

## 10.9 Engineered Wood Products Manufacturing

### 10.9.1 General<sup>1</sup>

Engineered wood products (EWP) are made from lumber, veneers, strands of wood, or from other small wood elements that are bound together with structural resins to form lumber-like structural products. They are designed for use in the same structural applications as sawn lumber (e.g., girders, beams, headers, joists, studs, and columns). These products allow production of large-lumber substitutes from small lower-grade logs. The engineered wood products discussed in this document include laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), I-joists, and glue-laminated beams (glulam). Engineered wood products manufacturing facilities often manufacture more than one type of engineered wood product.

EWP are classified under Standard Industrial Classification (SIC) code 2439, for “Structural Wood Members, Not Elsewhere Classified”. The North American Industrial Classification System (NAICS) Code for is 321213, for “Engineered Wood Member Manufacturing”.

### 10.9.2 Process Description<sup>1</sup>

#### 10.9.2.1 LVL Process Description -

Laminated veneer lumber consists of layers of wood veneers laminated together with the grain of each veneer aligned primarily along the length of the finished product. The veneers used to manufacture LVL are about 3.2 millimeters (mm) (0.125 inches [in]) thick and are made from rotary-peeled hardwood (e.g., yellow poplar) or softwood species. Laminated veneer lumber is used for headers, beams, rafters, and I-joint flanges. Figure 10.9-1 is a diagram of the LVL manufacturing process.

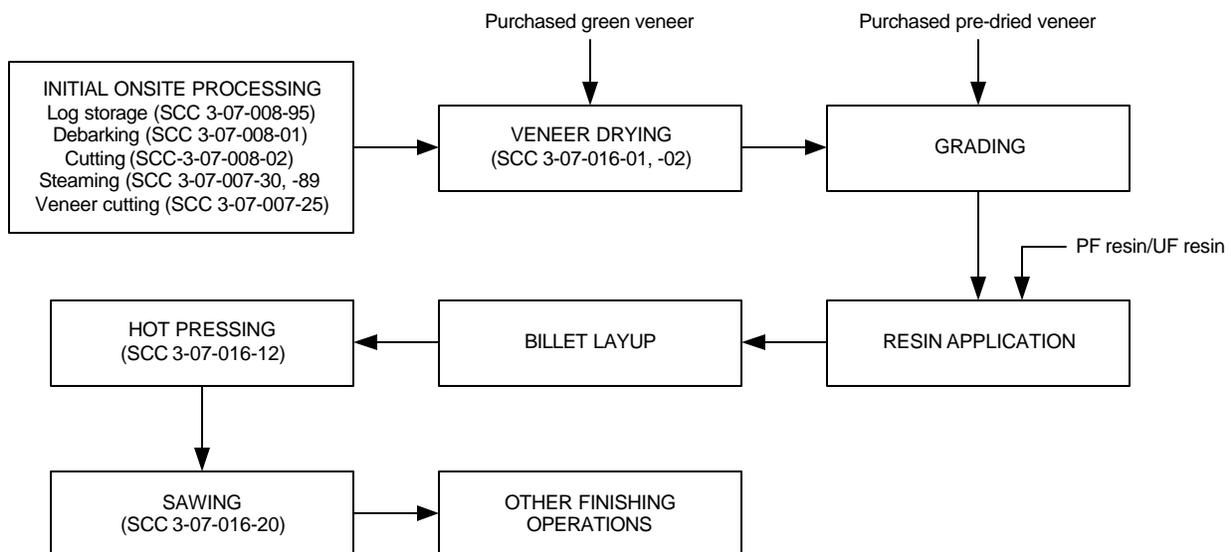


Figure 10.9-1. Process flow diagram for laminated veneer lumber manufacturing.

The start of the LVL manufacturing process depends on how the plant obtains veneers. Plants either peel and dry veneers onsite, purchase green veneers and dry them onsite, or purchase pre-dried veneers. If the plant peels and dries veneers onsite, the first steps in the process are log debarking, cutting, steaming, and veneer cutting. If the plant purchases green veneers, the LVL manufacturing process begins with veneer drying. If the plant purchases pre-dried veneer, grading is the first step in the LVL manufacturing process.

The veneer dryers used at LVL plants are the same types of veneer dryers in use at plywood plants. Section 10.5 discusses and provides emission factors for plywood veneer dryers. Veneer dryers used at LVL plants are used to dry either predominantly hardwood or predominantly softwood species at a typical drying temperature of around 180°C (350°F). The veneer dryer may be a longitudinal dryer, which circulates air parallel to the veneer, or a jet dryer. Jet dryers direct hot, high velocity air at the surface of the veneers through jet tubes. Veneer dryers may be either direct-fired or indirect-heated. In direct-fired dryers, the combustion gases are blended with recirculated exhaust from the dryer to reduce the combustion gas temperature. Air is warmed over steam coils and circulated over the veneer in indirect-heated veneer dryers.

Once the veneers are dried, they are graded ultrasonically for stiffness and strength. The lower grade veneers are used for the LVL core and the higher grade veneers are used in the LVL face. Once graded, the veneers are passed under a curtain or roll coater where phenol-formaldehyde (PF) resin is applied. Plants that manufacture LVL from hardwood species may use urea-formaldehyde (UF) resin rather than PF resin.

Once resinated, the veneers are manually laid up into a long thick stack. The veneer stack is fed to a hot press where the veneers are pressed into a solid billet under heat and pressure. The LVL is manufactured to either a fixed length using a batch press, or to an indefinite length using a continuous press. The LVL presses are heated by electricity, microwaves, hot oil, steam, or radio-frequency (RF) waves. Press temperatures range from about 120° to 230°F (250° to 450°F). Batch presses may have one or more openings. Shorter lengths of LVL can be produced using multi-opening platen presses similar to the hot presses used in plywood manufacturing. However, most plants employ continuous pressing systems.

