around 230°C (450°F) and outlet temperatures of around 160°C (320°F). From the dryer, the fiber mats pass through a press predryer or preheat oven. The purpose of the predryer is to reduce the mat moisture content in order to minimize the hot press cycle. Steam-heated batch presses are used in wet/dry hardboard manufacturing. Press temperatures average around 140°C (470°F) for press cycle times of nearly 4 minutes. As for dry and wet process hardboard, the wet/dry process hardboard mats are heat treated in hardboard ovens and humidification kilns following pressing. Wet/dry process hardboard densities range from 720 to 1,150 kg/m^3 (45 to 72 lb/ft^3).

10.6.4.3 Emissions and Controls -

The primary emission sources at hardboard/fiberboard mills are tube dryers, rotary dryers, hardboard ovens, board conveyor dryers, press preheat ovens, and hot presses. Other emission sources may include boilers, chip and fiber production operations, mat formers, board coolers, humidification kilns, and finishing operations such as sanding and trimming. 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.

Emissions from tube dryers or rotary dryers that are exhausted from the product 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_2), and nitrogen oxides (NO_x), 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 or from the resin if resinated fibers are dried, 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.

Unlike tube dryers and rotary dryers, hardboard ovens, board conveyor dryers, and press preheaters process fiber mats or pressed boards and do not rely on pneumatic conveyance of fibers through the dryers. Thus, there is less potential for emissions of PM from hardboard ovens, conveyor dryers, and press preheaters. However, these dryers are sources of VOCs, CO, CO_2, NO_x, and other organic compounds. The emissions from hardboard ovens, conveyor dryers, and press preheaters depend on whether the dryer is indirect-heated or direct-fired, the fuel used if the dryer if direct-fired, wood species, and type of resin, binder, or drying oil employed.

Emissions from board hot presses are dependent on the type and amount of resin (if any) used to bind the wood fibers together, as well as wood species, wood moisture content, additives used, and press conditions. When the press opens, vapors that may include resin ingredients (if resins are used) such as formaldehyde, phenol, and other organic compounds are released. The rate at which organic compounds are emitted during pressing operations is a function of the resin formulation, board thickness, press temperature, and press cycle time.

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 hardboard 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 1,000°F), which reduces auxiliary fuel usage.

Biofiltration systems are also used effectively for control of a variety of pollutants including organic compounds, NO_x, CO, and PM from press exhaust streams. Biofiltration uses microrganisms 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_2, 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).

In addition to the control devices mentioned above, absorption systems such as scrubbers are often used to control PM from hardboard/fiberboard dryers and presses.

Operations such as log chipping, in addition to chip piles and bins, and chip handling systems 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 hardboard/fiberboard mills where log chipping is performed onsite, PM and PM-10 emissions from log debarking, sawing, and grinding operations can be controlled through capture in an exhaust system connected to a fabric filter collection system. Emissions of PM and PM-10 from final sanding and sawing 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 direct-fired dryer burners.

Fiber production operations such as digesters, pressurized refiners, atmospheric refiners, and fiber washers may be sources of organic emissions. Emissions from these sources are typically uncontrolled, except for pressurized refiners that vent directly into tube dryers at dry process hardboard plants. When exhausted through a tube dryer, the pressurized refiner exhaust exits through the tube dryer control device.

Hardboard/fiberboard mat forming systems may also emit small amounts of organic emissions, and PM emissions in the case of dry forming systems. Emission factors for wet forming vacuum systems are provided in this section. No emission factors are available for dry hardboard formers; however, the magnitude of the emissions from dry formers may be comparable to the emissions from dry formers used to form other reconstituted wood products (e.g., medium density fiberboard).

Hardboard board coolers and humidification kilns may also be sources of organic emissions. Exhaust from board coolers is typically uncontrolled or is routed to the press control device. No emission factors are available specifically for hardboard board coolers, but emission factors are available for particleboard and MDF board coolers. Humidification kilns are usually uncontrolled. Emission factors for humidification kilns are provided in this section.

