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Air

Background Information Document for Proposed Plywood and Composite Wood Products NESHAP

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For U. S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards

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1.0 INTRODUCTION

1.1 PURPOSE OF THE BID

This report was prepared to support development of national emission standards for hazardous air pollutants (NESHAP) for the plywood and composite wood products (PCWP) manufacturing industry. Plywood and composite wood products include the following:

- particleboard
- oriented strandboard (OSB)
- medium density fiberboard (MDF)
- fiberboard
- hardboard
- softwood plywood
- softwood veneer
- hardwood plywood
- hardwood veneer
- laminated veneer lumber (LVL)
- laminated strand lumber (LSL)
- parallel strand lumber (PSL)
- wood I-joists
- glue-laminated beams
- other engineered wood products

These PCWP are generally manufactured by adhering wood pieces (e.g., particles, fibers, flakes, veneers, or lumber) with glue or other binder and pressing into a consolidated product.

The purpose of this document is to present information on PCWP manufacturing related to the hazardous air pollutants (HAP) emitted from PCWP processes and HAP control strategies. This document contains the following:

- description of PCWP manufacturing processes and process units,
- description of the air pollution control devices (APCD) used to reduce HAP emissions,
- summary of nationwide counts of process units and APCD,
- summary of nationwide and per-process-unit average HAP emission estimates,

- summary of the HAP reduction capabilities of APCD,
- nationwide costs associated with the PCWP rulemaking, and
- nationwide environmental and energy impacts associated with the PCWP rulemaking.

Much of the information presented in this document is based on detailed information documented in supporting memoranda. Section 1.2 describes the information sources used to develop this background information document (BID) and introduces the additional supporting memoranda.

1.2 INFORMATION USED TO DEVELOP THE BID

The data and analyses presented in this document are based on information gathered by or submitted to the U.S. Environmental Protection Agency (EPA) prior to proposal of the PCWP NESHAP. The EPA conducted a survey (information collection request) of the industry in 1998 to collect 1997 base year information from PCWP facilities related to their manufacturing operations and air pollution controls. Different surveys were sent to companies according to the products manufactured. Manufacturers of particleboard, OSB, MDF, hardboard, fiberboard, and softwood plywood or veneer completed the "general" survey; manufacturers of hardwood plywood or veneer that operate either hot presses or veneer dryers completed the "hardwood plywood" survey; and manufacturers of LVL, LSL, PSL, laminated beams, and I-joists completed the "engineered wood products" survey. The overall response rate for the surveys was greater than 90 percent. The survey responses were incorporated into three separate databases (according to the type of survey) and were summarized in three separate memoranda.[1,2,3] Much of the information presented in this BID is based on the three survey response summary memoranda.

The process unit and control counts presented in this document are based on the survey response summary memoranda, the survey databases, and updated information received following the survey.[1,2,3,8] In some cases, the equipment counts were developed using the survey databases directly or process flow diagrams submitted with the surveys because the distinctions made between the types of process units presented in this document were not readily apparent from the survey response summary memoranda.

Emissions test data were obtained from three resources: (1) an extensive HAP emission testing program conducted by the National Council of the Paper Industry for Air and Stream

Improvement (NCASI), (2) numerous emission test reports (dated 1995 or later) collected through EPA's survey of the industry, and (3) EPA's *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (commonly referred to as AP-42). The emissions test data were used to develop emission factors (i.e., mass of pollutant emitted per unit production factors) for PCWP process units and to evaluate the ability of various control technologies to reduce HAP. The PCWP emission factors are summarized in a separate memorandum.[4] The HAP reduction efficiency of various control technologies is also documented in a separate memorandum and is summarized in Chapter 3 of this document.[5] The PCWP emission factors and control efficiency information was coupled with the plant-specific information from the survey responses to develop uncontrolled and baseline emission estimates and to predict which facilities may be major sources of HAP emissions. A major source is defined as any stationary source or group of stationary sources within a contiguous area and under common control that emits or has the potential to emit, considering controls, in the aggregate, 10 tons/yr or more of any single HAP or 25 tons/yr of any combination of HAP. The plant-specific emission estimates are documented in a separate memorandum and are summarized in Chapter 2 of this document.[6]

In addition to the EPA's survey data and the emission test data, information was collected through site visits to PCWP facilities; communication with representatives from the PCWP industry, State and Federal agencies, and emission control device vendors; and operating permits. All of these resources were used to identify the maximum achievable control technology (MACT) level of HAP emission control for the PCWP NESHAP. A separate memorandum documents the selection of MACT.[7] The aforementioned resources were also used to estimate the cost, environmental, and energy impacts associated with the MACT level of control. The cost, environmental, and energy impacts are summarized in this document.

1.3 ORGANIZATION OF THE BID

This BID is divided into five chapters. Chapter 1 is the introduction. Chapter 1 provides orientation for the reader; explains the information upon which the PCWP NESHAP is based; and provides a list of acronyms, abbreviations, and special terms used in this document.

Chapter 2 is divided into separate sections for each PCWP. Each section of Chapter 2 describes the processes used to manufacture PCWP, provides nationwide counts of process units and APCD, and summarizes the nationwide and per-process-unit average uncontrolled and baseline emission estimates. In addition, Chapter 2 presents the Standard Industrial Classification (SIC) and North American Industrial Classification System (NAICS) codes for PCWP, summarizes the number of plants that manufacture PCWP, describes where the PCWP plants are located, and provides projections of the number of new PCWP facilities.

Chapter 3 discusses the control techniques that may be applied to reduce HAP emissions from PCWP process units. Chapter 3 discusses the operation and performance of incineration-based controls, biofiltration, permanent total enclosures (PTE), wet electrostatic precipitators (WESP), and other control techniques.

Chapter 4 describes the methodology used to develop the cost estimates associated with the MACT level of control for the PCWP NESHAP. The cost estimates are based on the use of regenerative thermal oxidizers (RTO) for all process units; a WESP followed by an RTO for rotary strand dryers; and a PTE and RTO for reconstituted wood product presses. Chapter 4 and Appendix A present the cost models used for RTO, WESP, and PTE. These cost models were coupled with the facility-specific information from the survey responses to develop facility specific cost estimates. Chapter 4 presents the number of facilities impacted and the nationwide costs. In addition to the control costs, Chapter 4 summarizes the testing, monitoring, reporting, and recordkeeping costs associated with the PCWP rulemaking.

Chapter 5 describes the methodology used to develop the environmental and energy impact estimates associated with the MACT level of control for the PCWP NESHAP and presents the nationwide impacts. As for the cost impact estimates, the environmental and energy impact estimates are facility-specific and are based on the use of RTO, WESP and PTE. Environmental impacts include HAP emission reductions, changes in criteria pollutant emissions, secondary air impacts, wastewater impacts, and solid waste impacts. Energy impacts are associated with electricity and fuel consumption by control devices.

1.4 ACRONYMS, ABBREVIATIONS, AND OTHER TERMINOLOGY

Numerous acronyms and abbreviations are used throughout this document. Most of the acronyms and abbreviations are defined the first time they appear in the text. Table 1-1 also defines the acronyms and abbreviations and can be used as a cross reference. In addition to the acronyms and abbreviations, some other terms that have special meaning are used in this document. The meaning of the terms is provided in the text and is also provided in Table 1-2 for convenience.

TABLE 1-1. ACRONYMS AND ABBREVIATIONS

Acronym or abbreviation	Meaning
APCD	air pollution control device(s)
BID	background information document
CO	carbon monoxide
CO_2	carbon dioxide
CPA	Composite Panel Association
dscfm	dry standard cubic feet per minute
EFB	electrified filter bed
EPA	U.S. Environmental Protection Agency
ESP	electrostatic precipitator
glulam	glue-laminated beams
gpm	gallons per minute
HAP	hazardous air pollutant(s)
lb/ft^3	pounds per cubic foot
lf/min	linear feet per minute
LSL	laminated strand lumber
LVL	laminated veneer lumber
MACT	maximum achievable control technology
MDF	medium density fiberboard
MDI	methylene diphenyl diisocyanate
MF	melamine-formaldehyde
mi	mile
min	minutes
MUF	melamine-urea-formaldehyde
N_2	nitrogen
NAICS	North American Industrial Classification System
NESHAP	national emission standards for hazardous air pollutants

TABLE 1-1. (Continued)

Acronym or abbreviation	Meaning
NGI	natural gas injection
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NSPS	new source performance standards
O_2	oxygen
OAQPS	Office of Air Quality Planning and Standards
OSB	oriented strandboard
Pb	lead
PCWP	plywood and composite wood product(s)
PEC	purchased equipment cost
PF	phenol-formaldehyde
PLV	parallel laminated veneer
PM	particulate matter
PM_{10}	particulate matter less than 10 micrometers in aerodynamic diameter
PRF	phenol-resorcinol-formaldehyde
PSL	parallel strand lumber
PTE	permanent total enclosure(s)
PVA	polyvinyl acetate
RCO	regenerative catalytic oxidizer(s)
RF	radio-frequency
RTO	regenerative thermal oxidizer(s)
RVRS	regenerative vapor recovery system
SIC	Standard Industrial Classification
SO_2	sulfur dioxide
TAC	total annualized cost
TCI	total capital investment
TCO	thermal catalytic oxidizer(s)
THC	total hydrocarbon

TABLE 1-1. (Continued)

Acronym or abbreviation	Meaning
tpy	tons per year
TTE	temporary total enclosure(s)
UF	urea-formaldehyde
VAPCCI	Vatavuk air pollution control cost index
VOC	volatile organic compound(s)
WESP	wet electrostatic precipitator(s)
yd^3	cubic yard

TABLE 1-2. TERMINOLOGY WITH A PARTICULAR MEANING USED IN THIS DOCUMENT

Term	Meaning as used in this document
Agriboard	Particleboard made from agricultural fiber
Incineration-based control(s)	Air pollution control devices or methods that rely on incineration (oxidation) such as RTO, RCO, TO, TCO or process incineration
Semi-incineration	Incineration of a portion (i.e., less than 75 volume percent) of the exhaust from a process unit in an onsite combustion unit such as a boiler or process heater
Permanent total enclosure (PTE)	An enclosure that meets the criteria for a permanent total enclosure in Appendix M of 40 CFR part 51
Process incineration	Incineration of all of the exhaust from a process unit

1.5 REFERENCES FOR CHAPTER 1

1. Memorandum from D. Bullock, K. Hanks, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. April 28, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) -- General Survey.

2. Memorandum from K. Hanks, B. Threatt, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. May 19, 1999. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) -- Hardwood Plywood and Veneer.

3. Memorandum from K. Hanks and B. Threatt, MRI, to M. Kissell, EPA/ESD. January 20, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) -- Engineered Wood Products.

4. Memorandum from D. Bullock and K. Hanks, MRI, to M. Kissell, EPA/ESD. April 27, 2000. Documentation of Emission Factor Development for the Plywood and Composite Wood Products Manufacturing NESHAP.

5. Memorandum from R. Nicholson, MRI, to M. Kissell, EPA/ESD. May 26, 2000. Control Device Efficiency Data for Add-on Control Devices at PCWP Plants.

6. Memorandum from K. Hanks and D. Bullock, MRI, to M. Kissell, EPA/ESD. June 9, 2000. Baseline Emission Estimates for the Plywood and Composite Wood Products Industry.

7. Memorandum from B. Nicholson and K. Hanks, MRI, to M. Kissell, EPA/ESD. July 13, 2000. Determination of MACT floors and MACT for the Plywood and Composite Wood Products Industry.

8. Memorandum from K. Hanks, MRI, to Project Files. April 18, 2000. Changes in the population of existing plywood and composite wood products plants and equipment following the information collection request.

2.0 INDUSTRY PROFILE

This chapter provides process descriptions, information on emissions sources and controls, and nationwide emission estimates for the PCWP industry. Section 2.1 presents an overview of the PCWP industry. Sections 2.2 through 2.5 discuss manufacturing of composite wood products; Sections 2.6 and 2.7 discuss softwood and hardwood plywood and veneer manufacturing; Sections 2.8 through 2.13 discuss manufacturing of engineered wood products; and Section 2.14 discusses kiln-dried lumber manufacturing. The sections in this chapter are organized by product for convenience.

2.1 INDUSTRY OVERVIEW

Plywood and composite wood products include reconstituted or composite wood products, plywood, veneer, and engineered wood products. Composite wood products, including particleboard, hardboard, fiberboard, MDF, and OSB, are categorized under Standard Industrial Classification (SIC) code 2493 for "Reconstituted Wood Products" (North American Industrial Classification System (NAICS) code 321219). Composite wood products are manufactured by combining dry wood particles, fibers, or flakes with resin and pressing the wood and resin mixture into a panel.

There are two types of plywood: softwood plywood and hardwood plywood. The majority of the U.S. plywood plants make either softwood plywood or hardwood plywood. Only a few plants produce both hardwood and softwood plywood. Softwood plywood is manufactured by gluing several layers of dry softwood veneers (thin wood layers or plies) together with an adhesive. Softwood plywood is classified under SIC code 2436, for "Softwood Plywood and Veneer," (NAICS code 321212). Hardwood plywood is made of hardwood veneers bonded with an adhesive. The outer layers (face and back) surround a core which is usually lumber, veneer, particleboard, or MDF. Hardwood plywood may be pressed into panels or plywood components (e.g., curved hardwood plywood, seat backs, chair arms, etc.). Hardwood plywood is classified under SIC code 2435, for "Hardwood Plywood and Veneer" (NAICS code 321211).

Engineered wood products are classified under SIC code 2439, for "Structural Wood Members Not Elsewhere Classified" (NAICS code 321213). Engineered wood products are made from lumber, veneers, strands of wood, or from other small wood elements that are bound together with structural adhesives 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.[1] The engineered wood products discussed in this document include LVL, LSL, PSL, and other engineered wood products such as comply, I-joists, and glue-laminated beams (glulam). Several facilities manufacture more than one engineered wood product at the same plant site.