Billets exiting the press may be up to 8.9 centimeters (cm) (3.5 in) thick. Billets are produced in widths of up to 2.8 meters (m) (6 feet [ft]). The billets are typically ripped into numerous strips based on customer specifications. The LVL is produced in lengths up to the maximum shipping length of 24 m (80 ft). Trademarks or grade stamps may be applied in ink to the LVL before it is shipped from the plant.

#### 10.9.2.2 LSL Process Description -

Laminated strand lumber is made up of wood strands glued together with the grain of each strand oriented parallel to the length of the finished product. Yellow poplar, aspen, and other hardwood species are used in the manufacture of LSL.

Figure 10.9-2 is a diagram of the LSL manufacturing process. Whole logs are received at the plant, debarked, cut to length, and conditioned in heated log vats. The conditioned logs are cut into approximately 30-cm (12-in) strands by rotating knives in a stranding machine (which is similar to a waferizer used in oriented strandboard manufacture). The strands are stored in green bins and screened to remove short strands before they are dried. These short strands may be used as fuel for the production process.

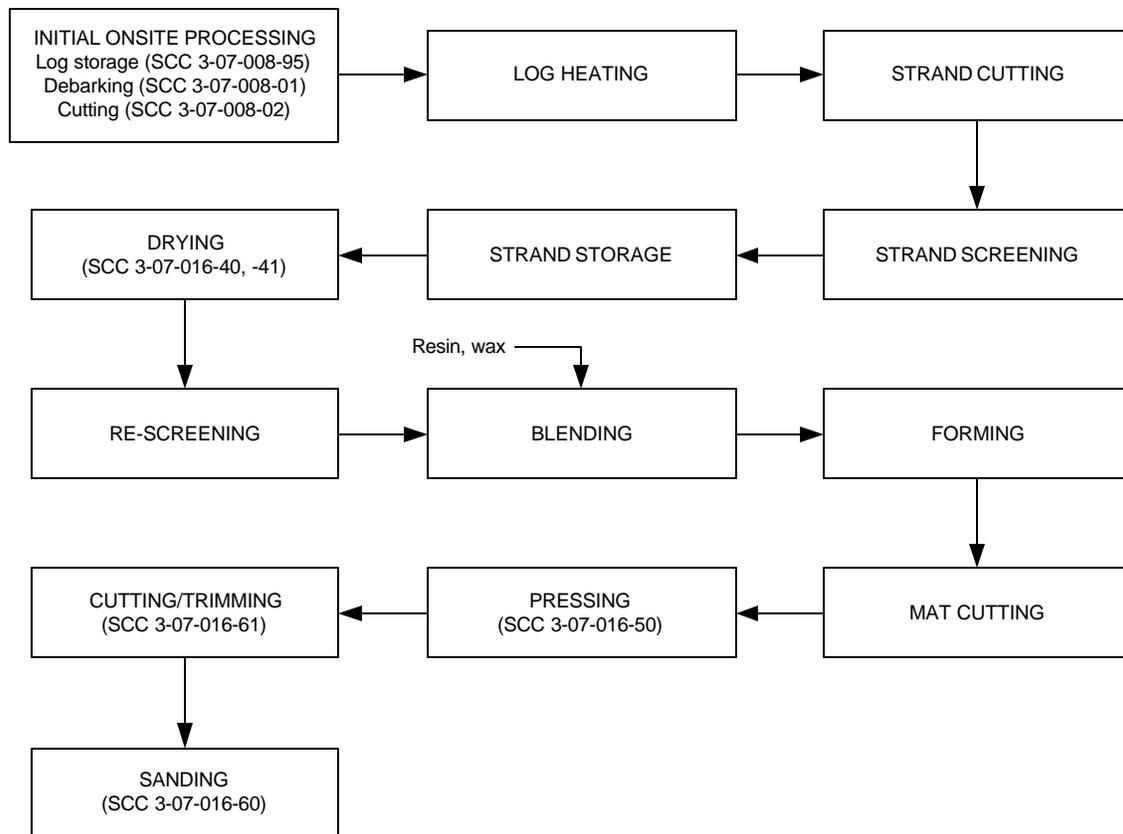


Figure 10.9-2. Process flow diagram for laminated strand lumber manufacturing.

The acceptable-sized strands are dried in either a conveyor or direct-wood fired rotary drum dryer and stored in a dry bin where they await further processing. The LSL strands are dried to four to seven percent moisture (dry basis) in either type of dryer. The rotary dryer inlet temperature is approximately 480°C (900°F). The LSL conveyor dryers are indirect-heated, and operate at 160° to 200°C (320° to 400°F). The same type of dryers used to dry LSL strands are used to dry strands for oriented strandboard. Operation of rotary and conveyor strand dryers is also discussed in Section 10.6.1.2.

Following drying, strands from the dry bin are re-screened to remove short strands and are conveyed to blenders for resin and wax application. Methylene diphenyl diisocyanate (MDI) resin is sprayed onto the strands as they tumble in a rotating blender.

From the blender, the resinated strands are discharged through forming heads which layup a continuous mat of aligned strands. The mats are cut to lengths appropriate for pressing and are conveyed into a single-opening, batch, steam-injection press. The press compacts the loose mat of strands into a billet within 6 minutes at a temperature of 150°C (310°F). Billets may be up to 2.4 m (8 ft) wide, 14 cm (5.5 in) thick, and 15 m (48 ft) long. Once the billets leave the press, they are sanded, cut to specific dimensions, and packaged for shipment.