Emissions from hardboard/fiberboard finishing operations are dependent on the type of products being finished. For most hardboard/fiberboard products, finishing involves cutting to size and, in some cases, application of edge seals, anti-skid coatings, primers, company logos, or trademark or grade stamps. Some products may require sanding. Sawing and sanding operations are sources of PM and PM-10 emissions. No data specific to hardboard/fiberboard sawing are available. However, emission factors for MDF sawing operations may provide an order of magnitude estimate for similar hardboard/fiberboard sawing operations. Available emission factors for sanding of hardboard are presented in this section.

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 10.6.4-1 presents emission factors for dryer emissions of PM, including filterable PM and condensible PM. Table 10.6.4-2 presents emission factors for dryer and oven emissions of NO_x, CO, and CO_2. Table 10.6.4-3 presents emission factors for dryer and oven emissions of VOC and speciated organic compounds. Table 10.6.4-4 presents emission factors for hardboard press emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.4-5 presents emission factors for hardboard press emissions of NO_x, CO, and CO_2. Table 10.6.4-6 presents emission factors for hardboard press emissions of VOC and speciated organic compounds. Table 10.6.4-7 presents emission factors for miscellaneous sources of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.6.4-8 presents emission factors for miscellaneous source emissions of NO_x, CO, and CO_2. Table 10.6.4-9 presents emission factors for miscellaneous source emissions of VOC and speciated organic compounds.

To the extent possible, separate emission factors for hardboard and fiberboard dryers are presented in Tables 10.6.4-1 to -3 for hardwoods and softwoods. Hardwoods generally correspond to deciduous species. For hardboard, fiberboard, plywood, and other composite wood products, commonly used hardwoods include aspen, oak, poplar, maple, cherry, alder, hickory, gum, beech, birch, and basswood. The emission factors for hardwood hardboard and fiberboard dryers presented in this section are based largely on the drying of aspen, birch, beech, oak, and maple furnish. Softwoods generally correspond to coniferous species. For hardboard, fiberboard, plywood, and other composite wood products, commonly used softwoods include pines, firs, and spruce. Pines are the most commonly used softwood species for hardboard and fiberboard manufacturing.

Table 10.6.4-1. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD DRYERS AND OVENS—PARTICULATE MATTER[a]

Source	Emission Control Device	Filterable[b]				Condensible[c]	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
Tube dryer, direct natural gas-fired, blowline blend, PF resin, hardwood (SCC 3-07-014-15)	None	1.9	E	ND		0.57	E

[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). Factors represent uncontrolled emissions. SCC = Source Classification Code. ND = no data available. Reference 2. See Table 10.6.4-10 for the hardwood and softwood species commonly used in the production of hardboard, fiberboard, 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 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] Condensible PM is that PM collected in the impinger portion of a PM sampling train (EPA Method 202).

Table 10.6.4-2. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD DRYERS, OVENS—NO_x, CO, AND CO_2[a]

Source	Emission Control Device[b]	Emission Factor Units[c]	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2	EMISSION FACTOR RATING
Hardboard tube dryer, direct natural gas-fired, blowline blend, PF resin, hardwood (SCC 3-07-014-15)	Uncontrolled	lb/ODT	0.44[d]	E	0.067[d]	E	384[d]	E
Hardboard tube dryer, direct wood-fired, blowline blend, PF resin, hardwood (SCC 3-07-014-10)	Uncontrolled	lb/ODT	ND		0.085	E	ND	
Hardboard tube dryer, second stage, indirect-heated, hardwood (SCC 3-07-014-25)	Uncontrolled	lb/ODT	ND		0.076	E	ND	
Hardboard board dryer, direct natural-gas fired, linseed oil binder, heated zones, softwood (SCC 3-07-014-16)	Uncontrolled	lb/MSF 1/2	ND		0.49[e]	E	ND	
Hardboard tempering oven, direct natural gas-fired, hardwood (SCC 3-07-014-20)	Uncontrolled	lb/MSF 1/8	ND		0.11	E	ND	
	RTO	lb/MSF 1/8	ND		0.0021	E	ND	
Fiberboard board dryer, indirect heated, starch binder, heated zones, softwood (SCC 3-07-015-10)	Uncontrolled	lb/MSF 1/2	ND		0.092	E	ND	
Fiberboard board dryer, indirect heated, 6-12% asphalt binder, heated zones, softwood (SCC 3-07-015-12)	Uncontrolled	lb/MSF 1/2	ND		0.029[e]	E	ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available. Reference 3 unless otherwise noted. See Table 10.6.4-10 for the hardwood and softwood species commonly used in the production of hardboard, fiberboard, 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 TTN website at: http://www.epa.gov/ttn/chief/.**

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

[c] 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 1/2-inch thick panel

(lb/MSF 1/2); one lb/MSF 1/2 = 0.38 kg/m^3; pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8); one lb/MSF 1/8 = 1.54 kg/m^3.