There are approximately 454 PCWP manufacturing facilities in the United States as of April 2000. Most of the facilities are concentrated in the Northwest, Southeast, and Midwestern States, where timber supplies are abundant. Figure 2-1 shows the locations of PCWP facilities in the United States.

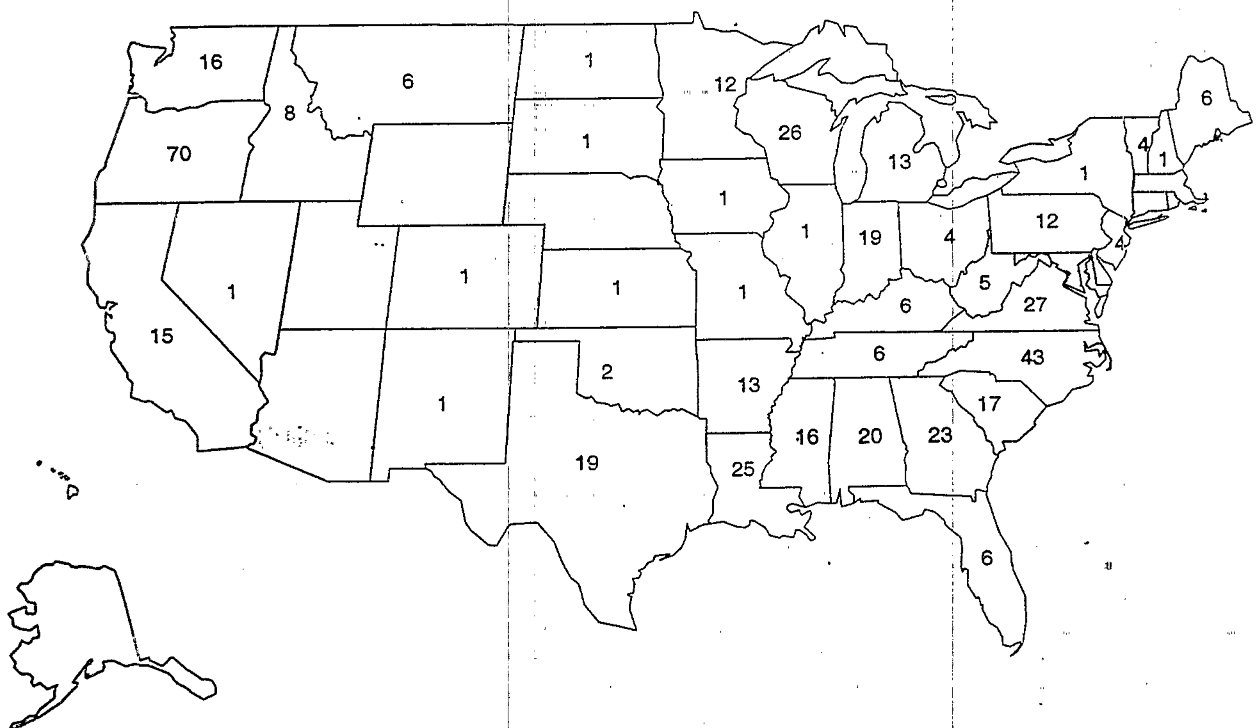

Figure 2-1. Locations of U.S. PCWP facilities.

While most facilities produce only one product, some PCWP facilities have multiple plants at one location and manufacture more than one product. Table 2-1 presents the number of plants that manufacture each product.

TABLE 2-1. NUMBER OF U.S. PLANTS MANUFACTURING PCWP

Product	Number of plants manufacturing product[a]
Fiberboard	7
Hardboard	18
MDF	24
OSB	37
Particleboard	45
Molded particleboard	6
Particleboard from agricultural fiber	5
Softwood plywood and/or veneer	105
Hardwood plywood and/or veneer	166
Engineered wood products	41

[a] Some plants also make more than one product (e.g., a plant making hardboard, particleboard, and softwood plywood). These plants are counted once for each product made in the above table.
[b] Plant counts based on information available as of April 2000.

Over the past decade, production of OSB, MDF, particleboard, hardwood plywood, LVL, glulam, and I-joists has increased. However, production of fiberboard, softwood plywood, and hardboard has decreased. As a result, it is expected that the number of PCWP plants producing products other than fiberboard, softwood plywood, and hardboard will increase in the next 5 years. Based on U.S. production trends, it is estimated that six new OSB plants, five new MDF plants, and four new particleboard plants will startup in the 5 years following 2000 and will be subject to the PCWP NESHAP. It is estimated that approximately seven new LVL facilities will begin operation in the next 5 years. Whether or not the seven LVL facilities will be subject to the PCWP NESHAP will depend on the emissions sources at each facility and whether the facility is a major source of HAP emissions. While there are estimated to be several new hardwood plywood and I-joist plants, these plants are not expected to be impacted by the PCWP NESHAP because these plants typically are not major sources of HAP emissions (as indicated by the emission estimates provided in Sections 2.7.3 and 2.11.3 below).[2]

2.2 PARTICLEBOARD

Particleboard is defined as a panel product manufactured from lignocellulosic materials, primarily in the form of discrete particles, combined with a synthetic resin or other suitable binder and bonded together under heat and pressure.[3] The major types of particles used to manufacture particleboard include wood shavings, flakes, wafers, chips, sawdust, strands, slivers, and wood wool. Particleboard is typically formed into panels which are used in manufacturing of furniture, cabinets, doors, counter tops, and other products. However, there are some plants in the United States that manufacture molded or extruded particleboard products. Molded particleboard products include molded pallets, containers, doorskins, and furniture parts. Plants that manufacture extruded particleboard in the United States are captive plants which produce the particleboard for use in another part of their business (e.g., furniture manufacture).[3] The extruded boards are typically overlaid with veneer or a laminate. Particleboard may also be manufactured from agricultural fiber such as wheat straw or bagasse. Particleboard manufactured from agricultural fiber (agriboard) is used in some of the same applications as conventional particleboard panels. Applications for agriboard include shelving, furniture, cabinets, containers, doors, and store fixtures.

2.2.1 Particleboard Process Description

The particleboard manufacturing process is described in the following three subsections. Conventional particleboard manufacturing is described in Section 2.2.1.1; agriboard manufacturing is described in Section 2.2.1.2; and molded and extruded particleboard manufacturing is described in Section 2.2.1.3.

2.2.1.1 Conventional Particleboard Process Description. The general steps used to produce particleboard panels include raw material procurement or generation, milling, classifying, drying, blending, mat forming, pressing, and finishing. Figure 2-2 presents a process flow diagram for a typical particleboard plant.[4]

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

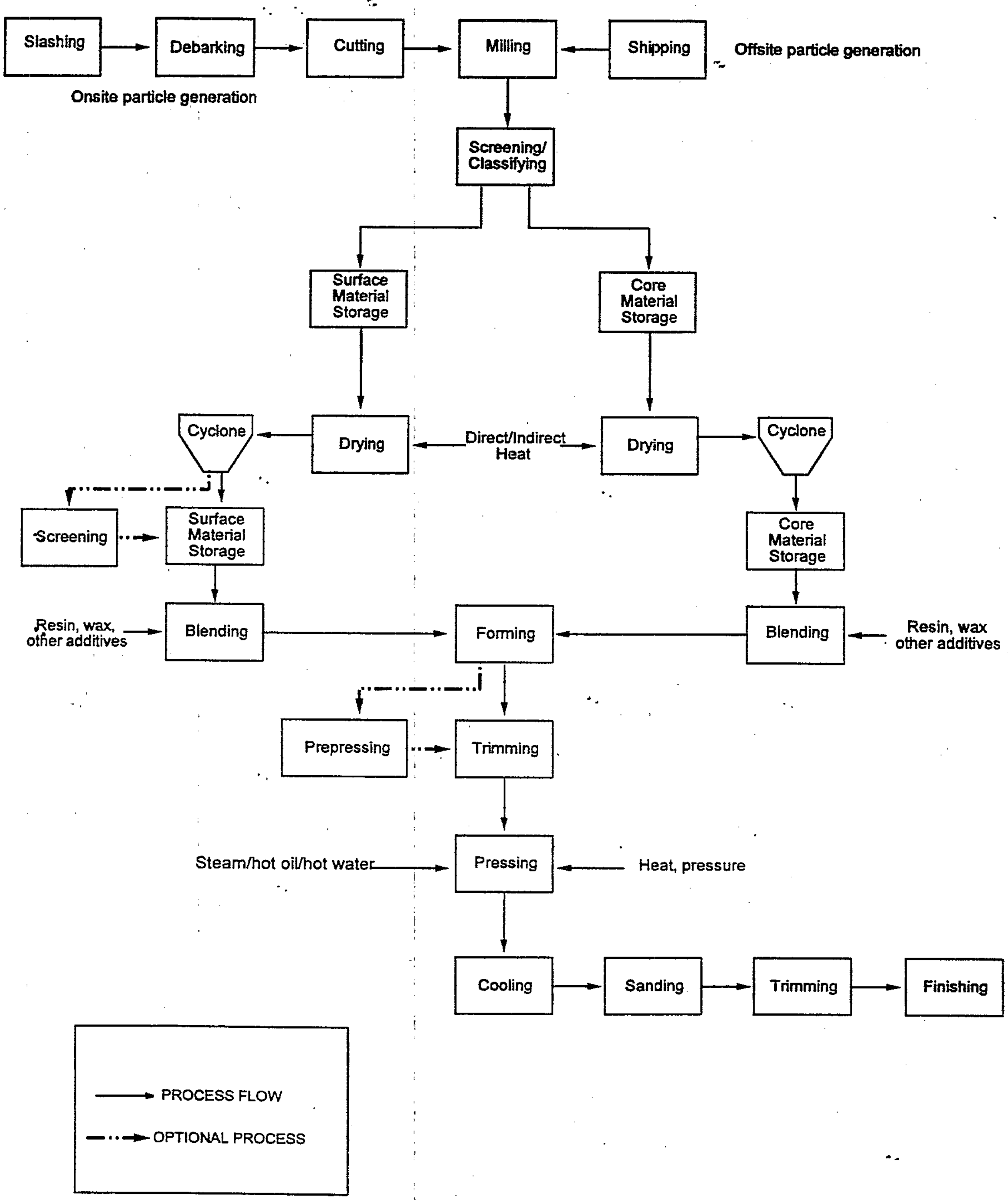

Figure 2-2. Process flow diagram for particleboard manufacturing.

The furnish or raw material for particleboard normally consists of wood particles, primarily wood chips, sawdust, and planer shavings. Most particleboard furnish is derived from softwood species; however, a mixture of hardwood and softwood furnish may also be used. Furnish may be shipped to the facility or generated onsite and stored until needed. The furnish may be further reduced in size by means of attrition mills such as hammermills, flakers, or refiners. After milling, the furnish is either screened using vibrating or gyratory screens, or the particles are air-classified. The purpose of this step is to remove the fines and to separate the core material from the face material. The screened or classified material then is transported to storage bins.

From the storage bins, the core and face material is conveyed to dryers. Rotary dryers are the most commonly used dryer type in the particleboard industry. Both single and triple-pass dryers are used, although triple-pass rotary dryers are the most common. Some facilities use tube dryers or other types of dryers. Direct wood-fired dryers, in which hot exhaust gases from a combustion unit (e.g., a wood waste burner) are routed directly through the dryer, are used at most facilities. However, indirect-heated dryers also are used. Steam coils are located within the path of the circulating air stream in indirect-heated dryers. Dryer inlet temperatures may be as high as 1500° to 1600°F if the furnish is wet (or green); for dry furnish, inlet temperatures are reduced to about 500° to 600°F.[3] Mixtures of dry and green material, particularly if unmanaged, can cause problems if introduced into the same dryer at the same time. For example, dryer fires can occur if relatively dry wood is exposed to temperatures that are too high. If wet furnish is not dried enough then the boards may blow in the press.[3] As a result, most particleboard dryers are dedicated to drying either relatively dry furnish or relatively green furnish. Core dryers often operate at higher temperatures than face dryers because a lower moisture content is more desirable for core material. The desired furnish moisture content at the dryer outlet determines the dryer inlet temperature. Dryer inlet temperatures are routinely adjusted based on furnish moisture measurements.

The moisture content of the particles entering the dryers may be as high as 50 percent on a wet basis (100 percent on a dry basis). Planer shavings are a predominant material used in the manufacture of particleboard.[3] The inlet moisture content associated with green planer shavings in the Northwest is about 30 percent (dry basis).[5] The moisture content of green pines is higher

(80 to 200 percent, dry basis) than the moisture content of green Douglas fir (40 percent), a common wood source in the Northwest.[3] Dry planer shavings have a moisture content of about 15 percent. Urban wood (another source of pre-dried wood) has a moisture content of 15 to 25 percent.[5] Drying reduces the moisture content to 2 to 8 percent, wet basis (2 to 9 percent, dry basis).[4]

After drying, the particles pass through a primary cyclone for product recovery and then are transferred to holding bins. Face material sometimes is screened to remove the fines, which tend to absorb much of the resin, prior to storage in the holding bins. From the holding bins, the core and face material is transferred to blenders, in which the particles are mixed with resin, wax, and other additives by means of spray nozzles, tubes, or atomizers. Urea-formaldehyde (UF) resin is the most commonly used resin type in particleboard manufacture. However, some plants use phenol-formaldehyde (PF) or melamine-urea-formaldehyde (MUF) resins.[6] Phenol-formaldehyde resins are water-proof and are used in particleboard manufactured for outdoor applications.