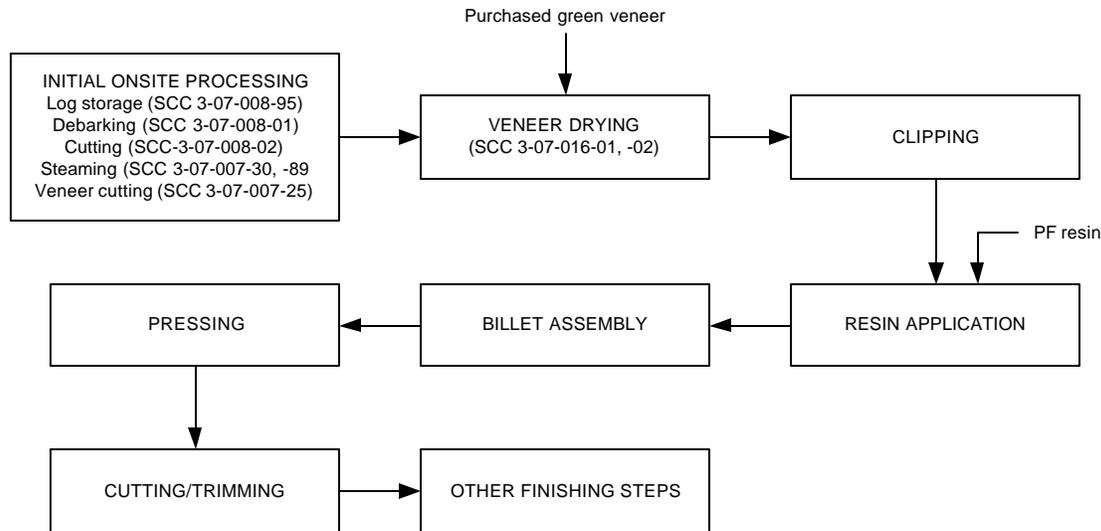


Figure 10.9-3. Process flow diagram for parallel strand lumber manufacturing.

#### 10.9.2.3 PSL Process Description -

Parallel strand lumber is manufactured by gluing strips of veneer together with the grain of each veneer piece oriented parallel to the length of the finished product. Figure 10.9-3 is a diagram of the PSL manufacturing process. Both hardwood (e.g., yellow poplar) and softwood (e.g., Douglas fir, western hemlock, and southern pine) species are used to manufacture PSL.

The manufacturing process begins with the rotary-peeling of logs into veneer about 3 mm (0.125 in) thick. The green veneer is clipped into sheets, sorted, and dried in a veneer dryer at around 200°C (400°F). Veneer dryers used to manufacture PSL are similar to veneer dryers used to manufacture plywood or LVL.

The dried veneer is clipped into strands approximately 19 mm (0.75 in) wide. One advantage of PSL is that pieces and scraps of veneer smaller than full size sheets may be used for its production. The veneer strands are coated with PF resin, aligned, and fed into a continuous press. The press uses microwaves to cure the PF resin. A variety of billet dimensions may be produced in the continuous press. Typical billet cross sections are 279 mm (11 in.) by 483 mm (19 in.). Billets may be up to 20 m (66 ft) long. Following pressing, the billets are cut into smaller sizes according to customer specifications and are packaged for shipment.

#### 10.9.2.4 I-Joist Process Description -

Wood I-joists are a family of engineered wood products consisting of a web made from a structural panel such as plywood or OSB which is glued between two flanges made from sawn lumber or LVL. I-joists are available in many sizes and depths. They are used in residential and commercial buildings as floor joists, roof joists, headers, and for other structural applications.

The processes for manufacturing wood I-joists vary throughout the industry. There are high-volume automated production lines that operate continuously and produce more than 107 linear meters (350 ft) per minute. There are also custom hand lay-up processes that are used for heavier commercial

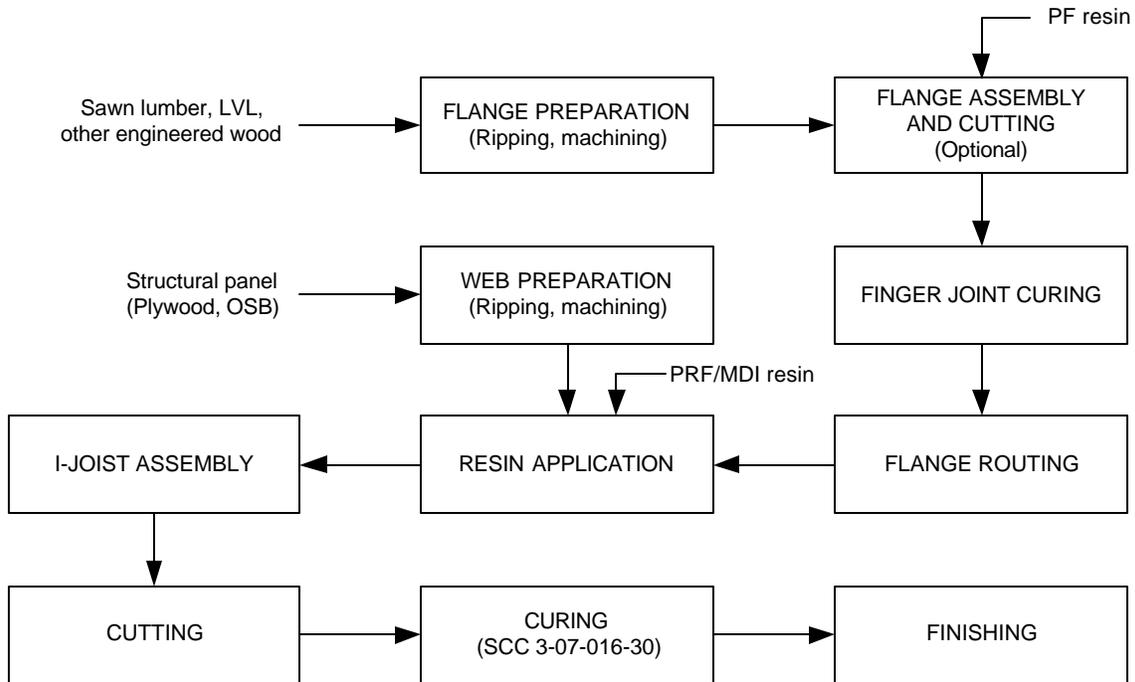


Figure 10.9-4a. Process flow diagram for I-joist manufacturing.

grade I-joists. Regardless of the process, the general steps used to fabricate I-joists are the same and include: flange preparation, web preparation, I-joist assembly, I-joist curing, cutting, and packaging for shipment. Figures 10.9-4a and 10.9-4b show a typical automated I-joist fabrication process.