[d] Reference 2.

[e] Emission factors apply only to the heated zones of the dryer; the cooling sections also have emissions but data were not available for cooling section emissions.

Table 10.6.4-3. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD DRYERS, OVENS—ORGANICS[a]

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard tube dryer, direct natural gas-fired, blowline blend, PF resin, hardwood (SCC 3-07-014-15)	None		THC as carbon[d]	3.2[f]	lb/ODT	E
			VOC as propane[e]	5.0	lb/ODT	E
		75-07-0	Acetaldehyde *	0.0096[f]	lb/ODT	E
		67-64-1	Acetone	0.0095[f]	lb/ODT	E
		107-02-8	Acrolein *	0.0041[f,g]	lb/ODT	E
		71-43-2	Benzene *	0.000088[f]	lb/ODT	E
			Benzo(a)pyrene	BDL		
			Bromomethane *	BDL		
		74-87-3	Chloromethane *	0.000019[f]	lb/ODT	E
			Ethanol	BDL		
		100-41-4	Ethylbenzene *	0.00013[f]	lb/ODT	E
		50-00-0	Formaldehyde *	1.1[f,g]	lb/ODT	E
		66-25-1	Hexaldehyde	0.052[f,g]	lb/ODT	E
			Isobutanol	BDL		
			m,p-Cresol *	BDL		
		67-56-1	Methanol *	1.4[f]	lb/ODT	E
		78-93-3	Methyl ethyl ketone *	0.00083[f]	lb/ODT	E
			Methyl propyl ketone	BDL		
			Methylene chloride *	BDL		
			Naphthalene *	BDL		
			o-Cresol *	BDL		
		108-95-2	Phenol *	0.056[f]	lb/ODT	E
			Propanol	BDL		
		123-38-6	Propionaldehyde *	0.041[f]	lb/ODT	E
			Pyridine	BDL		
		100-42-5	Styrene *	0.0027[f]	lb/ODT	E
		108-88-3	Toluene *	0.00023[f]	lb/ODT	E
		75-69-4	Trichlorofluoromethane	0.000020[f]	lb/ODT	E
		1330-20-7	Xylenes *	0.000056[f]	lb/ODT	E

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard tube dryer, direct wood-fired, blowline blend, PF resin, hardwood (SCC 3-07-014-10)	None		THC as carbon[d]	0.74	lb/ODT	D
			VOC as propane[e]	1.1	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.11	lb/ODT	D
		67-64-1	Acetone	0.018	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 *	0.26	lb/ODT	D
			Limonene	BDL		
		67-56-1	Methanol *	1.0	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 *	0.083	lb/ODT	D
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard tube dryer, second stage, indirect-heated, hardwood (SCC 3-07-014-25)	None		THC as carbon[d]	0.23	lb/ODT	D
			VOC as propane[e]	0.27	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
		67-64-1	Acetone	0.031	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 *	0.017	lb/ODT	D
			Limonene	BDL		
		67-56-1	Methanol *	0.042	lb/ODT	D
			Methyl isobutyl ketone *	BDL		
			Methyl ethyl 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 *	0.039	lb/ODT	D
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard board dryer, direct natural-gas fired, linseed oil binder (heated zones), softwood (SCC 3-07-014-16)	None		1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.053[h]	lb/MSF 1/2	E
		67-64-1	Acetone	0.021[h]	lb/MSF 1/2	E
		107-02-8	Acrolein *	0.037[h]	lb/MSF 1/2	E
			Alpha-pinene	BDL		
		71-43-2	Benzene *	0.0021[h]	lb/MSF 1/2	E
			Beta-pinene	BDL		
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
		50-00-0	Formaldehyde *	0.059[h]	lb/MSF 1/2	E
			Limonene	BDL		
		67-56-1	Methanol *	0.047[h]	lb/MSF 1/2	E
		78-93-3	Methyl ethyl ketone *	0.0013[h]	lb/MSF 1/2	E
		108-10-1	Methyl isobutyl ketone *	0.0034[h]	lb/MSF 1/2	E
			Methylene chloride *	BDL		
			m,p-Xylene *	BDL		
			o-Xylene *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
		108-95-2	Phenol *	0.0019[h]	lb/MSF 1/2	E
		123-38-6	Propionaldehyde *	0.025[h]	lb/MSF 1/2	E
		100-42-5	Styrene *	0.00016[h]	lb/MSF 1/2	E
		108-88-3	Toluene *	0.0010[h]	lb/MSF 1/2	E