Waxes are added to impart water resistance, increase the stability of the finished product under wet conditions, and to reduce the tendency for equipment plugging. For furnishes that are low in acidity, catalysts also may be blended with the particles to accelerate the resin cure and to reduce the press time. Formaldehyde scavengers also may be added in the blending step to reduce formaldehyde emissions from the process.[4]

Blenders generally are designed to discharge the resinated particles into a plenum over a belt conveyor that feeds the blended material to a forming machine. The forming machine deposits the resinated material onto the conveyor in the form of a continuous mat. To produce multilayer particleboard, several forming heads can be used in series, or air currents can produce a gradation of particle sizes from face to core.

The particleboard mat may be prepressed at room temperature with a roller as it leaves the former. The mat is then cut into desired lengths and conveyed to the hot press. The hot press applies heat and pressure to activate the resin and bond the wood particles into a solid panel. Most plants operate multi-opening batch presses, although a few single-opening batch presses exist.[6] Figure 2-3 depicts a multi-opening batch press.[4] A few plants operate continuous presses which press the continuous particleboard mat as it exits the former. Most batch particleboard presses are steam-heated using steam generated by a boiler that burns wood residue. However, hot oil and hot water also are used to heat batch presses. Continuous presses are typically heated with hot oil. Total press time is around 6 minutes (min) for particleboard presses. The operating temperatures for particleboard presses generally range from 260° to 450°F and average around 330°F. The finished particleboard density ranges from 29 to 72 pounds per cubic foot (lb/ft^3).[6]

After pressing, the boards are passed through a board cooler prior to stacking. Cooling of urea-bonded boards is necessary because the board will not reach its maximum properties until it has cooled, and some urea resins may break down if the boards are hot stacked. Star or wicket type board coolers are commonly used in particleboard manufacture. Newer types of coolers are enclosed chambers where the boards are transported on edge through the cooler.[3]

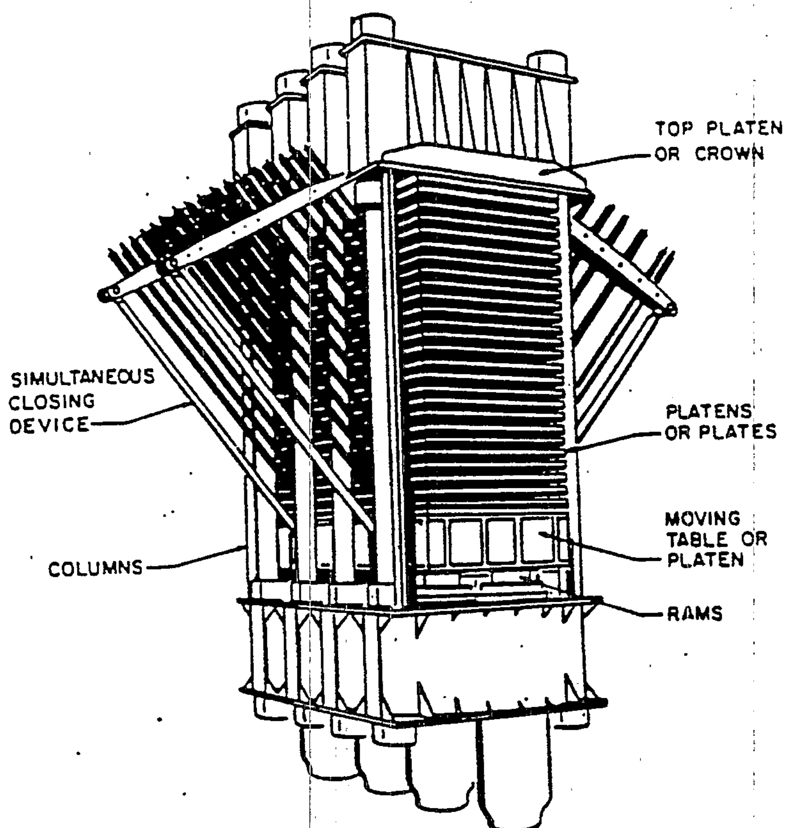

Figure 2-3. Multi-opening batch press.

Once cooled, the particleboard panels are sanded and trimmed to final dimensions. Edge seals, grade stamps and trademarks, company logo information, nail lines, or shelving edge fillers may be applied to the particleboard as part of the finishing process before the particleboard is bundled for shipment. Some facilities use the finished particleboard for onsite furniture manufacture or in production of laminated panels.

2.2.1.2 Agriboard Process Description. Particleboard manufactured from agricultural fiber, or agriboard, is used in some of the same applications as conventional particleboard panels. The primary difference in agriboard and conventional particleboard is the raw materials. The general steps used to produce agriboard panels include raw material procurement, milling, classifying, drying (if necessary), blending, mat forming, pressing, and finishing.

Agriboard is produced from wheat straw, soy stalks, grass straw, or sugar cane bagasse. Large quantities of agricultural fiber, such as wheat or soy, are grown in certain regions of the United States. Once the wheat grain or soy beans are harvested, the plant stalk remains. In the past, farmers have eliminated the plant stalks by tilling them into the ground or burning them in the field. However, this agricultural fiber may be baled and sold for production of agriboard. Procurement of agricultural fiber for agriboard occurs once per year just after the annual harvest. The agricultural fiber is stored for the year by the agriboard plant or its suppliers.[7]

The bales of agricultural fiber are broken and the fiber is reduced in size to one-half inch or shorter pieces by hammermills, grinders, or refiners (attrition mills). The moisture content of sugar cane bagasse used by one plant is approximately 100 percent (dry basis). The bagasse is stored until the moisture content is reduced to approximately 33 percent (dry basis).[8,9] For the plant using a mixture of soy and wheat straw, the fiber moisture content ranges from 11 to 82 percent (dry basis). The moisture content of grass straw used by one plant and of wheat straw used by another plant ranges from 11 to 14 percent (dry basis).[8] Another plant uses wheat straw with a moisture content ranging from 5 to 50 percent (dry basis).[6]

Of the five agriboard plants operating in the United States, three operate rotary dryers to remove excess moisture from the agricultural fiber. The plant that processes sugar cane bagasse uses a gas-fired, single-pass rotary dryer to reduce the moisture content of the bagasse from approximately 33 to 11 percent (dry basis) with a dryer inlet temperature of approximately 650°F.[10] The plant that processes a mixture of soy stalks and wheat straw, uses a gas-fired, triple pass rotary dryer. In this dryer the agricultural fiber moisture content is reduced to about 2 percent (dry basis) with a dryer inlet temperature of approximately 490°F.[8,9] Another plant reduces the moisture content of wheat straw from about 50 to 15 percent (dry basis) in an indirect-heated, single pass rotary dryer with an inlet temperature of about 400°F or less.[6]

Following sizing and/or drying, the agricultural fiber is mixed with methylene diphenyl diisocyanate (MDI) resin in blenders. Resinated material is formed into mats, cut to length, and pressed. Multi-opening batch presses are typically used in the manufacture of agriboard. Continuous presses may also be employed, although no continuous presses are currently used at operating U.S. agriboard plants. All five of the U.S. agriboard plants operate presses with fewer than 10 openings. Agriboard presses are typically steam heated, although one press is heated by hot oil.[6,8] The steam-heated press at one plant for which industry survey data are available operates at a temperature of around 170°F and has a 4-minute press cycle. The press heated by hot oil operates at around 350°F and has a press cycle that varies from 2 to 20 min.[6] Following pressing, agriboard panels are cooled in a board cooler, cut to size, inspected, sanded, finished, and shipped. The density of pressed agriboard panels ranges from 37 to 45 lb/ft^3.[6]

2.2.1.3 Molded and Extruded Particleboard Process Description. The milling, classifying, blending, and drying processes used in molded or extruded particleboard manufacture are generally the same as for plants that manufacture conventional particleboard. The forming, pressing, and finishing operations at molded or extruded particleboard plants differ from similar operations in conventional particleboard manufacture.

In molded particleboard manufacturing, dry wood particles blended with UF resin are routed into several presses. The presses are not platen presses as in conventional particleboard manufacture, but are heated molds that shape the wood particles into the finished product. Based on the results of EPA's industry survey, molded particleboard plants typically operate several (e.g., 10 or more) single-opening press molds. The presses are heated by hot water to around 365°F. The density of molded particleboard products ranges from 45 to 62 lb/ft^3.[6] The press time and temperature, as well as the finished product density, vary depending on the molded product produced. Once the molded parts exit the hot press, they are finished and stored for shipment.

Like conventional particleboard, extruded particleboard is made from dry wood particles blended with UF resin. Resinated particles from the blender enter an extrusion press, which is a heated die that is either vertically or horizontally oriented. The particles are continuously spread over the cross-section of the heated die, while a reciprocating hydraulic ram forces the particles through the die. The extruders cure particleboard at around 375°F.[3,6]

2.2.2 <u>Emission Sources and Controls at Particleboard Plants</u>

The primary sources of HAP emissions at conventional particleboard plants include wood dryers, blenders, formers, presses, and board coolers. Wood dryers are also present at molded and extruded particleboard plants. Extruders, molded particleboard presses, and agriboard presses are also sources of HAP emissions.

There are a total of 144 particleboard dryers and three agriboard dryers in the United States. Table 2-2 summarizes the types of dryers and APCD used to control emissions from the dryers. Table 2-3 presents the number of conventional and molded particleboard rotary dryers and APCD according to furnish type (i.e., green versus dry furnish).[11]

There are typically two to three blenders at conventional particleboard plants. The actual number of blenders depends on the amount of board produced at the plant. In addition, there is usually one former for each press at conventional particleboard and agriboard plants. Molded particleboard plants with press molds or extruders do not operate formers. Although a specific count of the number of blenders and formers and control devices is not attainable, no known blenders or formers operate with HAP control devices. Most vent through baghouses.

Tables 2-4 and 2-5 summarize the APCD used to control emissions from the particleboard presses and board coolers used in the United States. The tables also summarize which control systems include PTE to capture and route exhaust to the APCD.[12] There are a total of 57 conventional particleboard presses. In addition, there are 41 uncontrolled press molds, seven extruders, and eight agriboard presses. There are a total of 53 board coolers in use at domestic particleboard plants.

TABLE 2-2. NUMBER OF PARTICLEBOARD DRYERS AND APCD IN THE UNITED STATES

APCD type	Conventional and molded particleboard dryers			Agriboard dryer
	Rotary	Tube	Other	Rotary
Incineration-based controls:				
• WESP and RTO	2			
• Multiclone, WESP, RTO	3			
• Multiclone and RTO	4			
• Semi-incineration	1			
WESPs and wet scrubbers:				
• Wet scrubber	21			
• WESP	15			
• Scrubber and WESP	8			
• Multiclone and WESP	3			
Dry scrubbers and other controls:				
• Baghouse	6	3		
• Cyclone	7			
• Multiclone	24			
• Sand filter	2			
• EFB	4			
• Cyclone and EFB	1			
• Multiclone, EFB, and baghouse	3			
Uncontrolled	34	1	2	3
Total	138	4	2	3

TABLE 2-3. NUMBER OF PARTICLEBOARD ROTARY DRYERS BY FURNISH TYPE AND APCD IN THE UNITED STATES

APCD type	Green furnish[a]	Dry furnish[a]
Incineration-based controls:		
• WESP and RTO	2	
• Multiclone, WESP, and RTO	3	
• Multiclone and RTO	4	
• Semi-incineration	1	
WESPs and wet scrubbers:		
• Wet scrubber	8	13
• WESP	15	
• Scrubber and WESP	8	
• Multiclone and WESP	3	
Dry scrubbers and other controls:		
• Baghouse	1	5
• Cyclone	3	4
• Multiclone	3	21
• Sand filter	2	
• EFB	2	2
• Cyclone and EFB	1	
• Multiclone, EFB, and baghouse	3	
Uncontrolled	21	13
Total	80	58

[a] Green furnish rotary dryers operate with an inlet furnish moisture content of greater than 30 percent (by weight, dry basis) or operate with an inlet temperature of greater than 600°F. Dry furnish rotary dryers operate with an inlet moisture content of less than or equal to 30 percent and an inlet temperature of less than or equal to 600°F.

TABLE 2-4. NUMBER OF PARTICLEBOARD PRESSES AND APCD IN THE UNITED STATES[a]

APCD type	Conventional particleboard presses	Molded particleboard press molds	Extruders	Agriboard presses
Incineration-based controls:				
• RTO	3 (3)			
• Semi-incineration and scrubber	2 (0)			
WESPs and wet scrubbers:				
• Wet scrubber	2 (0)			
• WESP	1 (0)			
Dry scrubbers and other controls:				
• Baghouse	2 (2)			
• Biofilter	1 (0)			
Uncontrolled	46 (2)	41 (0)	7 (0)	8 (0)
Total	57 (7)	41 (0)	7 (0)	8 (0)

[a] The numbers outside of the parentheses represent the number of presses with each control device. The numbers in parentheses indicate the number of fully enclosed presses with each control device.

TABLE 2-5. NUMBER OF PARTICLEBOARD BOARD COOLERS AND APCD IN THE UNITED STATES[a]

APCD type	Conventional particleboard board coolers
Incineration-based controls:	
• RTO	
• Semi-incineration and scrubber	
Dry scrubbers and other controls:	
• Baghouse	2 (0)
• Biofilter	1 (0)
Uncontrolled	50 (12)
Total	53 (12)

[a] The numbers outside of the parentheses represent the number of board coolers with each control device. The numbers in parentheses indicate the number of fully enclosed board coolers with each control device.