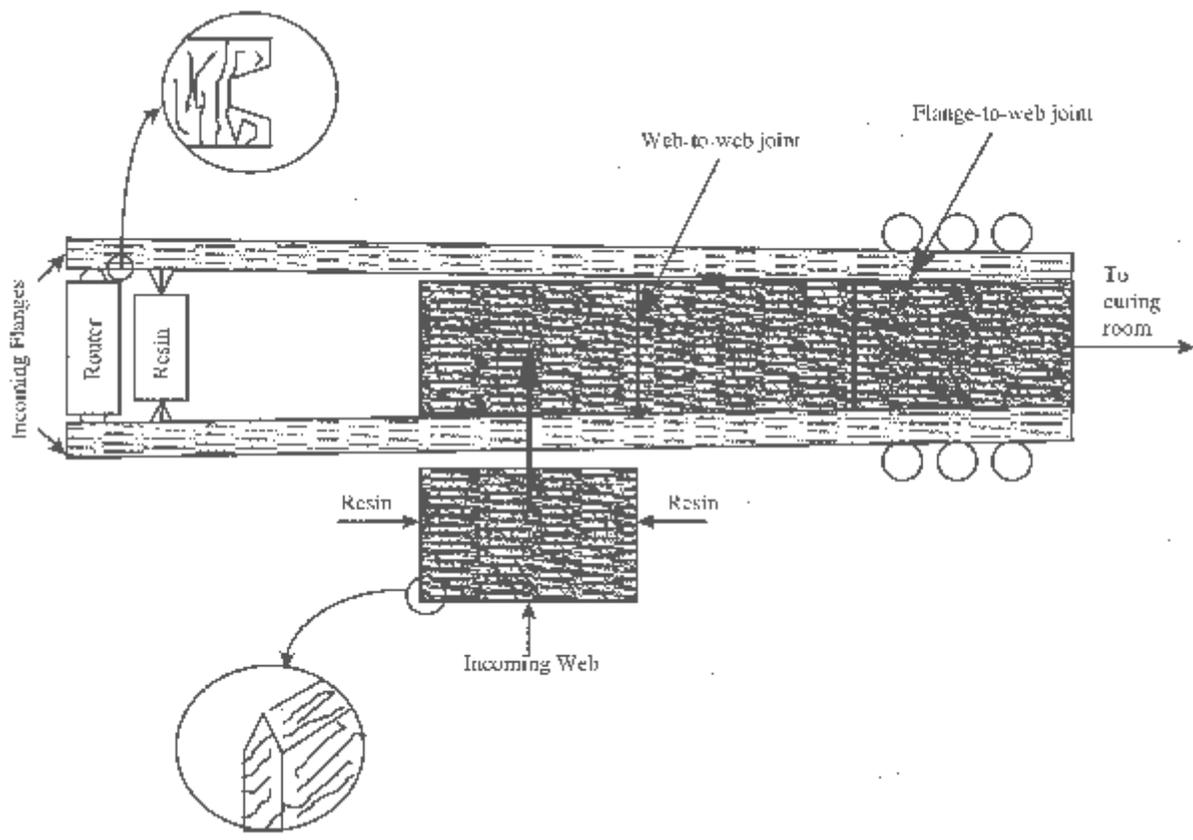


Figure 10.9-4b. Basic I-joist assembly.

In the automated fabrication process, web preparation includes ripping of the web into sections of desired length and machining (tapering) the edges of the web. Knockouts (thin circular areas in the web that may be “knocked out” during construction for installation of electrical wiring) may be machined into the web prior to or after I-joist assembly.

Flanges are prepared by ripping of sawn lumber, LVL, or other engineered wood material to the desired width. If required, the flanges may be finger-jointed end-to-end. During the finger-jointing process, grooves are cut into the end of each flange, a phenol-resorcinol-formaldehyde (PRF) finger-jointing resin is applied between the grooves, the flanges are fitted together end-to-end, and the finger-jointing resin is cured. Finger-jointing resins are typically cured in an RF tunnel. The result is a continuous flange which can be cut to the desired length before or after I-joist assembly. Before the flanges enter the I-joist assembly machine, a profiled groove is routed into one face of the flange along its length.

Immediately prior to entering the I-joist assembler, PRF or MDI resin is applied in the flange groove for formation of the flange-to-web joints. The resin is also applied to the short edges of the web material for formation of the web-to-web joints. Shortly after resin application, the webs are mechanically fitted into the resinated grooves between two flanges in the assembler. The assembler presses the flanges and webs together into an I-joist.

After exiting the assembler, the I-joists are cut to length and passed through an oven or curing chamber to cure the resin. Resin curing chambers may be rooms surrounded by a solid wall or heavy plastic flaps. Curing rooms are typically heated to around 49° to 107°C (120° to 225°F) by a gas-fired heater. However, some I-joist curing ovens operate near room temperature by employing infrared or RF curing techniques. Once cured, the finished I-joists are inspected and bundled for shipment.

#### 10.9.2.5 Glulam Process Description -

Glue-laminated beams are manufactured by gluing lumber faces together to form larger structural members for applications such as ridge beams, garage door headers, floor beams, and arches. The glulam manufacturing process consists of four phases: (1) drying and grading the lumber; (2) end-jointing the lumber into longer laminations; (3) face gluing the laminations; and (4) finishing and fabrication. Figure 10.9-5 shows the glulam process.