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard tempering oven, direct natural gas-fired (SCC 3-07-014-20)	None		THC as carbon[d]	0.50	lb/MSF 1/8	E
			VOC as propane[e]	0.61	lb/MSF 1/8	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.076	lb/MSF 1/8	E
		67-64-1	Acetone	0.0034	lb/MSF 1/8	E
		107-02-8	Acrolein *	0.024	lb/MSF 1/8	E
			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 *	0.0043	lb/MSF 1/8	E
			Limonene	BDL		
		67-56-1	Methanol *	0.015	lb/MSF 1/8	E
		78-93-3	Methyl ethyl ketone *	0.00075	lb/MSF 1/8	E
		108-10-1	Methyl isobutyl ketone *	0.0046	lb/MSF 1/8	E
			Methylene chloride *	BDL		
			m,p-Xylene *	BDL		
			o-Xylene *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
		108-95-2	Phenol *	0.0019	lb/MSF 1/8	E
		123-38-6	Propionaldehyde *	0.10	lb/MSF 1/8	E
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Hardboard tempering oven, direct natural gas-fired (SCC 3-07-014-20)	RTO		THC as carbon[d]	BDL		
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
		67-64-1	Acetone	0.00091	lb/MSF 1/8	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		
			Formaldehyde *	BDL		
			Limonene	BDL		
		67-56-1	Methanol *	0.00087	lb/MSF 1/8	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		
		108-95-2	Phenol *	0.0020	lb/MSF 1/8	E
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Fiberboard board dryer, indirect heated, starch binder (heated zones), softwood (SCC 3-07-015-10)	None		THC as carbon[d]	0.063[h]	lb/MSF 1/2	E
			VOC as propane[e]	0.082[h]	lb/MSF 1/2	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.00097[h]	lb/MSF 1/2	E
		67-64-1	Acetone	0.0038[h]	lb/MSF 1/2	E
		107-02-8	Acrolein *	0.00057[h]	lb/MSF 1/2	E
		80-56-8	Alpha-pinene	0.013[h]	lb/MSF 1/2	E
			Benzene *	BDL		
			Beta-pinene	BDL		
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
		50-00-0	Formaldehyde *	0.0093[h]	lb/MSF 1/2	E
			Limonene	BDL		
		67-56-1	Methanol *	0.017[h]	lb/MSF 1/2	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		
		108-95-2	Phenol *	0.0012[h]	lb/MSF 1/2	E
		123-38-6	Propionaldehyde *	0.00069[h]	lb/MSF 1/2	E
			Styrene *	BDL		
			Toluene *	BDL		

Table 10.6.4-3 (cont.).

Source	Emission Control Device	CASRN[b]	Pollutant	Emission Factor	Emission Factor Units[c]	EMISSION FACTOR RATING
Fiberboard board dryer, indirect heated, 6-12% asphalt binder (heated zones), softwood (SCC 3-07-015-12)	None		THC as carbon[d]	0.11[h]	lb/MSF 1/2	D
			VOC as propane[e]	0.14[h]	lb/MSF 1/2	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.0029[h]	lb/MSF 1/2	E
		67-64-1	Acetone	0.0048[h]	lb/MSF 1/2	E
		107-02-8	Acrolein *	0.0012[h]	lb/MSF 1/2	E
		80-56-8	Alpha-pinene	0.014[h]	lb/MSF 1/2	E
			Benzene *	BDL		
			Beta-pinene	BDL		
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
		50-00-0	Formaldehyde *	0.013[h]	lb/MSF 1/2	E
			Limonene	BDL		
		67-56-1	Methanol *	0.026[h]	lb/MSF 1/2	E
			Methyl isobutyl ketone *	BDL		
			Methyl ethyl 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 *	0.0014[h]	lb/MSF 1/2	E
			Propionaldehyde *	BDL		
			Styrene *	BDL		
			Toluene *	BDL		