2.2.3 Nationwide HAP Emissions from Particleboard Plants

Nationwide baseline total HAP emissions for conventional and molded particleboard plants are estimated to be 5,400 tons per year (tpy). The average total uncontrolled HAP emissions per plant is 127 tpy for conventional particleboard plants and 9 tpy for molded particleboard plants. The average baseline HAP emissions per plant is 121 tpy for conventional particleboard plants and 9 tpy for molded particleboard plants. Table 2-6 presents the average uncontrolled emissions per particleboard process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

Nationwide baseline emissions are not estimated for agriboard plants due to lack of available information. However, review of air permits for agriboard plants suggests that individual agriboard plants are likely to emit far less than 25 tpy of total HAP.[9,10,14]

TABLE 2-6. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR PARTICLEBOARD PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)	
	Conventional particleboard	Molded particleboard
Green furnish rotary dryer	11	3
Dry furnish rotary dryer	3	NA
Tube dryer	7	NA
Paddle-type dryer	<1	NA
Press	37 (conventional press)	<1 (press molds or extruders)
Board cooler	5	NA
Blender/former	45	3 (blender only)
Refiner/hammermill	<1	<<1
Sanders	2	NA
Saws	<1	NA

2.3 ORIENTED STRANDBOARD

Oriented strandboard is a structural panel produced from thin wood strands cut from whole logs, bonded together with resin, and hot pressed. The chief markets for OSB include sheathing, single-layer flooring, underlayment in light-frame construction, and I-joist web.

2.3.1 OSB Process Description

Figure 2-4 presents a typical process flow diagram for an OSB plant.[15] Oriented strandboard manufacturing begins with softwood or hardwood (e.g., aspen, yellow poplar) whole logs. In northern plants, these logs are put in hot ponds for thawing prior to flaking during winter months. The logs are then debarked and fed into the flakers. Flakers slice the logs into strands approximately 1.5 inches wide, 4.5 to 6 inches long, and 0.025 inches thick.[1,15] The strands then are conveyed to wet strand storage bins to await processing through the dryers.

Most OSB plants in the United States use triple-pass rotary drum dryers. Rotary dryers are normally direct-fired with wood residue from the plant, but occasionally oil or natural gas also are used as fuels. The wood strands are generally dried from around 60 percent moisture (dry basis) to around 5 percent (dry basis).[6] Most rotary dryers are dedicated to drying either core or surface material to allow independent adjustment of moisture content. This independent adjustment is particularly important where different resins are used in core and surface materials. Rotary strand dryers operate with an inlet dryer temperature of around 1,000°F. The inlet dryer temperature can range up to 1,600°F.[6]

Two plants in the United States use three-section conveyor dryers to dry OSB strands. These dryers operate at lower temperatures than do OSB rotary dryers. Conveyor dryers have inlet temperatures of around 320°F. Conveyor dryers are typically indirect-heated. As for rotary dryers, the strands in conveyor dryers are generally dried from around 60 percent moisture (dry basis) to around 5 percent (dry basis).[6]

After drying, the strands are conveyed pneumatically from the rotary dryer and separated from the gas stream at the primary cyclone. Strands exiting conveyor dryers are transported on a conveyor rather than pneumatically. Dry strands are screened to remove fines (which could absorb excessive amounts of resin) and to separate the strands by surface area and weight. Undesired material is sent to a fuel preparation system for the dryer burner or boiler. The screened strands are stored in dry bins.

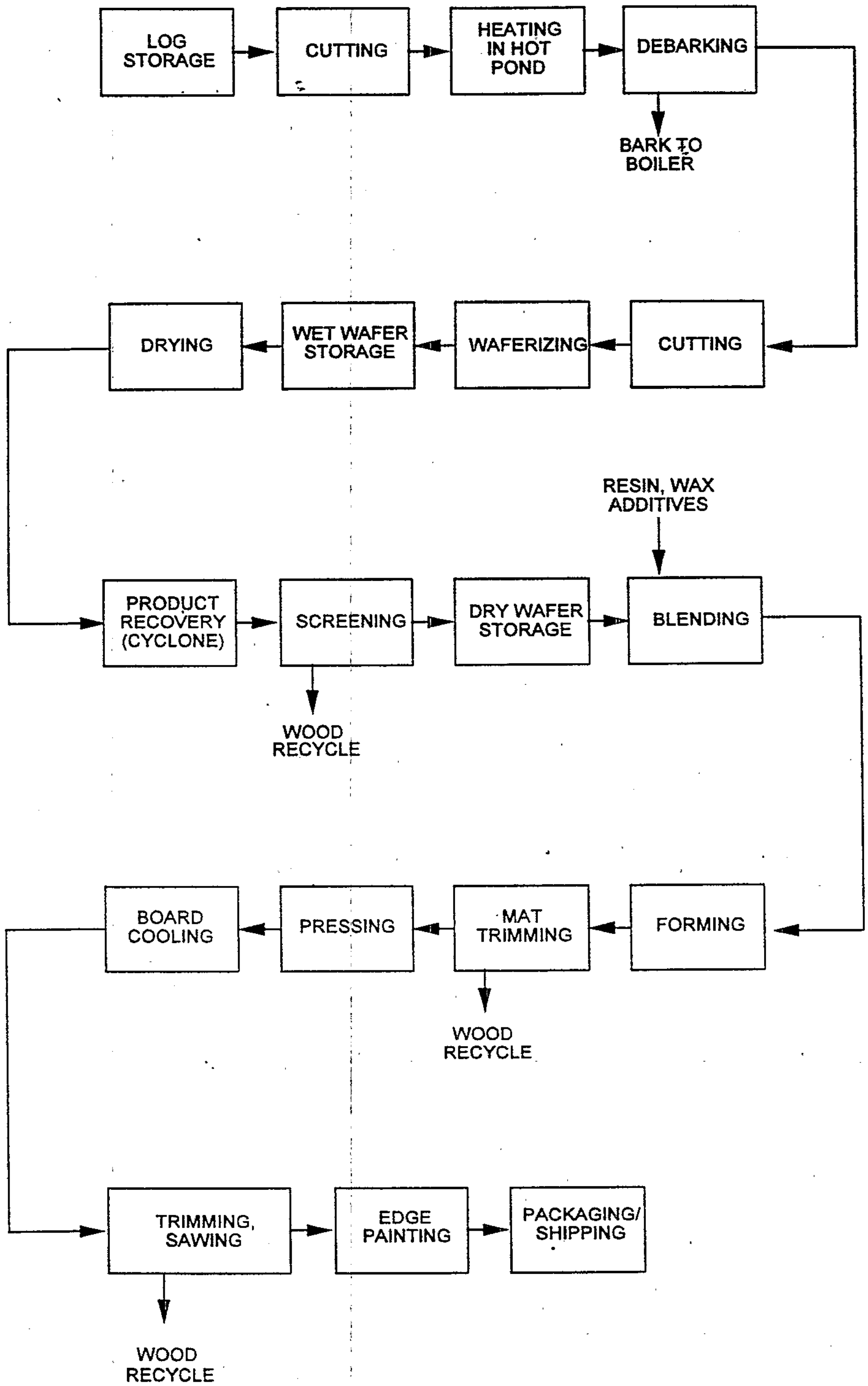

Figure 2-4. Typical process flow diagram for an oriented strandboard plant.

The strands are conveyed from the dry bins to a blender, where they are blended with resin, wax, and other additives. Oriented strandboard plants typically operate two or more blenders, one for core material and one for face material. Different resin types or formulations are used in the face and core material. Face resins are typically liquid or powdered PF resins, while core resins are PF or MDI. A few plants use MDI in both the face and core of the OSB panel. The use of MDI resins for core strands is growing because MDI cures at lower temperatures (and therefore faster) than PF resins.[1]

From the blender the resinated strands are conveyed to the former, where they are metered out on a continuously moving screen system. Screenless systems in which the OSB mat lies directly on the conveyor belt may also be used. The strands are mechanically oriented in one direction as they fall to the screen below. Subsequent forming heads form distinct layers in which the strands are oriented perpendicular to those in the previous layer. The alternating oriented layers result in a structurally superior panel.

In the mat trimming section, the continuous formed mat is cut into desired lengths by a traveling saw. The trimmed mat then is passed to the accumulating press loader and sent to the hot press. Presses used in OSB manufacture are multi-opening batch presses similar to those used in particleboard manufacture. One plant recently installed a continuous OSB press. The batch or continuous press applies heat and pressure to activate the resin and bond the strands into a solid reconstituted panel. Board densities reported in responses to the EPA's industry survey ranged from 33 to 51 lb/ft^3. Hot oil supplied by a thermal oil heater is used to heat most hot presses. Steam generated by a boiler that burns plant residuals may also be used to heat the press. Presses are operated at temperatures of around 400°F with cycle times averaging around 5 min.[6]

Some plants cool boards following pressing. However, operation of board coolers at OSB plants is uncommon because hot stacking of boards made using PF resin can strengthen the resin bond. Next, panels are trimmed to final dimensions, finished (if necessary), and the product is packaged for shipment. Finishing may include face sanding and profiling tongue and groove edges as well as application of edge coatings, nail lines, and trademarks or grade stamps.

2.3.2 Emission Sources and Controls at OSB Plants

The primary sources of HAP emissions at OSB plants include wood dryers, blenders, formers, presses, and board coolers. In addition to emissions from dryers and presses, HAP emissions may also be released from some finishing operations at OSB plants. Emissions from finishing operations are dependent on the type of products being finished. For most OSB products, finishing involves trimming to size and possibly painting or coating the edges. Generally, water-based coatings are used to paint OSB edges, and the resultant HAP emissions are relatively small.

There are a total of 125 OSB dryers in the United States. Table 2-7 summarizes the types of dryers and APCD used to control emissions from the dryers. Table 2-8 summarizes the capture and control devices used to control emissions from 39 presses and two board coolers used in the United States to manufacture OSB.[12]

TABLE 2-7. NUMBER OF OSB DRYERS AND APCD IN THE UNITED STATES

APCD type	OSB dryers	
	Rotary	Conveyor
Incineration-based controls:		
• WESP and RTO	30	
• WESP and RCO	4	
• Cyclone, WESP and RTO	12	
• Multiclone, WESP, and RTO	9	
• Multiclone and RTO	14	
• Rotary bed protector and RTO	10	
• Process incineration and baghouse	2	
• Process incineration and dry ESP		3
• Process incineration, multiclone, and dry ESP	6	
WESPs and wet scrubbers:		
• WESP	19	
• Multiclone, scrubber, and WESP	2	
• Multiclone and WESP	4	
Dry scrubbers and other controls:		
• Cyclone or multiclone	4 multiclone	1 cyclone
• Multiclone and EFB	5	
Uncontrolled		
Total	121	4

TABLE 2-8. NUMBER OF OSB PRESSES AND BOARD COOLERS AND APCD IN THE UNITED STATES

APCD type	OSB presses	OSB board coolers
Incineration-based controls:		
• RTO	14 (13)	
• RCO	1 (1)	
• TCO	1 (1)	
• WESP and RTO	1 (0)	
• Semi-incineration	1 (0)	
Other controls:		
• Biofilter	2 (0)	
Uncontrolled	19 (0)	2 (0)
Total	39 (15)	2 (0)

[a] The numbers outside of the parentheses represent the number of presses or board coolers with each control device. The numbers in parentheses indicate the number of fully enclosed presses and board coolers with each control device.

There are typically two to three blenders at OSB plants. The actual number of blenders depends on the amount of board produced at each plant. There is usually one former for each OSB press. Although a specific count of the number of blenders and formers and control devices is not attainable, there are no known blenders or formers that operate with HAP control devices. Most vent through baghouses.

2.3.3 Nationwide HAP Emissions from OSB Plants

Nationwide baseline total HAP emissions from OSB plants are estimated to be 3,500 tpy. The average total uncontrolled and baseline HAP emissions per plant are 194 tpy and 90 tpy, respectively. Table 2-9 presents the average uncontrolled emissions per OSB process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-9. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR OSB PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Rotary dryer	32
Conveyor dryer	5[a]
Press	76
Blender/former	11

[a] Emissions were estimated based on rotary dryer emission factors that were scaled down using ratios of rotary dryer and conveyor dryer formaldehyde and total hydrocarbon. See the baseline emissions memo for details.[13]

2.4 MEDIUM DENSITY FIBERBOARD

The Composite Panel Association (CPA) defines MDF as a dry-formed panel product manufactured from lignocellulosic fibers combined with a synthetic resin or other suitable binder. Medium density fiberboard can be finished to a smooth surface and grain printed, eliminating the need for veneers and laminates. Most of the thicker MDF panels (0.5 to 0.75 inches) are used as core material in furniture panels. Medium density fiberboard panels thinner than one-half inch typically are used for siding.[16] Major markets for MDF include furniture, cabinets, moulding, store fixtures, and shelving.[6]

2.4.1 MDF Process Description

The general steps used to produce MDF include mechanical pulping of wood chips to fibers (refining), drying, blending fibers with resin and sometimes wax, forming the resinated material into a mat, and hot pressing. Figure 2-5 presents a process flow diagram for a typical MDF plant.