Lumber used to manufacture glulam may be dried in onsite lumber kilns or purchased pre-dried from suppliers. The moisture content of the lumber entering the glulam manufacturing process can be determined by sampling from the lumber supply with a hand-held moisture meter or with a continuous in-line meter that checks the moisture of each board. Those boards with a moisture content greater than a given threshold are removed from the process and re-dried. Re-drying may be accomplished through air drying or kiln drying. Lumber kilns are discussed in Section 10.1. Once the lumber is checked for moisture, knots appearing on the ends of the lumber may be trimmed off and the lumber is graded. The lumber is sorted into stacks based on the grade it receives.

To manufacture glulam in lengths beyond those commonly available for sawn lumber, the lumber must be end-jointed. The most common end joint is a finger joint about 2.8 cm (1.1 in) long. The finger joints are machined on both ends of the lumber with special cutter heads. A structural resin, such as an RF curing melamine-formaldehyde (MF) or PF resin, is applied and the joints in successive boards are mated. The resin is cured with the joint under end pressure. Most manufacturers use a continuous RF curing system to cure end joints.

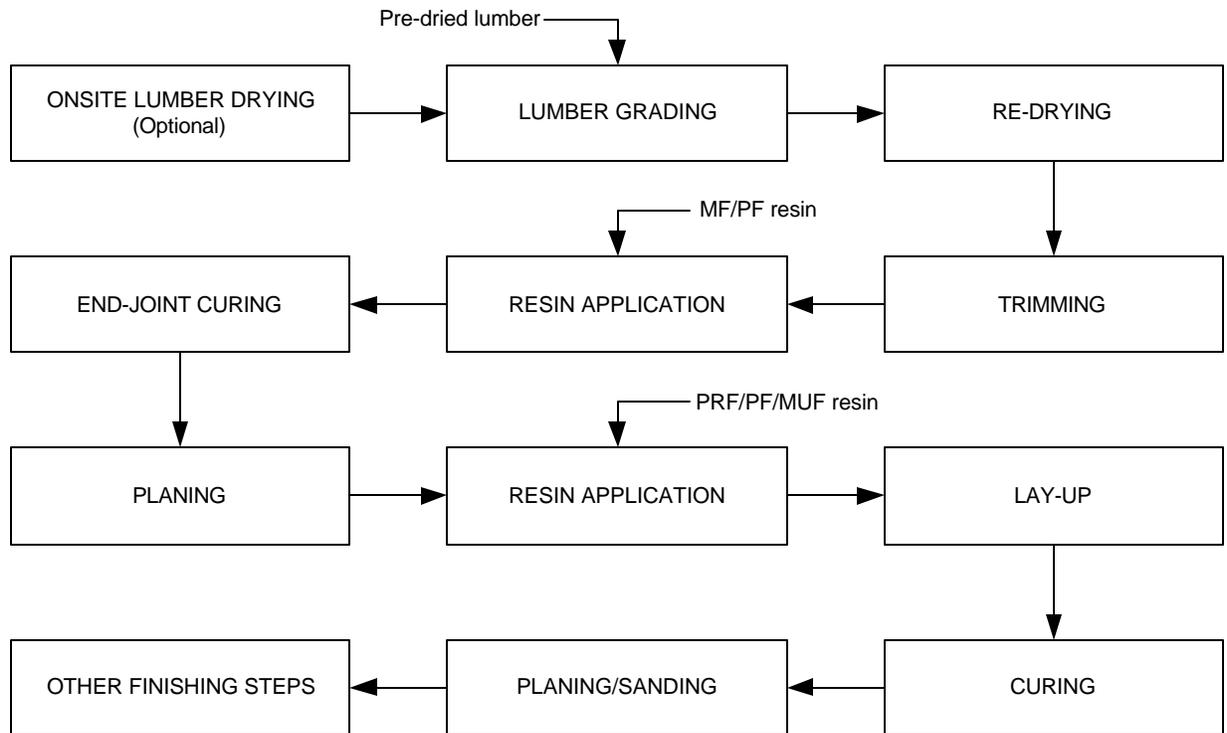


Figure 10.9-5. Process flow diagram for glulam manufacturing.

Just before the face gluing process, the end-jointed lumber is planed on both sides to ensure clean, parallel surfaces for gluing. The resin is spread onto the lumber with a glue extruder. Phenol-resorcinol-formaldehyde is the most commonly used resin for face gluing. Other resins used for face gluing include PF resin or melamine-urea-formaldehyde (MUF) resin.

The resinated lumber is assembled into a specified lay-up pattern. Straight beams are clamped in a clamping bed where a mechanical or hydraulic system brings the lumber into close contact. Curved beams are clamped in a curved form. With the batch-type clamping process, glulam beams are allowed to cure at room temperature for 5 to 16 hours before the pressure is released. Some of the newer clamping systems combine continuous hydraulic presses and RF curing to reduce the amount of time required for the face gluing process.

After the glulam beams are removed from the clamping system, the wide faces (sides) are planed or sanded to remove beads of resin that have squeezed out between the boards. The narrow faces (top and bottom) of the beam may be lightly planed or sanded depending on appearance requirements. Edges (corners) are often eased (rounded) as well. The specified appearance of the member dictates whether additional finishing is required at this point in the manufacturing process. Knot holes may be filled with putty patches and the beams may be further sanded. End sealers, surface sealers, finishes, or primer coats may also be applied.

### 10.9.3 Emissions and Controls<sup>1-10</sup>

The primary emission sources at EWP facilities are dryers and presses. Other emission sources may include boilers and finishing operations such as sanding, sawing, and application of sealers, putty patches, or trademarks. Other potential emissions sources ancillary to the manufacturing process may include wood handling systems, glue application, and resin storage and handling systems.

Operations such as sawing, sanding, and fingerjointing generate particulate matter (PM) and PM less than 10 micrometers in aerodynamic diameter (PM-10) emissions in the form of sawdust and wood particles. In addition, these processes may be sources of PM less than 2.5 micrometers in aerodynamic diameter (PM-2.5) emissions. In engineered wood products mills where wood strands are generated onsite, PM and PM-10 emissions from log debarking, sawing, and stranding 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 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 burner.

Emissions from dryers 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<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>), 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.