[a] Factors represent uncontrolled emissions. 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 3 unless otherwise noted. See Table 10.6.4-10 for the hardwood and softwood species commonly used in the production of hardboard, fiberboard, 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 TTN website at: http://www.epa.gov/ttn/chief/.**

[b] CASRN = Chemical Abstracts Service Registry Number.

[c] 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 1/2-inch thick panel (lb/MSF 1/2); one lb/MSF 1/2 = 0.38 kg/m^3; pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8); one lb/MSF 1/8 = 1.54 kg/m^3.

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

Table 10.6.4-3 (cont.).

[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”.

[f] Reference 2.

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

[h] Emission factors apply only to the heated zones of the dryer; the cooling sections also have emissions but data were not available for cooling section emissions.

Table 10.6.4-4. EMISSION FACTORS FOR HARDBOARD PRESSES--PARTICULATE MATTER[a]

Source[c]	Emission Control Device	Filterable[b]				Condensible[d]	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
Hardboard hot press, PF resin (SCC 3-07-014-40)	Uncontrolled	0.14	E	0.086	E	0.12	E

[a] Emission factor units are pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8). One lb/MSF 1/8 = 1.54 kg/m^3. Factors represent uncontrolled emissions. SCC = Source Classification Code. Reference 4. **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] 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] PF = phenol formaldehyde.

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

Table 10.6.4-5. EMISSION FACTORS FOR HARDBOARD PRESSES--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
Hardboard hot press, PF resin (SCC 3-07-014-40)	Uncontrolled	ND		ND		ND	

[a] Emission factor units are pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8). One lb/MSF 1/8 = 1.54 kg/m^3. Factors represent uncontrolled emissions. 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 TTN website at: http://www.epa.gov/ttn/chief/.**

[b] PF = phenol formaldehyde.

Table 10.6.4-6. EMISSION FACTORS FOR HARDBOARD PRESSES--ORGANICS[a]

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	EMISSION FACTOR RATING
Hardboard hot press, PF resin (SCC 3-07-014-40)	Uncontrolled		THC as carbon[e]	0.42	D
			VOC as propane[f]	0.52	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			2,4-Dimethylbenzaldehyde	BDL	
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.016	D
		67-64-1	Acetone	0.0055[g]	D
			Acrolein *	BDL	
			Alpha-pinene	BDL	
			Benzaldehyde	BDL	
			Benzene *	BDL	
			Beta-pinene	BDL	
			Bromomethane *	BDL	
			Butyraldehyde	BDL	
			Camphene	BDL	
			Chloroethane *	BDL	
			Chloroethene *	BDL	
			Cis-1,2-dichloroethylene	BDL	
			Crotonaldehyde	BDL	
			Cumene *	BDL	
		50-00-0	Formaldehyde *	0.014	D
			Hexaldehyde	BDL	
			Isovaleraldehyde	BDL	
			Limonene	BDL	
		67-56-1	Methanol *	0.24[g]	D
			Methyl ethyl ketone *	BDL	
			Methyl isobutyl ketone *	BDL	
			Methylene chloride *	BDL	
		1330-20-7	m,p-Xylene *	0.0053	D
			o-,m-,p-Tolualdehyde	BDL	
		95-47-6	o-Xylene *	0.0036	D
			p-Cymene	BDL	
			p-Mentha-1,5-diene	BDL	
		108-95-2	Phenol *	0.010	D
			Propionaldehyde *	BDL	
			Styrene *	BDL	
		108-88-3	Toluene *	0.0011	D
			Valeraldehyde	BDL	

Table 10.6.4-6 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	EMISSION FACTOR RATING
Hardboard hot press, PF resin (SCC 3-07-014-40)	Scrubber		THC as carbon[e]	0.043	E
			VOC as propane[f]	0.052	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
		75-07-0	Acetaldehyde *	0.0033	E
		67-64-1	Acetone	0.0039	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	
		50-00-00	Formaldehyde *	0.0034	E
			Limonene	BDL	
		67-56-1	Methanol *	0.15	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 10.6.4-6 (cont.).