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

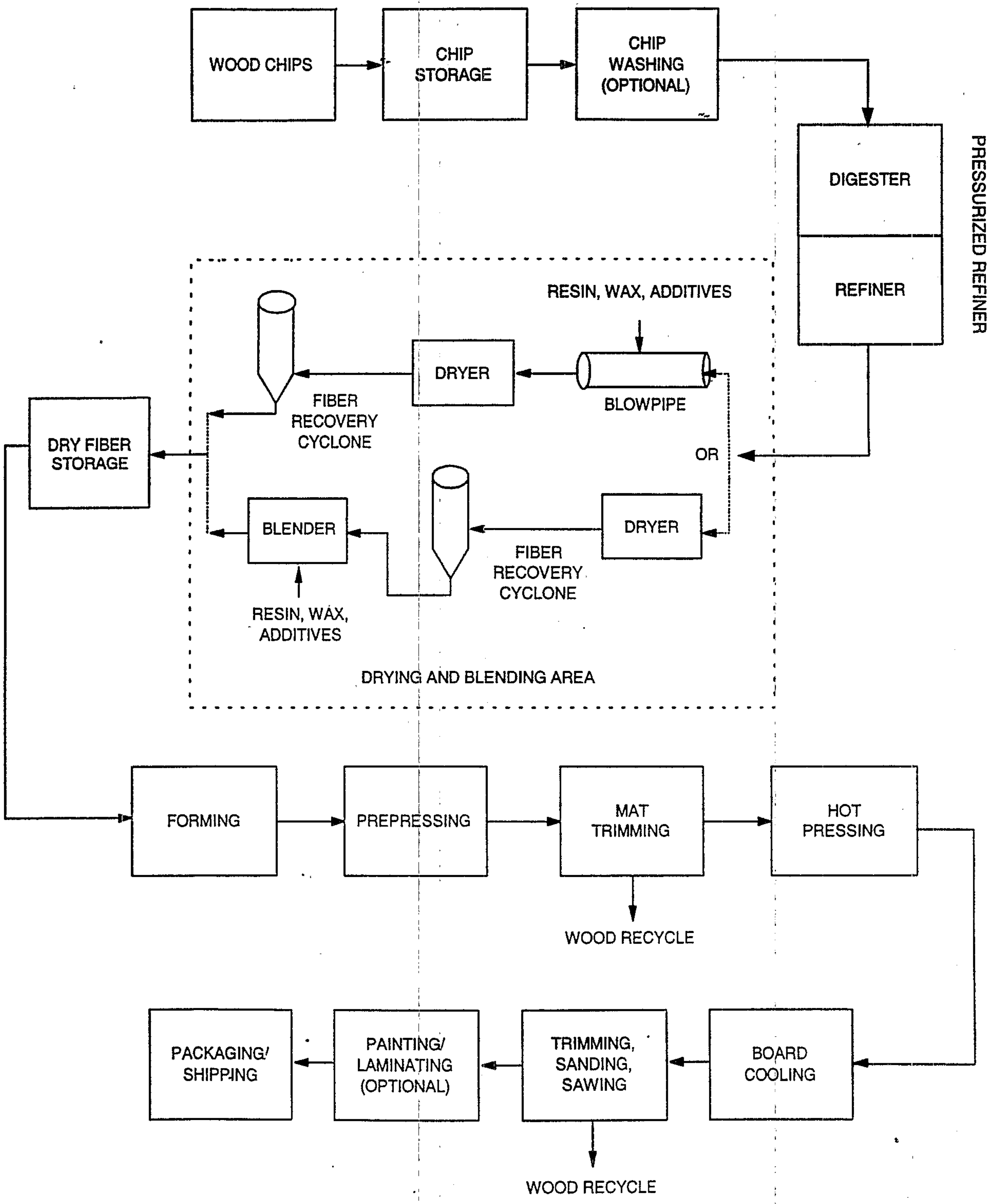

Figure 2-5. Typical process flow diagram for a medium density fiberboard (MDF) plant.

Clean chips are softened by steam and rubbed apart or ground into fibers in pressurized 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.

From the pressurized refiners, the fibers move to the drying and blending area of the MDF plant. The sequence of the drying and blending operations depends on the method by which resins and other additives are blended with the fibers. Most plants inject resin into a blowline system, although some plants inject resins into a short-retention blender. If a blowline system is used, the fibers leaving the pressurized refiners are blended with resin, wax, and other additives in a blowpipe which discharges the resinated fibers to the dryer. After drying, the resinated fibers are conveyed to a dry fiber storage bin. If resin is added in a blender, the fibers are first dried and then conveyed to the blender. The fibers are blended with resin, wax, and any other additives and conveyed to a dry fiber storage bin. Urea-formaldehyde resins are the most common resins used in the manufacture of MDF. Melamine urea formaldehyde, PF, or MDI resins are also used.

Medium density fiberboard plants use tube dryers. Tube dryers are either single-stage or multiple-stage drying systems. Most of the multiple-staged tube drying systems incorporate two stages. One plant uses a three-stage tube drying system, but the third stage at this plant does not remove moisture from the wood material.[17] In multiple-stage tube dryers, there is a primary tube dryer and a secondary tube dryer in series separated by an emission point (e.g., a cyclonic collector). Tube dryers (either single-stage or multiple-stage) are typically used to reduce the moisture content of the fibers from around 47 percent to 9 percent (dry basis).[6] Single-stage and double-stage tube dryers are shown in Figures 2-6a and 2-6b. Heat is provided to tube dryers by either indirect heating or direct firing with wood residuals, gas, or oil. Primary dryer inlet temperatures average around 270°F and secondary dryer inlet temperatures average around 130°F.[6] Wood fiber is pneumatically drawn though the tube dryers and is separated from the dryer exhaust in a cyclonic collector. The dried wood fibers are discharged from the cyclonic collectors into dry storage bins. Rotary dryers may also be used for pre-drying of wood material prior to refining, but are not common.

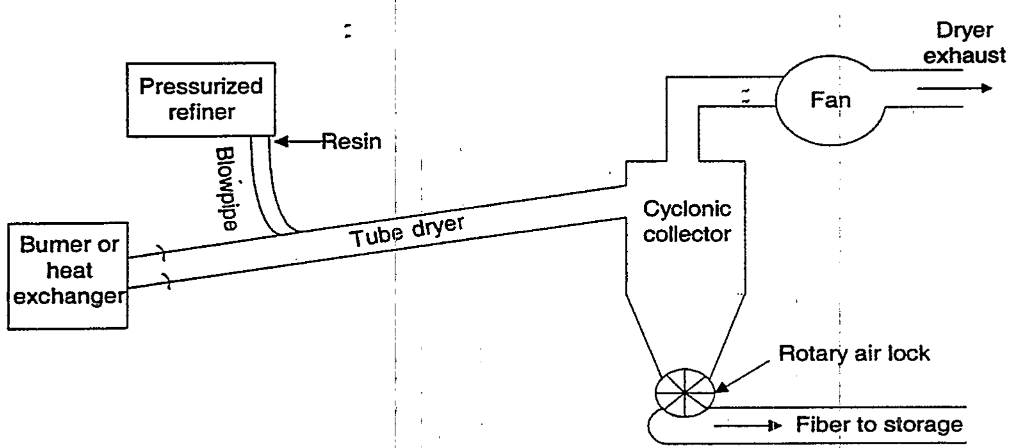

Figure 2-6a. Single-stage tube dryer.

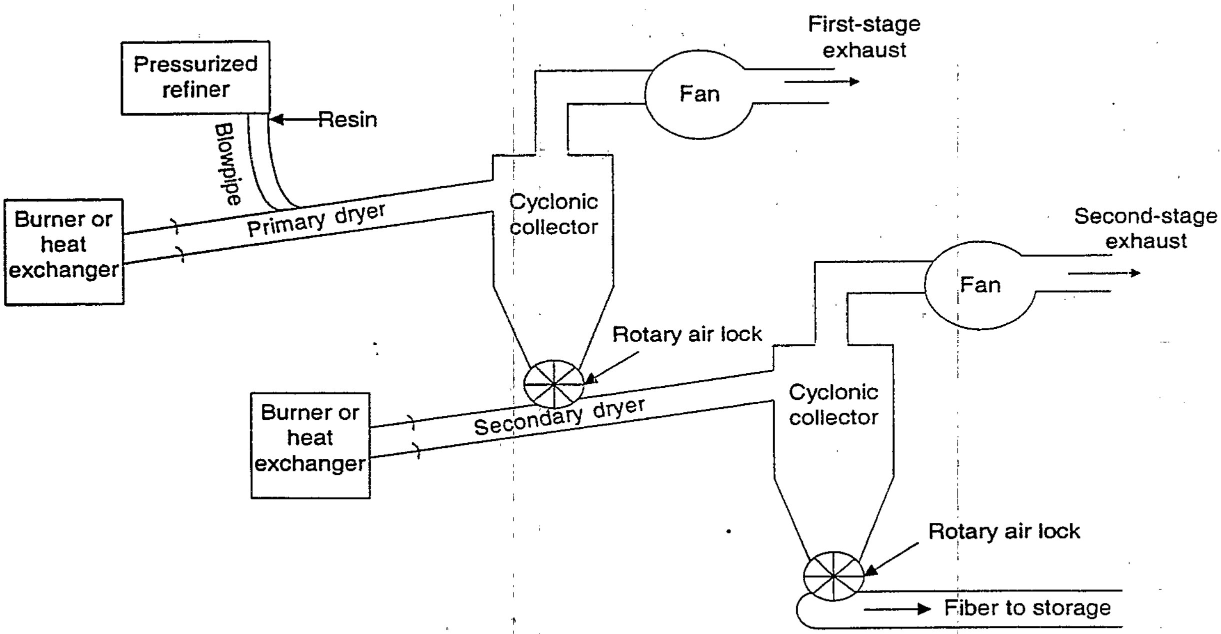

Figure 2-6b. Double-stage tube dryer.

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

The prepressed and trimmed mats then are transferred to the hot press which applies heat and pressure to activate the resin and bond the fibers into a solid panel. Press temperatures range from 240° to 450°F (averaging around 330°F), for an average press cycle of about 7 min. Typically, the mat is cut by a flying cutoff saw into individual mats that are then loaded into a multi-opening, batch hot press. Continuous presses may also be used for MDF manufacture. Steam or hot oil heating of the press is common for MDF plants.[6]

After pressing, the boards are cooled in a board cooler. The cooled boards are sanded and trimmed to final dimensions. Other finishing operations such as application of trademarks, grade stamps, and fire retardants are done, and the finished product is packaged for shipment.

2.4.2 Emission Sources and Controls at MDF Plants

The primary sources of HAP emissions at MDF plants include emissions from pressurized refiners, wood dryers, blenders, formers, presses, and board coolers. Finishing operations at MDF plants may also be a source of HAP emissions. Table 2-10 summarizes the types of MDF dryers and APCD used to control emissions from the dryers.[18] Table 2-11 summarizes the capture and control systems used to control emissions from MDF presses and board coolers used in the United States.[12]

As shown in Table 2-10, there is one rotary dryer used at an MDF plant. This dryer is used to predry green furnish before it is dried in a tube dryer.[19] There are 32 single-stage tube dryers and 11 multiple-stage tube dryers, for a total of 43 tube drying systems at MDF plants.[18] Several of the multiple-stage tube dryers have separate control devices for the first and second stage emission points. However, there are some multiple-stage tube dryers where the exhaust from the second stage is routed back through the first stage and is exhausted through the first stage control device. There are no multiple-stage tube dryers with the second stage exhaust routed directly to the same control device as the first stage without first passing through the first stage. All but one of the multiple-stage tube dryers have two stages. One multiple-stage tube dryer incorporates a tertiary stage that humidifies rather than dries the wood material processed.[17]

TABLE 2-10. NUMBER OF MDF DRYERS AND APCD IN THE UNITED STATES

APCD type	Primary tube dryers[a]	Secondary tube dryers[a]	Rotary dryers
Incineration-based controls:			
• RTO	9	1	
• TO	1		
• Baghouse, WESP, and RTO	3		
• WESP and TCO	1	1	
• Process incineration and baghouse	2	2	
• Semi-incineration and WESP	1		
WESPs and wet scrubbers:			
• Wet scrubbers	2		
• WESP	5		1
Dry scrubbers and other controls:			
• Baghouse	2	7	
• Rotary bed protector	1		
Uncontrolled	16		
Total	43	11	1

[a] Primary tube dryers are single-stage tube dryers and the first stage of staged tube drying systems. Secondary tube dryers are the second stage of staged tube drying systems.

TABLE 2-11. NUMBER OF MDF PRESSES AND BOARD COOLERS AND APCD IN THE UNITED STATES[a]

APCD type	MDF presses	MDF board coolers
Incineration-based controls:		
• RTO	6 (5)	6 (4)
• WESP and TCO	1 (0)	
• Baghouse, WESP, and RTO		1 (1)
• Scrubber, baghouse, WESP, and RTO	1 (1[b])	
• Process incineration	1 (0)	
• Process incineration and baghouse	1 (0)	
Other controls:		
• Wet scrubber	1 (0)	
• Baghouse	2 (2)	
Uncontrolled	17 (0)	24 (4)
Total	30 (8)	31 (9)

[a] The numbers outside of the parentheses represent the number of presses or board coolers with each control device. The numbers in parentheses indicate the number of fully enclosed presses and board coolers with each control device.

[b] This enclosure is not a PTE, but was tested and achieved 99.8% capture efficiency.[6]

Because the tertiary stage does not function as a dryer, it was not included in Table 2-10. The tertiary stage is routed to the RTO used to control the first and second stages of the multiple-stage tube dryer.

Process flow diagrams and other information submitted with the industry survey responses were reviewed to approximate the number of pressurized refiners used by MDF plants. Given the varying level of detail on the flow diagrams, obtaining an exact count of pressurized refiners was not possible. The flow diagrams show that there are approximately 30 pressurized refiner systems at MDF plants. At least seven (and possibly as many as 14) of these pressurized refiners vent directly into tube dryers that are controlled with incineration-based controls. Thus, the emissions from the pressurized refiners are also controlled by incineration. In addition to the pressurized refiners, there appear to be two stand-alone digesters and 12 atmospheric refiners at MDF plants. Emissions from the stand-alone digesters and atmospheric refiners are not controlled.[20]

Blenders are operated by MDF plants that do not perform blowline blending. Thus, most MDF plants do not operate blenders. Formers are used by all MDF plants. There is one former per MDF press. Although a specific count of the number of blenders and formers and control devices is not attainable, there are no known blenders or formers that operate with HAP control devices. Most vent through baghouses.