The PM and PM-10 emissions from strand dryers can be controlled with an electrified filter bed (EFB) and the wet electrostatic precipitator (WESP). These electrostatic control devices provide highly efficient control of PM and PM-10, but lesser control of condensible organic pollutants in the exhaust streams from dryers.

Regenerative thermal oxidizers (RTOs) can be used to control emissions of VOC and condensible organics from strand dryers or veneer dryers. The RTO can also control reduce emissions of CO from direct-fired dryers. Thermal oxidizers destroy these pollutants by burning them at high temperatures. The 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 preheated 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 incoming gases to be treated, thereby reducing auxiliary fuel requirements.

Emissions from presses are dependent on the type and amount of resin used to bind the wood components together, as well as wood species, wood moisture content, and press conditions. When the press opens and the engineered wood product exits the press, vapors that may include resin ingredients such as formaldehyde, phenol, and other VOCs are released. The rate at which formaldehyde is emitted

during pressing operations is a function of the amount of excess formaldehyde in the resin, product thickness, press temperature, and press cycle time.

Emissions from finishing operations are dependent on the type of products being finished. For most products, finishing involves cutting to size, sanding, and application of edge sealers. Putty patches may be applied to the edges of glulam, depending on end use of the product.

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:

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

or

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

After the THC emission factor has been converted from a carbon to a propane basis, the formaldehyde emission factor is added (where available), then the available emission factors for

non-VOC compounds, including acetone, methane, and methylene chloride, are subtracted. This procedure is expressed simply by the following equation:

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

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

Table 10.9-1 presents emission factors for engineered wood products dryer emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.9-2 presents emission factors for dryer emissions of NO<sub>x</sub>, CO, and CO<sub>2</sub>. Table 10.9-3 presents emission factors for dryer emissions of VOC and speciated organic compounds, some of which are listed as HAPs under section 112(b) of the Clean Air Act. Separate emission factors are presented in Table 10.9-3 for the heated zones and cooling section of LVL veneer dryers. When estimating total emissions from the drying process, emissions from heated zones and cooling section should be combined. Additional emission factors for wood strand dryers may be found in Section 10-6.1 (Oriented Strandboard). Section 10.5 (Plywood) contains additional emission factors for veneer dryers. Section 10.1 (Lumber) contains emission factors for lumber kilns.

Table 10.9-4 presents emission factors for press emissions of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.9-5 presents emission factors for press emissions of NO<sub>x</sub>, CO, and CO<sub>2</sub>. Table 10.9-6 presents emission factors for press emissions of VOC and speciated organic compounds, some of which are listed HAPs. Table 10.9-7 presents emission factors for miscellaneous sources of PM, including filterable PM, filterable PM-10, and condensible PM. Table 10.9-8 presents emission factors for miscellaneous source emissions of VOC and speciated organic compounds. Some of the compounds also are listed HAPs

Although the emission factors presented in Tables 10.6.3-1 to -3 are all for hardwood EWP dryers, EWP also is manufactured using softwoods. Hardwoods generally correspond to deciduous species. For EWP, 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 EWP dryers presented in this section are based largely on the drying of aspen, birch, and poplar furnish. Softwoods generally correspond to coniferous species. For EWP, plywood, and other composite wood products, commonly used softwoods include pines, firs, spruce, and hemlock. Pines, firs, and hemlock are the most commonly used softwood species for EWP manufacturing.

Table 10.9-1. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS DRYERS--  
PARTICULATE MATTER<sup>a</sup>

Source <sup>c</sup>	Emission Control Device <sup>d</sup>	Emission Factor Units <sup>e</sup>	Filterable <sup>b</sup>				Condensible <sup>f</sup>	EMISSION FACTOR RATING
			PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
LSL rotary dryer, direct wood-fired, hardwood (SCC 3-07-016-40)	EFB	lb/ODT	0.43 <sup>g</sup>	D	ND		0.33 <sup>g</sup>	D
LSL conveyor dryer, indirect-heated, hardwood (SCC 3-07-016-41)	EFB	lb/ODT	0.31 <sup>h</sup>	D	ND		ND	
LVL veneer dryer, indirect-heated, cooling section, hardwood (SCC 3-07-016-02)	Uncontrolled	lb/MSF 3/8	0.18 <sup>j</sup>	E	ND		ND	

<sup>a</sup> Emission factor units: pounds of pollutant per oven-dried ton of wood material out of dryer (lb/ODT); one lb/ODT = 0.5 kg/Mg (oven-dried); pounds of pollutant per thousand square feet of 3/8-inch thick veneer (lb/MSF 3/8). One lb/MSF 3/8 = 0.5 kg/m<sup>3</sup>. Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data available. See Table 10.9-8 for the hardwood and softwood species commonly used in the production of engineered wood products 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/>.**

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

<sup>c</sup> LSL = laminated strand lumber; LVL = laminated veneer lumber.

<sup>d</sup> Emission control device: EFB = electrified filter bed.

<sup>e</sup> Emission factor units: pounds of pollutant per oven-dried ton of wood material (lb/ODT); one lb/ODT = 0.5 kg/Mg (oven-dried); pounds of pollutant per thousand square feet of 3/8-inch thick panel (lb/MSF 3/8); one lb/MSF 3/8 = 0.5 kg/m<sup>3</sup>.

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

<sup>g</sup> References 3 and 4.

<sup>h</sup> References 5 and 6.

<sup>j</sup> Reference 7. Emission factors apply only to the cooling section of the dryer; the heated zones also have emissions but data were not available for heated zone emissions.