Source[b]	Emission Control Device[c]	CASRN[d]	Pollutant	Emission Factor	EMISSION FACTOR RATING
Hardboard hot press, linseed oil binder (SCC 3-07-014-42)	Uncontrolled		THC as carbon[e]	0.58	E
			VOC as propane[f]	0.71	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
		75-070	Acetaldehyde *	0.036	E
		67-64-1	Acetone	0.015	E
		107-02-8	Acrolein *	0.0057	E
			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 *	0.018	E
			Limonene	BDL	
		67-56-1	Methanol *	0.093	E
		78-93-3	Methyl ethyl ketone *	0.0045	E
			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 *	0.0039	E
		123-38-6	Propionaldehyde *	0.031	E
			Styrene *	BDL	
			Toluene *	BDL	

[a] Emission factor units are pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8). One lb/MSF 1/8 = 1.54 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 3 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 available on EPA's TTN website at: http://www.epa.gov/ttn/chief/.**

[b] PF = phenol formaldehyde.

[c] Emission control device: scrubber consists of a water quench, followed by a water tray tower, followed by a high-energy venturi scrubber with a 49-inch pressure drop, followed by a chevron demister.

Table 10.6.4-6 (cont.).

[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 3 and 4.

Table 10.6.4-7. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD MISCELLANEOUS SOURCES–PARTICULATE MATTER[a]

Source	Emission Control Device	Filterable[b]				Condensible[c]	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
Hardboard sander (SCC 3-07-014-80)	Fabric filter	0.030	E	ND		ND	
Log storage (SCC 3-07-008-95)	Uncontrolled	ND		ND		ND	
Debarking (SCC 3-07-008-01)	Uncontrolled	ND		ND		ND	
Log cutting (SCC 3-07-008-02)	Uncontrolled	ND		ND		ND	
Log chipping (SCC 3-07-014-82)	Uncontrolled	ND		ND		ND	
Chip storage (SCC 3-07-008-21)	Uncontrolled	ND		ND		ND	

[a] Emission factor units are pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8). One lb/MSF 1/8 = 1.54 kg/m^3. SCC = Source Classification Code. ND = no data available. Reference 4.

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

Table 10.6.4-8. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD MISCELLANEOUS SOURCES--NO_x, CO, AND CO_2[a]

Source	Emission Control Device	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2	EMISSION FACTOR RATING
Hardboard humidification kiln, indirect heated (SCC 3-07-014-30)	Uncontrolled	0.0028	E	0.16	E	ND	

[a] Emission factor units are pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8). One lb/MSF 1/8 = 1.54 kg/m^3. SCC = Source Classification Code. ND = no data available. Reference 2.

Table 10.6.4-9. EMISSION FACTORS FOR HARDBOARD AND FIBERBOARD MISCELLANEOUS SOURCES--ORGANICS[a]

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Log storage (SCC 3-07-008-95)	Uncontrolled		THC, VOC	ND		
Debarking (SCC 3-07-008-01)	Uncontrolled		THC, VOC	ND		
Log cutting (SCC 3-07-008-02)	Uncontrolled		THC, VOC	ND		
Chip storage (SCC 3-07-008-21)	Uncontrolled		THC, VOC	ND		
Hardboard log chipper, hardwood (SCC 3-07-014-82)	None		THC as carbon[e]	0.0041	lb/ODT	E
			VOC as propane[f]	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		

Table 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Hardboard pressurized digester/ refiner, hardwood (SCC 3-07-014-84)	None		THC as carbon[e]	0.40	lb/ODT	E
			VOC as propane[f]	0.49	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.030	lb/ODT	E
		67-64-1	Acetone	0.0042	lb/ODT	E
		107-02-8	Acrolein *	0.0024	lb/ODT	E
		80-56-8	Alpha-pinene	0.0039	lb/ODT	E
			Benzene *	BDL		
		127-91-3	Beta-pinene	0.0063	lb/ODT	E
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
			Cumene *	BDL		
		50-00-0	Formaldehyde *	0.0045	lb/ODT	E
		138-86-3	Limonene	0.0026	lb/ODT	E
		67-56-1	Methanol *	0.35	lb/ODT	E
		78-93-3	Methyl ethyl ketone *	0.00025	lb/ODT	E
		108-10-1	Methyl isobutyl ketone *	0.00024	lb/ODT	E
			Methylene chloride *	BDL		
			m,p-Xylene *	BDL		
			o-Xylene *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
		108-95-2	Phenol *	0.0012	lb/ODT	E
		123-38-6	Propionaldehyde *	0.00091	lb/ODT	E
		100-42-5	Styrene *	0.00016	lb/ODT	E
			Toluene *	BDL		