2.4.3 Nationwide HAP Emissions from MDF Plants

Nationwide baseline total HAP emissions for MDF plants are estimated to be 2,500 tpy. The average uncontrolled and baseline total HAP emissions per plant are 168 tpy and 103 tpy, respectively. Table 2-12 presents the average uncontrolled emissions per MDF process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-12. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR MDF PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Primary tube dryer	65
Secondary tube dryer	2
Green furnish rotary dryer	<1
Blender/former (non-blowline blend plants)	8
Former (blowline blend plants)	2
Press	38
Board cooler	3
Sanders	<1
Saws	<1

2.5 FIBERBOARD/HARDBOARD

Fiberboard products include: (1) low-density insulation board or cellulosic fiberboard (called "fiberboard" in this document), (2) MDF (discussed in Section 2.4 above), and (3) hardboard. 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 be mixed with resin, formed into mats, and pressed and/or dried to form panel products.

Fiberboard products are manufactured through dry processing, wet processing, or wet/dry 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. Fiberboard is manufactured by wet processing. Dry processing is used to manufacture MDF. Hardboard may be manufactured by wet processing, dry processing, or wet/dry processing. Figure 2-7 summarizes the processes used to manufacture fiberboard products. Resin is used in wet hardboard and dry hardboard processing, but not in wet/dry hardboard or fiberboard processing.

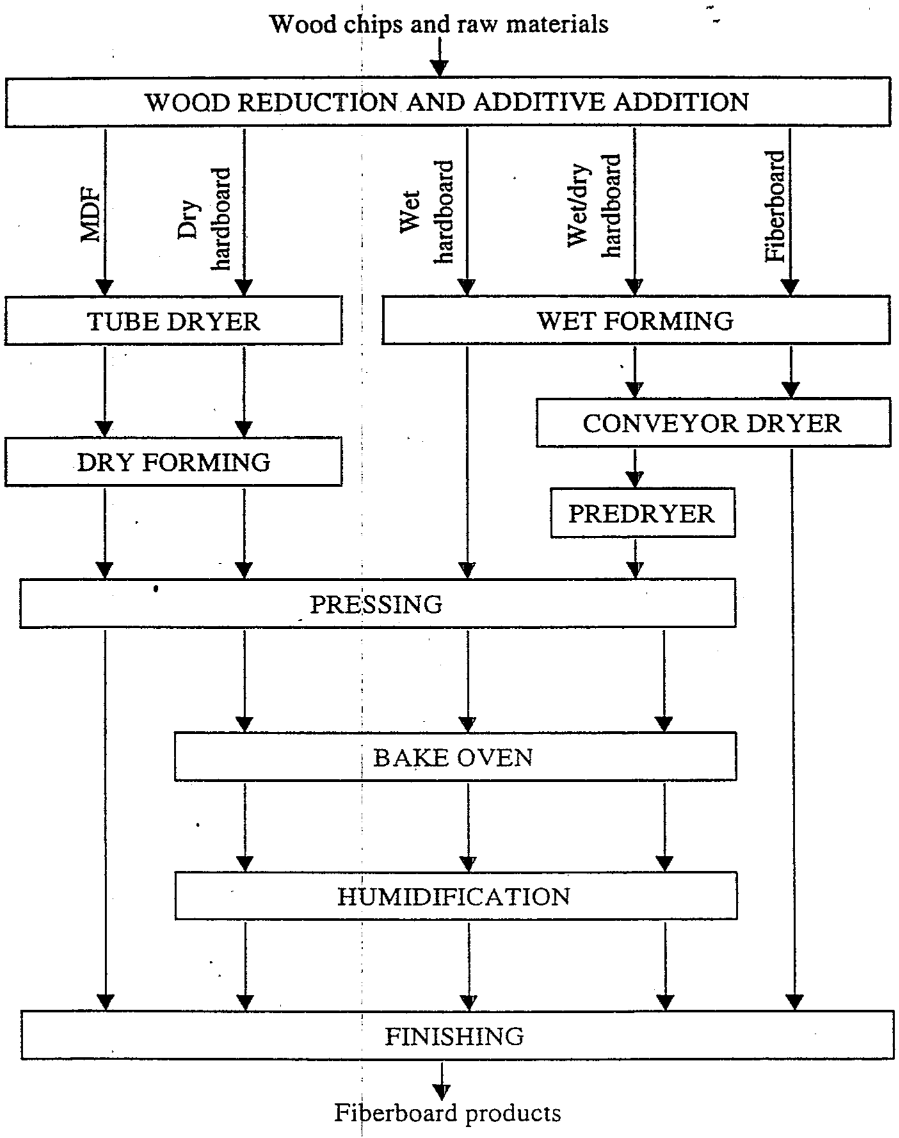

Figure 2-7. Fiberboard products manufacturing processes.

Major markets for fiberboard include housing, roofing, and office furnishings. Hardboard markets include, among others, housing (e.g., exterior siding, garage doors, and interior door facings), furniture, store fixtures, automotive interiors, and toys.[6]

2.5.1 Fiberboard/Hardboard Process Description

2.5.1.1 Dry Process Hardboard. Dry processing of hardboard is similar to MDF manufacturing. As in MDF manufacture, the general steps used to produce dry process hardboard include mechanical pulping of hardwood or softwood chips to fibers (digesting and refining), blending of fibers with resin and wax, drying, forming the resinated material into a mat, and hot pressing. Heat treatment and humidification of the pressed boards is an additional step in the hardboard manufacturing process that is usually not necessary for MDF manufacture.

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

Clean chips are either processed in pressurized refiners, as used in MDF manufacture, or are softened by steam in a digester and sent to atmospheric refiners. Atmospheric refiners use single or double revolving disks to mechanically pulp the chips into fibers suitable for making hardboard. Wax may be added to the wood chips in the digester. The PF resin and other additives (if used) are added to the wood fiber immediately following refining. Most hardboard plants inject PF resin into a blowpipe that discharges the resinated fibers to a tube dryer. However, there is one hardboard plant that operates rotary dryers to dry resinated furnish. The resin is added to the rotary dryer furnish as it is refined prior to drying.[11] After drying, the resinated fibers are conveyed to a dry fiber storage bin where they await forming.

Single- or multiple-stage tube dryers are most commonly used in dry process hardboard manufacture. 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 from 145° to 475°F (averaging around 280°F). Secondary tube dryers further dry the wood furnish to around 6 percent moisture (dry basis).[6] Heat is provided to the hardboard tube dryers by either direct-firing with wood residuals, gas, or oil or by indirect-heating. One plant uses indirect-heated, triple-pass rotary dryers to dry the wood fiber. The inlet temperature of the rotary dryers is about 550°F and the wood fiber is dried from roughly 45 to 9 percent moisture (dry basis).[6] Wood fiber is pneumatically drawn though the hardboard dryers and is separated from the dryer exhaust in a cyclonic collector.

Dried, resinated fibers next 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 min. The hardboard presses are heated by steam to an average temperature of around 410°F.[6] Following pressing, boards are routed through a board cooler at some plants. However, most plants do not operate board coolers.[6]

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 340°F.[6] Humidification of boards is done immediately following heat treatment to bring the board moisture content back into equilibrium with ambient air conditions.[21] Humidifiers are often integrated with hardboard ovens (i.e., the boards coming out of the hardboard oven go straight into the humidifier). Following humidification, the hardboard is finished and packaged for shipment. Dry process hardboard densities range from 39 to 69 lb/ft^3.[6]

2.5.1.2 Wet Process Fiberboard. The general steps in production of fiberboard manufacture include pulping of hardwood or softwood wood chips, wet forming, drying, and finishing. The 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.[21]

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 is 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 mat dryer where their moisture content is reduced to about 4 percent. Fiberboard mat dryers operate with inlet temperatures of around 450°F and outlet temperatures of around 320°F. Finished fiberboard density ranges from 12 to 24 lb/ft^3.[6] Once dried the fiberboard is trimmed and may be coated with asphalt. Next, the fiberboard is packaged for shipment.

2.5.1.3 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.

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.[22] 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.[21,22]

The carrying wire takes the fiber mats to a preloader to await pressing. The fiber mats are loaded into the press so that each mat is paired with a patterned caul plate which imparts the pattern onto the top of the mat during pressing. The bottom side of the hardboard bears the pattern of the carrying wire. 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).[6] Wet process hardboard presses are typically multi-opening, steam-heated, batch presses. The hardboard mats are pressed for roughly 8 min at around 390°F.[6]

As with dry process hardboard, the wet process hardboard mats may be transported to the hardboard 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 50 to 70 lb/ft^3.[6]

2.5.1.4 <u>Wet/Dry Process Hardboard</u>. 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.[6,23]

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 (like those used in MDF and dry process hardboard manufacture) 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 wet processing of 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 mat dryer where their moisture content is reduced to around 4 percent. Mat dryers operate with inlet temperatures of around 450°F and outlet temperatures of around 320°F.[6] 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.[17] Steam-heated batch presses are used in wet/dry hardboard manufacturing. Press temperatures average around 470°F for press cycle times of nearly 4 min.[6] As for dry and wet process hardboard, the wet/dry process hardboard mats are heat treated in hardboard ovens following pressing. Wet/dry process hardboard densities range from 45 to 72 lb/ft^3.[6]

2.5.2 Emission Sources and Controls at Fiberboard/Hardboard Plants

The primary sources of HAP emissions at fiberboard/hardboard plants are mat conveyor dryers, tube dryers, hardboard ovens, press preheat ovens, and hot presses. Board coolers and humidifiers may also be sources of HAP emissions at hardboard plants. Tables 2-13 and 2-14 summarize the number of each type of dryer, oven, or humidifier used to manufacture fiberboard/hardboard and the APCD used to control emissions from these sources.[18] Table 2-15 summarizes the number of hardboard presses and board coolers and the capture and control systems used to control emissions from the presses and coolers.[12]

TABLE 2-13. NUMBER OF FIBERBOARD/HARDBOARD DRYERS AND APCD IN THE UNITED STATES

APCD type	Primary tube dryers	Secondary tube dryers	Rotary dryers
WESPs and wet scrubbers: • Wet scrubber only	 8	 8	
Dry scrubbers and other controls: • Baghouse • Cyclone	 3 3		
Uncontrolled	10	3	3
Total	24	11	3

TABLE 2-14. NUMBER OF FIBERBOARD/HARDBOARD MAT DRYERS, OVENS, AND HUMIDIFIERS AND APCD IN THE UNITED STATES

APCD type	Press preheat ovens	Hardboard/ fiberboard mat conveyor dryers	Hardboard ovens	Hardboard humidifiers
Incineration-based controls: • RTO • RCO • Semi-incineration • Semi-incineration and scrubber	 1 1	 1 1 1[a]	 2 1	
WESPs and wet scrubbers: • Wet scrubber only		 1	 2	
Uncontrolled	3	7	15	23
Total	5	11	20	23

[a] This dryer is used to dry a bagasse fiber mat. All of the other dryers dry wood fiber mats.

TABLE 2-15. NUMBER OF HARDBOARD PRESSES AND APCD IN THE UNITED STATES[a]

APCD type	Hardboard presses	Board coolers
Incineration-based controls: • RTO	 1 (1)	
WESPs and wet scrubbers: • Wet scrubber only	 8 (3)	
Dry scrubbers and other controls: • Biofilter • Multiclone • Cyclone	 2 (1) 1 (0) 1 (0)	 2 (1)
Uncontrolled	27 (0)	17 (2)
Total	40 (5)	19 (3)

[a] The numbers outside of the parentheses represent the number of presses or board coolers with each control device. The numbers in parentheses indicate the number of fully enclosed presses and board coolers with each control device.

As shown in Table 2-13, there are three rotary dryers that are used at one dry process hardboard plant to dry green, resinated furnish. There is no subsequent drying of the furnish once it leaves the rotary dryers.[13] There are 13 single-stage tube dryers and 11 multiple-stage tube dryers, for a total of 24 tube drying systems at dry process hardboard plants.[18] All of the controlled multiple-stage tube dryers have separate control devices for the first and second stage emission points.

Digesters and refiners (including pressurized refiners, stand-alone digesters, and atmospheric refiners) are also sources of HAP emissions at fiberboard and hardboard plants. Process flow diagrams and other information submitted with the industry survey responses was reviewed to approximate the number of digesters and refiners used by fiberboard/hardboard plants. Given the varying level of detail on the flow diagrams, obtaining an exact count of these equipment was not possible. However, from the flow diagrams there appear to be at least 13 pressurized refiner systems at fiberboard/hardboard plants. Most of these pressurized refiners vent directly through tube dryers. There also appear to be 24 stand-alone digesters at fiberboard and hardboard plants. None of these digesters appears to be controlled. In addition, the flow diagrams show approximately 61 atmospheric refiners, all of which are uncontrolled.[20]

Wet process hardboard and fiberboard plants use wet formers. There is typically one former per press at hardboard plants and one former per process line for fiberboard plants. Most wet formers are uncontrolled; however, one wet/dry hardboard plant operates a scrubber on a wet former. Dry formers are used by all dry process hardboard plants. There is typically one former per dry hardboard press. No dry hardboard formers are known to be controlled.

Additional HAP emissions may be associated with finishing operations at hardboard and fiberboard plants. Emissions from finishing operations are dependent on the type of products being finished. Edge seals, anti-skid coatings, or primers may be added to fiberboard or hardboard products. Some fiberboard products are coated with asphalt. In addition, company logos, trademarks, or grade stamps may be applied.

2.5.3 Nationwide HAP Emissions from Fiberboard/Hardboard Plants

The estimated nationwide and plant average baseline total HAP emissions for hardboard and fiberboard plants are presented in Table 2-16. Table 2-17 presents the average uncontrolled emissions per hardboard and fiberboard process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13] Only those process units for which emission factors are available are included in Table 2-17. Emissions from blenders, board coolers, sanders, and saws, were not estimated. However, it is expected that the magnitude of the emissions from these process units would be similar to the emissions from similar process units at plants making other PCWP.