Table 10.9-2. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS DRYERS--  
NO<sub>x</sub>, CO, AND CO<sub>2</sub> <sup>a</sup>

Source <sup>b</sup>	Emission Control Device	Emission Factor Units <sup>c</sup>	NO <sub>x</sub>	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO <sub>2</sub>	EMISSION FACTOR RATING
LSL rotary dryer, direct wood-fired, hardwood (SCC 3-07-016-40)	Uncontrolled	lb/ODT	0.47 <sup>d</sup>	D	1.3 <sup>e</sup>	D	920 <sup>e</sup>	D
LSL conveyor dryer, indirect-heated, hardwood (SCC 3-07-016-41)	Uncontrolled	lb/ODT	2.3 <sup>f</sup>	D	ND		ND	

<sup>a</sup> Factors represent uncontrolled emissions. SCC = Source Classification Code. ND = no data available. See Table 10.9-8 for the hardwood and softwood species commonly used in the production of engineered wood products 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/>.**

<sup>b</sup> LSL = laminated strand lumber.

<sup>c</sup> Emission factor units: pounds of pollutant per oven-dried ton of wood material (lb/ODT); one lb/ODT = 0.5 kg/Mg (oven-dried).

<sup>d</sup> References 3 and 4.

<sup>e</sup> References 3, 4, and 8.

<sup>f</sup> References 5 and 6.

Table 10.9-3. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS DRYERS--  
ORGANICS<sup>a</sup>

Source <sup>b</sup>	Emission Control Device	CASRN <sup>c</sup>	Pollutant	Emission Factor	Emission Factor Units <sup>d</sup>	EMISSION FACTOR RATING
LSL rotary dryer, direct wood-fired, hardwood (SCC 3-07-016-40)	Uncontrolled	107-02-8 50-00-0	THC as carbon <sup>e</sup>	0.16 <sup>g</sup>	lb/ODT	D
			VOC as propane <sup>f</sup>	0.29	lb/ODT	E
			Acrolein *	0.0062 <sup>g,h</sup>	lb/ODT	E
			Formaldehyde *	0.096 <sup>g</sup>	lb/ODT	D
LSL conveyor dryer, indirect-heated, hardwood (SCC 3-07-016-41)	Uncontrolled	50-00-0	Formaldehyde *	BDL		
LVL veneer dryer, indirect-heated, heated zones, hardwood <sup>k</sup> (SCC 3-07-016-01)	Uncontrolled		THC as carbon <sup>e</sup>	0.013 <sup>j</sup>	lb/MSF 3/8	E
			VOC as propane <sup>f</sup>	0.016	lb/MSF 3/8	E
LVL veneer dryer, indirect-heated, cooling section, hardwood <sup>k</sup> (SCC 3-07-016-02)	Uncontrolled		THC as carbon <sup>e</sup>	0.21 <sup>j</sup>	lb/MSF 3/8	E
			VOC as propane <sup>f</sup>	0.26	lb/MSF 3/8	E

<sup>a</sup> Factors represent uncontrolled emissions. BDL = below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. SCC = Source Classification Code. \* = hazardous air pollutant. See Table 10.9-8 for the hardwood and softwood species commonly used in the production of engineered wood products 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/>.**

<sup>b</sup> LSL = laminated strand lumber; LVL = laminated veneer lumber.

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

<sup>d</sup> Emission factor units: pounds of pollutant per oven-dried ton of wood material (lb/ODT); one lb/ODT = 0.5 kg/Mg (oven-dried); pounds of pollutant per thousand square feet of 3/8-inch thick panel (lb/MSF 3/8); one lb/MSF 3/8 = 0.5 kg/m<sup>3</sup>.

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

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

<sup>g</sup> References 3 and 4.

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

<sup>j</sup> Reference 7.

<sup>k</sup> 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 10.9-4. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS PRESSES--  
PARTICULATE MATTER<sup>a</sup>

Source <sup>c</sup>	Emission Control Device	Filterable <sup>b</sup>				Condensable <sup>d</sup>	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
LSL Hot press, MDI resin (SCC 3-07-016-50)	Uncontrolled	0.44	E	ND		0.27	E

<sup>a</sup> Emission factor units are pounds of pollutant per thousand cubic feet of product (lb/1000 ft<sup>3</sup>). One lb/1000 ft<sup>3</sup> = 0.016 kg/m<sup>3</sup>. Factors represent uncontrolled emissions. SCC = Source Classification Code. ND = no data available. 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 Technology Transfer Network (TTN) website at: <http://www.epa.gov/ttn/chief/>.**

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

<sup>c</sup> LSL = laminated strand lumber; MDI = methylene diphenyl diisocyanate.

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

Table 10.9-5. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS PRESSES--  
NO<sub>x</sub>, CO, AND CO<sub>2</sub> <sup>a</sup>

Source <sup>b</sup>	Emission Control Device	NO <sub>x</sub>	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO <sub>2</sub>	EMISSION FACTOR RATING
LSL Hot press, MDI resin (SCC 3-07-016-50)	Uncontrolled	BDL		0.70	E	ND	

<sup>a</sup> Emission factor units are pounds of pollutant per thousand cubic feet of product (lb/1000 ft<sup>3</sup>). One lb/1000 ft<sup>3</sup> = 0.016 kg/m<sup>3</sup>. Factors represent uncontrolled emissions. BDL = below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. SCC = Source Classification Code. ND = no data available. 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 Technology Transfer Network (TTN) website at: <http://www.epa.gov/ttn/chief/>.**

<sup>b</sup> LSL = laminated strand lumber; MDI = methylene diphenyl diisocyanate.