Table 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Hardboard former vacuum system, wet, PF resin (SCC 3-07-014-86)	None		1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.0058	lb/ODT	D
		67-64-1	Acetone	0.0032	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 *	0.00026	lb/ODT	D
			Limonene	BDL		
		67-56-1	Methanol *	0.054	lb/ODT	D
		78-93-3	Methyl ethyl ketone *	0.00030	lb/ODT	D
		108-10-1	Methyl isobutyl ketone *	0.00023	lb/ODT	D
			Methylene chloride *	BDL		
			p-Cymene	BDL		
			p-Mentha-1,5-diene	BDL		
		108-95-2	Phenol *	0.00071	lb/ODT	D
		123-38-6	Propionaldehyde *	0.00021	lb/ODT	D
			Styrene *	BDL		

Table 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Fiberboard atmospheric refiner and dump chest, softwood (SCC 3-07-015-30)	None		THC as carbon[e]	0.79	lb/ODT	E
			VOC as propane[f]	0.96	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.0027	lb/ODT	E
		67-64-1	Acetone	0.0039	lb/ODT	E
		107-02-8	Acrolein *	0.00030	lb/ODT	E
		80-56-8	Alpha-pinene	0.72	lb/ODT	E
			Benzene *	BDL		
		127-91-3	Beta-pinene	0.099	lb/ODT	E
			Bromomethane *	BDL		
			Camphene	BDL		
			Chloroethane *	BDL		
			Chloroethene *	BDL		
			Cis-1,2-dichloroethylene	BDL		
		98-82-8	Cumene *	0.0034	lb/ODT	E
		50-00-0	Formaldehyde *	0.00061	lb/ODT	E
		138-86-3	Limonene	0.017	lb/ODT	E
		67-56-1	Methanol *	0.0084	lb/ODT	E
		78-93-3	Methyl ethyl ketone *	0.00021	lb/ODT	E
			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		
		123-38-6	Propionaldehyde *	0.00026	lb/ODT	E
			Styrene *	BDL		
		108-88-3	Toluene *	0.00029	lb/ODT	E

Table 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Fiberboard washer, softwood (SCC 3-07-015-40)	None		THC as carbon[e]	0.19	lb/ODT	E
			VOC as propane[f]	0.23	lb/ODT	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.015	lb/ODT	E
		67-64-1	Acetone	0.0047	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 *	0.0026	lb/ODT	E
			Limonene	BDL		
		67-56-1	Methanol *	0.13	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 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Fiberboard former vacuum system, wet, 6-12% asphalt (SCC 3-07-015-50)	None		THC as carbon[e]	0.15	lb/MSF 1/2	E
			VOC as propane[f]	0.17	lb/MSF 1/2	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
		75-07-0	Acetaldehyde *	0.0075	lb/MSF 1/2	E
		67-64-1	Acetone	0.014	lb/MSF 1/2	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 *	0.0036	lb/MSF 1/2	E
			Limonene	BDL		
		67-56-1	Methanol *	0.014	lb/MSF 1/2	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		
		108-88-3	Toluene *	0.0023	lb/MSF 1/2	E

Table 10.6.4-9 (cont.).