TABLE 2-16. AVERAGE BASELINE TOTAL HAP EMISSIONS FOR FIBERBOARD/HARDBOARD PROCESS UNITS

Hardboard/fiberboard process	Nationwide baseline total HAP emissions (tpy)	Average total HAP emissions per plant (tpy)	
		Uncontrolled	Baseline
Fiberboard	78	11	11
Wet process hardboard	1,000	128	128
Wet/dry process hardboard	340	125	86
Dry process hardboard	1,900	245	240
Total[a]	3,300		

[a] Total may not sum exactly due to rounding.

2.6 SOFTWOOD PLYWOOD

Softwood plywood is a building material consisting of veneers (thin wood layers or plies) bonded with an adhesive. Softwood plywood is generally made by gluing several layers of softwood veneer together. Softwood plywood is used for exterior applications such as sheathing, roof decking, concrete formboards, floors, and containers.

TABLE 2-17. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR FIBERBOARD/HARDBOARD PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Log chipper	<<1
Fiberboard mat dryer	9
Fiber washer	6[a]
Atmospheric refiners	<1
Wet former	5
Hardboard oven	18
Digester/refiners	21
Humidifier	2
Press	23
Press predryer	15
Primary tube dryer	60
Secondary tube dryer	3
Green furnish rotary dryer	15

[a] Excludes one fiber washer with an unusually high estimated throughput.

2.6.1 Softwood Plywood and Veneer Process Description

The manufacture of softwood plywood consists of seven steps: log debarking and bucking, heating the logs, peeling the logs into veneers, drying the veneers, gluing the veneers together, pressing the veneers in a hot press, and finishing processes such as sanding, patching, and trimming. Figure 2-8 is a generic process flow diagram for a plywood mill that produces and dries veneers for onsite use in plywood manufacturing.[24] A few softwood plywood plants purchase some dry veneer from offsite sources. However, the majority of softwood plywood plants in the United States peel and dry veneers onsite.

The first step of plywood manufacturing is debarking. Prior to or after debarking, the logs are cut to appropriate lengths (called blocks). The blocks are heated to improve the cutting action of the veneer lathe or slicer, thereby generating a veneer with better surface finish. Blocks

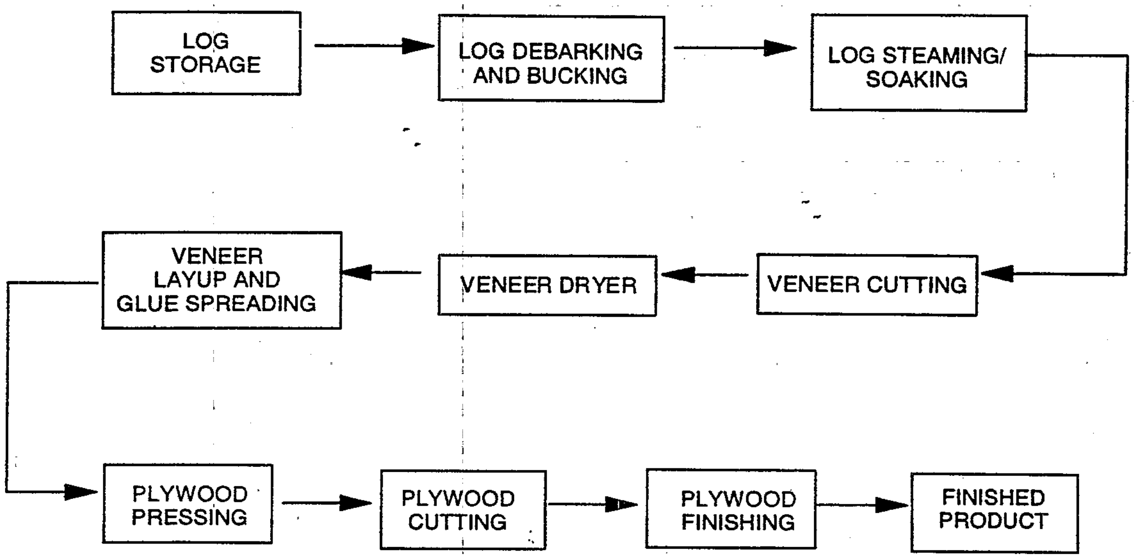

Figure 2-8. Generic process flow diagram for a plywood mill.

are heated in a roughly 200°F medium such as hot water baths, steam heat, hot water spray, or a combination of the three until the core temperature has reached around 105°F.[24, 25]

After heating, the logs are processed to generate veneer. For most applications, a veneer lathe is used, but some veneer is generated with a veneer slicer. The slicer and veneer lathe both work on the same principle; the wood is compressed while the veneer knife cuts the blocks into veneers that are typically 0.125 inches thick. These pieces are then clipped to a usable width, typically 54 inches, to allow for shrinkage and trim.[24]

Veneers are taken from the clipper to a veneer dryer where they are dried to moisture contents that range from 1.5 to 25 percent and average around 9 percent (dry basis). Target moisture contents depend on the type of resin used in subsequent gluing steps. The typical drying temperature is around 360°F.[6] The veneer dryer may be a longitudinal dryer, which circulates air parallel to the veneer, or a jet dryer. Jet dryers have jet tubes to direct hot air onto the surface of the veneers. 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. Veneer dryers are divided into separate air circulation zones, with each zone having a hot air source, fans to move the warm air, and an exhaust vent or stack. Veneer dryers typically have one to three heated zones followed by a cooling zone or section. The cooling section circulates ambient air over the veneer to reduce the veneer temperature just before it exits the dryer. The veneers must be cooled to prevent glue from curing on the veneers before they reach the plywood press. A few plants in the United States dry veneer in kilns. Kiln drying is a batch operation where the veneers are stacked with stickers (narrow wood strips) and dried in the kiln.

Veneer moisture is checked against the target moisture level as the veneer exits the dryer. Some plants operate veneer redryers to redry veneer that did not reach the target moisture content. The veneer that must be redried is called "redry." Most plants operate in order to minimize the amount of redry, and often attempt to limit the amount of redry to five percent of the veneer produced.[26] Veneer redryers are typically heated by radio frequency (RF) and are designed to handle only a fraction of the throughput from full-scale veneer dryers.

When the veneers have been dried to their specified moisture content, they are glued together. Most softwood plywood plants use PF resin. However, one plant that manufactures plywood from mixed hardwood and softwood species uses UF resin.[6] Resin is applied to the veneers by glue spreaders, curtain coaters, or spray systems. Generally, resin is spread on two sides of one ply of veneer, which is then placed between two plies of unresinated veneer. Curtain coaters or spray systems are used on automated plywood layup lines. With these systems, veneer passes under the coater or spray, an unresinated veneer is placed on top of the resinated veneer, the two stacked veneers pass under a second coater, another unresinated veneer is added to the stack, and so on, until the plywood panel is formed.

Assembly of the plywood panels must be symmetrical on either side of a neutral center in order to avoid excessive warpage. For example, a five-ply panel would be laid up in the following manner. A back, with the grain direction parallel to the long axis of the panel, is placed on the assembly table. The next veneer has a grain direction perpendicular to that of the back, and is spread with resin on both sides. Then, the center is placed, with no resin, and with the grain perpendicular to the previous veneer (parallel with the back). The fourth veneer has a grain perpendicular to the previous veneer (parallel with the short axis of the panel) and is spread with resin on both sides. The final, face, veneer with no resin is placed like the back with the grain parallel to the long axis of the plywood panel.

The laid-up assembly of veneers then is sent to a hot press in which it is consolidated under heat and pressure. Hot pressing has two main objectives: (1) to press the glue into a thin layer over each sheet of veneer; and (2) to activate the thermosetting resins. Typical press temperatures range from 200° to 380°F (averaging around 310°F), while press times average around 7 min. The time and temperature vary depending on the wood species used, the resin used, and the press design. Plywood presses are most often steam heated, although some are heated by hot oil.[6]

The plywood then is taken to a finishing process where edges are trimmed. Wood putty or synthetic patches may be applied to defects in plywood faces prior to sanding. The face and back of the plywood panel may or may not be sanded smooth. Concrete forming oil may be applied to plywood destined for use as concrete forms. Overlays may be applied to some plywood panels. The type of finishing depends on the end product desired. Edge sealers, logos, trademarks, and grade stamps are routinely applied to stacks of plywood panels.

2.6.2 Emission Sources and Controls at Softwood Plywood and Veneer Plants

The primary sources of HAP emissions at plywood plants are veneer dryers and plywood presses. There are a total of 280 veneer dryers at softwood plywood plants in the United States. Table 2-18 summarizes APCD used to control emissions from the veneer dryers.[27] In addition, there are two softwood veneer kilns and nine uncontrolled RF veneer dryers (primarily used as re-dryers) in the United States.[6] None of the 226 softwood plywood presses used in the United States are operated with an APCD. However, three presses were reported to be enclosed.[12] There are a total of eight board coolers in use at softwood plywood plants in the United States. None of the board coolers exhaust through a control device, although one cooler was reported to be fully enclosed.[12] In addition to dryers and presses, miscellaneous finishing operations at plywood plants may also be sources of HAP emissions.

TABLE 2-18. NUMBER OF VENEER DRYERS AND APCD AT SOFTWOOD PLYWOOD PLANTS IN THE UNITED STATES

APCD type	Softwood veneer dryers[a]	Hardwood veneer dryers[a]
Incineration-based controls:		
• RTO	44	
• RCO	7	
• TO	3	
• Process incineration	5	
• Process incineration and scrubber	5	
• Semi-incineration and scrubber	8	
• Semi-incineration and multiclone	2	
WESPs and wet scrubbers:		
• Wet scrubbers	47	
• WESP	36	
• Scrubber and WESP	4	
Dry scrubbers and other controls:		
• EFB	8	
Uncontrolled	105	6
Total	274	6

[a] Softwood veneer dryers dry 30 percent or more (on a volume basis) softwood species. Hardwood veneer dryers dry less than 30 percent softwood species.

2.6.3 Nationwide HAP Emissions from Softwood Plywood and Veneer Plants

Nationwide baseline total HAP emissions from softwood plywood and veneer plants are estimated to be 3,700 tpy. The average total uncontrolled HAP emissions per plant is 38 tpy. The average total baseline HAP emissions per plant is 36 tpy. Table 2-19 presents the average uncontrolled emissions per softwood plywood and veneer process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-19. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR SOFTWOOD PLYWOOD AND VENEER PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Softwood veneer dryer	5
Hardwood veneer dryer	8
Softwood veneer kiln	<1
RF veneer redryer	<1
Log vats	1
Veneer and panel chippers	2
Press	7
Sanders	2
Saws	1

2.7 HARDWOOD PLYWOOD

Unlike softwood plywood plants which typically produce softwood veneers and softwood plywood on the same plant site, the majority of the plants in the hardwood plywood and veneer industry typically produce either hardwood plywood or hardwood veneer. Hardwood veneer plants cut and dry hardwood veneers. Hardwood plywood plants typically purchase hardwood veneers and press the veneers onto a purchased core material. Only around 15 percent of hardwood plywood plants cut and dry veneer onsite. As a result, hardwood plywood and hardwood veneer plants are generally smaller than softwood plywood plants in terms of number of employees and production.[6,26]

Hardwood plywood is made of hardwood veneers bonded with an adhesive. The outer layers surround a lumber, veneer, particleboard, or MDF core. Hardwood plywood may be pressed into panels or plywood components (e.g., curved hardwood plywood, seat backs, chair arms, etc.). Hardwood plywood is used for furniture, cabinets, architectural millwork, paneling for commercial buildings, flooring, store fixtures, and doors.[26] Hardwood veneer is used for hardwood plywood, furniture, doors, flooring, and produce containers.

2.7.1 Hardwood Plywood and Veneer Process Description

The manufacture of hardwood veneer and plywood consists of the following processes: log debarking and bucking, heating the logs, cutting the logs into veneers, drying the veneers, gluing the veneers together, pressing the veneers in a hot press, and finishing. Figure 2-9 provides a generic process flow diagram for hardwood veneer and plywood manufacturing. As mentioned earlier, cutting and drying of veneers typically occurs at a hardwood veneer plant while layup and pressing of the plywood occurs at a separate hardwood plywood plant. A few plants produce both hardwood veneer and plywood on the same plant site. The veneer and plywood manufacturing process is essentially the same, regardless of whether the veneers are produced at the same site where the plywood is produced, or at an offsite location.