Table 10.9-6. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS PRESSES--  
ORGANICS<sup>a</sup>

Source <sup>b</sup>	Emission Control Device	CASRN <sup>c</sup>	Pollutant	Emission Factor	EMISSION FACTOR RATING
LSL Hot press, MDI resin (SCC 3-07-016-50)	Uncontrolled	50-00-0 101-68-8	THC as carbon <sup>d</sup>	BDL	E D
			Acrolein *	BDL	
			Formaldehyde *	0.029 <sup>f</sup>	
			MDI *	0.090 <sup>g</sup>	
LVL Hot press, PF resin (SCC 3-07-016-12)	Uncontrolled	75-07-0 67-64-1	THC as carbon <sup>d</sup>	9.2 <sup>h</sup>	D
			VOC as propane <sup>e</sup>	10.4	E
			1,2-Dichloroethane *	BDL	
			1,2,4-Trichlorobenzene *	BDL	
			3-Carene	BDL	
			Acetaldehyde *	0.29	E
			Acetone	1.1	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 67-56-1	Formaldehyde *	0.29 <sup>h</sup>	D
			Limonene	BDL	
			Methanol *	3.1	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	
		123-38-6	Phenol *	BDL	
Propionaldehyde *	0.24		E		
Styrene *	BDL				
Toluene *	BDL				

<sup>a</sup> Emission factor units are pounds of pollutant per thousand cubic feet of product (lb/1000 ft<sup>3</sup>). One lb/1000 ft<sup>3</sup> = 0.016 kg/m<sup>3</sup>. Factors represent uncontrolled emissions unless otherwise noted. BDL =

below test method detection limit; indicates that this pollutant has not been detected in any test runs on this source. SCC = Source Classification Code. \* = hazardous air pollutant. 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 available on EPA's Technology Transfer Network (TTN) website at: <http://www.epa.gov/ttn/chief/>.**

- <sup>b</sup> LSL = laminated strand lumber; LVL = laminated veneer lumber; MDI = methylene diphenyl diisocyanate; PF = phenol formaldehyde.
- <sup>c</sup> CASRN = Chemical Abstracts Service Registry Number.
- <sup>d</sup> THC as carbon = total hydrocarbon measurements using EPA Method 25A.
- <sup>e</sup> VOC as propane =  $(1.22 \times \text{THC}) + \text{formaldehyde} - (\text{acetone} + \text{methane} + \text{methylene chloride})$ ; a value of zero is inserted in the equation for the specified compounds where no emission factor is available, or where the emission factor is reported only as "BDL".
- <sup>f</sup> Reference 4.
- <sup>g</sup> References 4 and 9.
- <sup>h</sup> References 7 and 10.

Table 10.9-7. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS MISCELLANEOUS SOURCES–PARTICULATE MATTER<sup>a</sup>

Source <sup>c</sup>	Emission Control Device	Filterable <sup>b</sup>				Condensable <sup>d</sup>	EMISSION FACTOR RATING
		PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING		
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 steaming (SCC 3-07-007-30, -89)	Uncontrolled	ND		ND		ND	
Veneer cutting (SCC 3-07-007-25)	Uncontrolled	ND		ND		ND	
LSL sander (SCC 3-07-016-60)	Fabric filter	ND		0.052	E	1.1	E
LSL saw (SCC 3-07-016-61)	Fabric filter	ND		0.41	D	0.23	D

<sup>a</sup> Emission factor units for LSL sanders and saws are pounds of pollutant per thousand cubic feet of product (lb/1000 ft<sup>3</sup>). One lb/1000 ft<sup>3</sup> = 0.016 kg/m<sup>3</sup>. Factors represent controlled emissions. ND = no data available. SCC = Source Classification Code. ND = no data available. 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 Technology Transfer Network (TTN) website at: <http://www.epa.gov/ttn/chief/>.**

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

<sup>c</sup> LSL = laminated strand lumber.

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

Table 10.9-8. EMISSION FACTORS FOR ENGINEERED WOOD PRODUCTS  
MISCELLANEOUS SOURCES--ORGANICS<sup>a</sup>

Source <sup>b</sup>	Emission Control Device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
Log storage (SCC 3-07-008-95)	Uncontrolled	ND	THC, VOC	ND		ND
Debarking (SCC 3-07-008-01)	Uncontrolled	ND	THC, VOC	ND		ND
Log cutting (SCC 3-07-008-02)	Uncontrolled	ND	THC, VOC	ND		ND
Log steaming (SCC 3-07-007-30, -89)	Uncontrolled	ND	THC, VOC	ND		ND
Veneer cutting (SCC 3-07-007-25)	Uncontrolled	ND	THC, VOC	ND		ND
LVL I-beam saw (SCC 3-07-016-20)	Uncontrolled	67-56-1	THC as carbon <sup>f</sup>	0.089	lb/MLF <sup>e</sup>	E
			VOC as propane <sup>g</sup>	0.11	lb/MLF <sup>e</sup>	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		
			Methanol *	0.016	lb/MLF <sup>e</sup>	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					

Table 10.9-8 (cont.).

Source <sup>b</sup>	Emission Control Device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
			Styrene * Toluene *	BDL BDL		

Table 10.9-8 (cont.).

Source <sup>b</sup>	Emission Control Device <sup>c</sup>	CASRN <sup>d</sup>	Pollutant	Emission Factor	Emission Factor Units	EMISSION FACTOR RATING
I-Joist curing chamber (SCC 3-07-016-30)	Uncontrolled	67-64-1	THC as carbon <sup>f</sup>	0.0028	lb/MLF <sup>e</sup>	E
			VOC as propane <sup>g</sup>	0.0035	lb/MLF <sup>e</sup>	E
			1,2-Dichloroethane *	BDL		
			1,2,4-Trichlorobenzene *	BDL		
			3-Carene	BDL		
			Acetaldehyde *	BDL		
			Acetone	0.00014	lb/MLF <sup>e</sup>	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 *	0.00018	lb/MLF <sup>e</sup>	E
			Limonene	BDL		
		67-56-1	Methanol *	0.00063	lb/MLF <sup>e</sup>	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				

<sup>a</sup> 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 10. **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/>.**

<sup>b</sup> LVL = laminated veneer lumber.

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

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

<sup>e</sup> Emission factor units: pounds of pollutant per thousand linear feet of product (lb/MLF).

Table 10.9-8 (cont.).

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

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

Table 10.9-9. WOOD SPECIES COMMONLY USED IN COMPOSITE WOOD PRODUCTS MANUFACTURING <sup>a</sup>

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

<sup>a</sup> Reference 2.

#### References For Section 10.9

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