Source	Emission Control Device[b]	CASRN[c]	Pollutant	Emission Factor	Emission Factor Units[d]	EMISSION FACTOR RATING
Hardboard humidification kiln, indirect heated (SCC 3-07-014-30)	None		THC as carbon[e]	0.62[g]	lb/MSF 1/8	E
			VOC as propane[f]	0.76	lb/MSF 1/8	E
			2,4-Dimethylbenzaldehyde	BDL		
		75-07-0	Acetaldehyde *	0.0018[g]	lb/MSF 1/8	E
		67-64-1	Acetone	0.0038[g]	lb/MSF 1/8	D
		107-02-8	Acrolein *	0.0087[g,h]	lb/MSF 1/8	E
			Benzaldehyde	BDL		
		71-43-2	Benzene *	6.2E-06[g]	lb/MSF 1/8	E
			Benzo(a)pyrene	BDL		
			Bromomethane *	BDL		
			Butyraldehyde	BDL		
		75-00-3	Chloroethane *	0.000014[g]	lb/MSF 1/8	E
		74-87-3	Chloromethane *	0.00012[g]	lb/MSF 1/8	E
			Crotonaldehyde	BDL		
			Ethanol	BDL		
		100-41-4	Ethylbenzene *	0.000032[g]	lb/MSF 1/8	E
		50-00-0	Formaldehyde *	0.0010[g,h]	lb/MSF 1/8	E
		66-25-1	Hexaldehyde	0.011[g,h]	lb/MSF 1/8	E
			Isobutanol	BDL		
			Isovaleraldehyde	BDL		
			Methanol *	BDL		
		78-93-3	Methyl ethyl ketone *	0.0014[g]	lb/MSF 1/8	E
			Methyl propyl ketone *	BDL		
			Methylene chloride *	BDL		
		1319-77-3	m,p-Cresol *	0.00033[g]	lb/MSF 1/8	E
			Naphthalene *	BDL		
		95-48-7	o-Cresol *	0.00021[g]	lb/MSF 1/8	E
			o-,m-,p-Tolualdehyde	BDL		
		108-95-2	Phenol *	0.00057[g]	lb/MSF 1/8	E
			Propanol	BDL		
		123-38-6	Propionaldehyde *	0.0077[g]	lb/MSF 1/8	E
			Pyridine	BDL		
			Styrene *	BDL		
		108-88-3	Toluene *	0.000034[g]	lb/MSF 1/8	E
			Trichlorofluoromethane	BDL		
			Valeraldehyde	BDL		
		1330-20-7	Xylenes *	0.000042[g]	lb/MSF 1/8	E

[a] 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 3 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 available on EPA's TTN website at: http://www.epa.gov/ttn/chief/.**

[b] Fabric filters (baghouses) are considered no control for organic pollutants.

[c] CASRN = Chemical Abstracts Service Registry Number.

Table 10.6.4-9 (cont.).

[d] 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 1/2-inch thick panel (lb/MSF 1/2); one lb/MSF 1/2 = 0.38 kg/m^3; pounds of pollutant per thousand square feet of 1/8-inch thick panel (lb/MSF 1/8); one lb/MSF 1/8 = 1.54 kg/m^3.

[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] Reference 2.

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

Table 10.6.4-10. 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 5.

References For Section 10.6.4

1. *Background Information Document For Proposed Plywood And Composite Wood Products NESHAP*, prepared for the U. S. Environmental Protection Agency, OAQPS, by Midwest Research Institute, Cary, NC, September 2000.

2. *Results Of The January 17-19, 1995 Source Emission Tests On The Dryer Stack, Dump Stack And Humidification Kiln Stack At The Georgia Pacific Facility Located In Phillips, Wisconsin*, prepared for CH2M Hill, by PACE, Inc., Project No. 941228.401, March 2, 1995.

3. *Volatile Organic Compound Emissions From Wood Products Manufacturing Facilities, Part VI - Hardboard/Fiberboard, Technical Bulletin No. 773*, National Council of the Paper Industry for Air and Stream Improvement, Inc., Research Triangle Park, NC, 1999.

4. *Title V Emissions Test Report, PM10, Particulate Matter, Condensible Particulate Matter, Aldehydes/Ketones, Phenols, Methanol, Oxygen, Carbon Dioxide, Carbon Monoxide, Nitrogen Oxides, And Cold Total Hydrocarbons From Process Stacks, Georgia Pacific Hardboard Manufacturing Plant, North Little Rock, Arkansas, Test Dates September 26-29, 1995*, prepared for CH2M Hill and Georgia Pacific Corporation, by DEECO, Inc., Report No. 95-1200-A, October 27, 1995.

5. *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, July 2003.