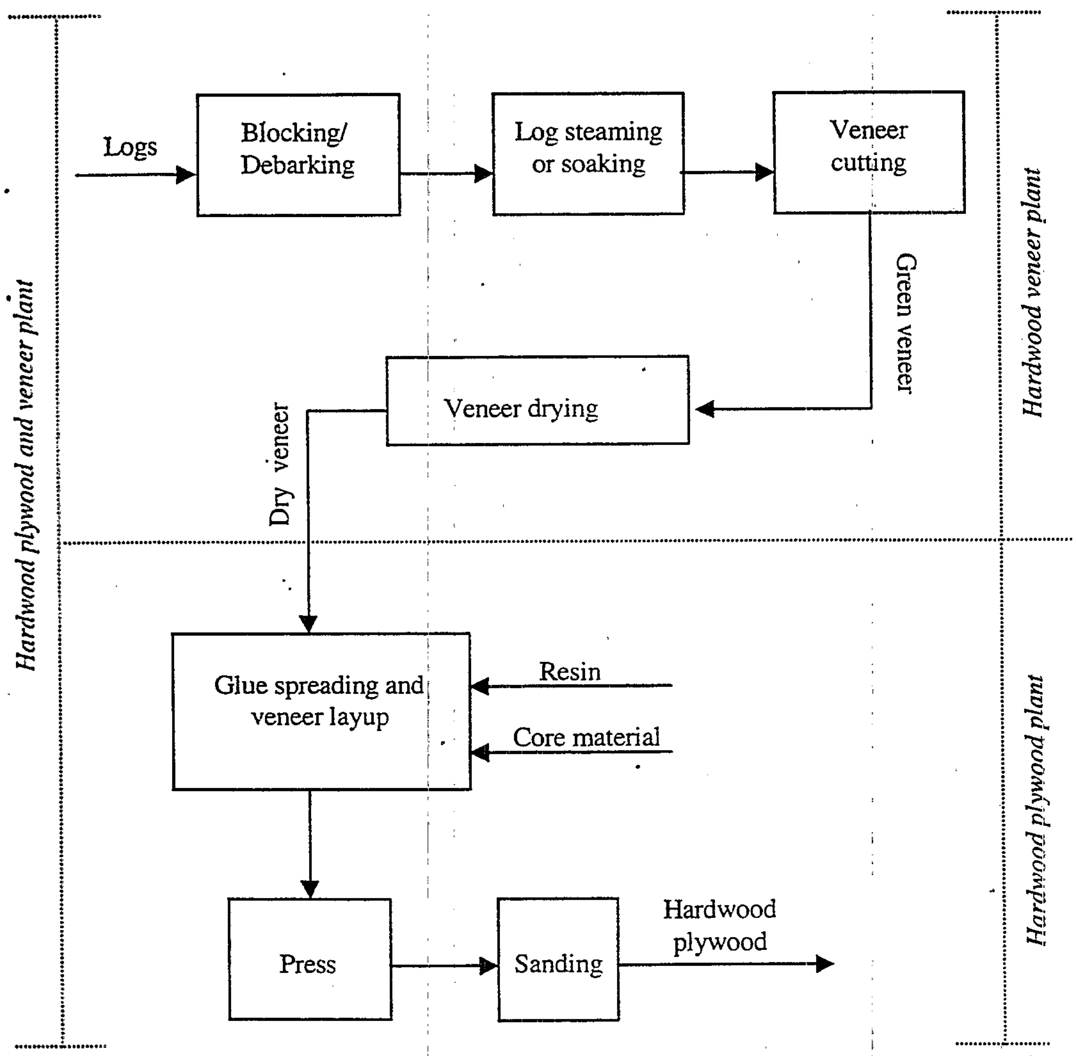

Figure 2-9. General steps in hardwood veneer and plywood manufacturing.

2.7.1.1 Hardwood Veneer Process Description. The initial step of log debarking is accomplished by feeding logs through one of several types of debarking machines. The purpose of this operation is to remove the outer bark of the tree without substantially damaging the wood. After the bark is removed, the logs are cut to veneer lengths in a step known as bucking.

The logs (now referred to as blocks or flitches) then are heated to improve the cutting action of the veneer lathe or slicer, thereby generating a veneer with better surface finish. Blocks are heated using hot water baths, steam heat, or hot water sprays.[24]

After heating, the logs are processed to generate veneer. A veneer lathe may be used for rotary cutting or a veneer slicer may be used to slice veneers. Depending on the way the veneer is cut, different visual effects may be achieved with the wood grain. Lumber may also be sliced into veneer. The slicer and veneer lathe both work on the same principle; the wood is compressed while the veneer knife cuts the flitches or blocks into veneers ranging in thickness from around 0.024 to 0.125 inches thick.[26] Rotary peeled veneers are clipped to appropriate widths before further processing.

Veneers are taken from the slicer or clipper and dried in a veneer dryer. Typical drying temperatures are around 250° to 300°F; however, drying temperatures as low as 110°F and as high as 450°F have been reported. Veneer dryers may be described by heating method and air flow pattern. Most hardwood veneer dryers are indirect-heated (or steam heated), but some are direct-fired. The air flow patterns for hardwood veneer dryers may be either longitudinal or jet. Veneer kilns are also used in hardwood veneer manufacturing.[26] For kiln drying, the veneers are piled and stickered (separated by wood sticks) and placed in the veneer kiln where they are dried.Kiln drying is a batch process. Most kilns used for hardwood veneer manufacturing are indirect-heated.

Once the veneers have been dried, they may be glued together on the edges with glue thread to form larger sheets of veneer. This process is called composing. Narrow veneer slices must be composed before they are used in plywood panels or other products requiring wider veneer sheets. Composing may be performed at the veneer plant or by the plant which purchases the veneers. Some facilities purchase narrow veneers only to compose them and resell larger sheets of veneer. Once composed (if necessary), the veneers are shipped or used onsite to manufacture plywood or other products (e.g., furniture, doors, flooring, etc.).

2.7.1.2 Hardwood Plywood Process Description. At the hardwood plywood plant, dried veneers are glued together with a thermosetting resin and hot pressed. Urea-formaldehyde resin is the most commonly used resin for hardwood plywood manufacturing. However, some plants use polyvinyl acetate (PVA), melamine-formaldehyde (MF), MUF, or PF resins as dictated by the end use for the plywood product.[26] The UF, MF, MUF, and PVA resins are colorless or light in color, making them suitable for use with thin hardwood face veneers. These resins offer water resistance appropriate for indoor applications. The PF resin is a dark-colored, water-proof resin used for structural grade plywood panels (e.g., a product similar to softwood plywood made from poplar or gum veneers).[28]

The resins are typically applied to the core panels or veneers by glue spreaders. Spreaders have a series of application rolls that apply the resin to both sides of a sheet of core veneer or core panel such as MDF or particleboard. The hardwood veneer back and face is applied to either side of the resinated core material. For example, a sheet of hardwood veneer is laid down for the panel back, resinated core material is placed on the hardwood veneer, and a sheet of hardwood veneer is placed on top of the resinated core to form the panel face. If veneer cores are used to construct the plywood panel, then the grain of each veneer is laid perpendicular to adjacent veneers in the panel.

The laid-up assembly of veneers is then taken to a cold press for prepressing. Next the panels are placed in a hot press which applies heat and pressure to cure the resin in the panels. Typical press temperatures range from 210° to 260°F for hardwood plywood, while press times range from less than 1 to 45 min. The average press cycle time is around 6 min for hardwood plywood.[26] Press time and temperature vary depending on the wood species used, the resin used, and the press design. Both single-opening and multi-opening presses are used for hardwood plywood. Single-opening presses may be heated by conventional methods (i.e., hot oil, hot water, or steam), RF, or electricity. Multi-opening presses used for hardwood plywood manufacturing are heated by conventional means. A few presses with two to four openings are heated by RF. Radio-frequency presses are frequently used for manufacture of plywood components or curved plywood products that cannot be placed in platen presses.

Once pressed, the hardwood plywood then is taken to a finishing process where edges are trimmed and the face and back may or may not be sanded smooth. The type of finishing depends on the end product desired.

2.7.2 Emission Sources and Controls at Hardwood Plywood and Veneer Plants

The primary sources of HAP emissions at hardwood plywood plants are veneer dryers and presses. Table 2-20 summarizes APCD used to control emissions from the veneer dryers at hardwood plywood plants.[27] In addition to the veneer dryers listed in Table 2-20, eight uncontrolled hardwood veneer kilns are operated at hardwood veneer plants in the United States. None of the 321 hardwood plywood presses used in the United States are operated with an APCD.[26] Composing and finishing operations at hardwood plywood plants may also be a source of HAP emissions.

TABLE 2-20. NUMBER OF VENEER DRYERS AND APCD AT HARDWOOD PLYWOOD PLANTS IN THE UNITED STATES

APCD type	Softwood veneer dryers	Hardwood veneer dryers
Incineration-based controls:		
• Semi-incineration		1
• Semi-incineration and scrubber	2	
WESPs and wet scrubbers:		
• Wet scrubbers	6	
Dry scrubbers and other controls:		
• EFB	3	
Uncontrolled	12	166
Total	23	167

[a] Softwood veneer dryers dry 30 percent or more (on a volume basis) softwood species. Hardwood veneer dryers dry less than 30 percent softwood species.

2.7.3 Nationwide HAP Emissions from Hardwood Plywood and Veneer Plants

Nationwide baseline total HAP emissions from hardwood plywood and veneer plants are estimated to be 161 tpy. The average total uncontrolled and baseline HAP emissions per plant are 1 tpy. Table 2-21 presents the average uncontrolled emissions per hardwood plywood and veneer process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-21. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR HARDWOOD PLYWOOD AND VENEER PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Softwood veneer dryer	1
Hardwood veneer dryer	<1
Hardwood veneer kiln	<1
Press	<1

2.8 LAMINATED VENEER LUMBER

2.8.1 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 0.125 inches thick and are made from rotary-peeled hardwood (e.g., yellow poplar) or softwood species.[1,29] Laminated veneer lumber is used for headers, beams, rafters, and I-joist flanges. Figure 2-10 is a diagram of the LVL manufacturing process.

The start of the LVL manufacturing process depends on how the plant obtains veneers. Plants either purchase pre-dried veneers, purchase green veneers and dry them onsite, or peel and dry veneers onsite. Unless the plant purchases pre-dried veneers, the LVL manufacturing process begins with veneer drying. Of the 15 LVL plants listed in the EPA's engineered wood products survey response data base, 10 purchase veneers from offsite, three peel veneers on-site, and two purchase a combination of green and dry veneers.[29] Thus, five (one-third) of the LVL plants dry veneer onsite in veneer dryers.

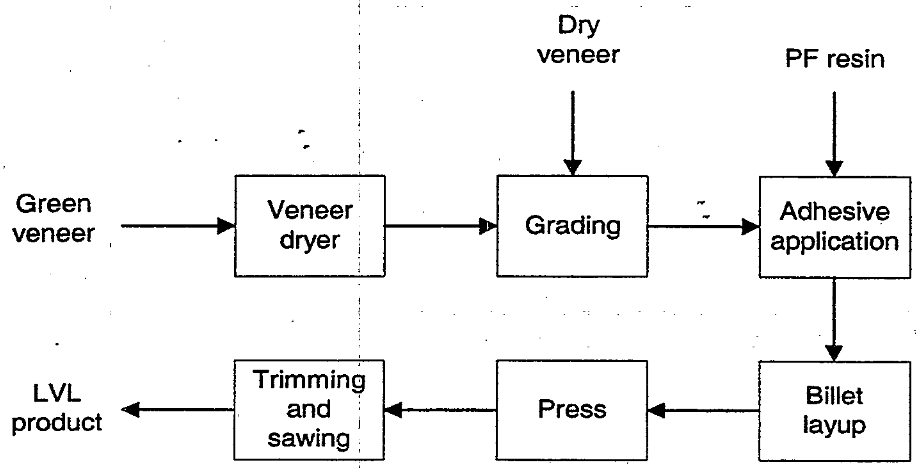

Figure 2-10. Laminated veneer lumber manufacturing process.

The veneer dryers used at LVL plants are the same types of dryers in use at plywood plants.. Veneer dryers used at LVL plants are used to dry either 100 percent hardwood or 100 percent softwood species.[29] The typical veneer drying temperature is around 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. The hardwood veneer dryers used at LVL plants are indirect-heated, while the softwood dryers are direct-fired by gas burners.[29]

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 PF resin is applied. Plants that manufacture LVL from hardwood species may use UF resin rather than PF resin.[29]

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. In the United States, 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 RF waves. Press temperatures range from about 250° to 450°F, averaging around 350°F. Batch presses may have one or more openings. A few plants produce short-length LVL using multi-opening platen presses similar to the hot presses used in plywood manufacturing.[29,30] However, most plants employ continuous pressing systems.

Billets exiting the press may be up to 3.5 inches thick, and may be made even thicker in a secondary gluing operation. The moisture content of the billets exiting the press is about 10 percent.[1] Billets are produced in widths of up to 6 feet.[29] 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 80 feet.[1] Trademarks or grade stamps may be applied in ink to the LVL before it is shipped from the plant.

2.8.2 Emission Sources and Controls at LVL Plants

The primary sources of HAP emissions at LVL plants include veneer dryers and presses. Table 2-22 summarizes APCD used to control emissions from the veneer dryers at LVL plants.[27,31] There are 43 uncontrolled presses in use at LVL plants in the United States. In addition to drying and pressing, glue application and application of trademarks or grade stamps may also be a source of HAP emissions at LVL plants.

TABLE 2-22. NUMBER OF VENEER DRYERS AND APCD AT LVL PLANTS IN THE UNITED STATES

APCD type	Softwood veneer dryers[a]	Hardwood veneer dryers[a]
Incineration-based controls:		
• RTO	4	
Uncontrolled		5[b]
Total	4	5[b]

[a] Softwood veneer dryers dry 30 percent or more (on a volume basis) softwood species. Hardwood veneer dryers dry less than 30 percent softwood species.
[b] Two of these dryers are shared for LVL and PSL production at the same plant.

2.8.3 Nationwide HAP Emissions from LVL Plants

Nationwide baseline total HAP emissions from LVL plants are estimated to be 94 tpy. The average uncontrolled HAP emissions per LVL plant is 8 tpy. The average baseline HAP emissions per plant is 7 tpy. Table 2-23 presents the average uncontrolled emissions per LVL process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-23. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR LVL PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Softwood veneer dryer	5
Hardwood veneer dryer	4
Press	2

2.9 LAMINATED STRAND LUMBER

2.9.1 LSL Process Description

Laminated strand lumber is a product manufactured by Trus-Joist MacMillan at two facilities in the United States. 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 2-11 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 12-inch strands. The strands are screened to remove short strands and are stored in green bins before they are dried. These short strands may be used as fuel for the production process.[1]

The acceptable-sized strands are dried in either a conveyor or rotary drum dryer and stored in a dry bin where they await further processing. One of the two LSL plants in the United States operates four triple-tier conveyor dryers. The other LSL plant operates two single-pass rotary dryers. The LSL strands are dried to four to seven percent moisture (dry basis) in either type of dryer. The rotary strand dryers are direct-fired by wood burners. The rotary dryer inlet temperature is approximately 900°F. The LSL conveyor dryers are indirect-heated, and operate at 320° to 400°F.[29]

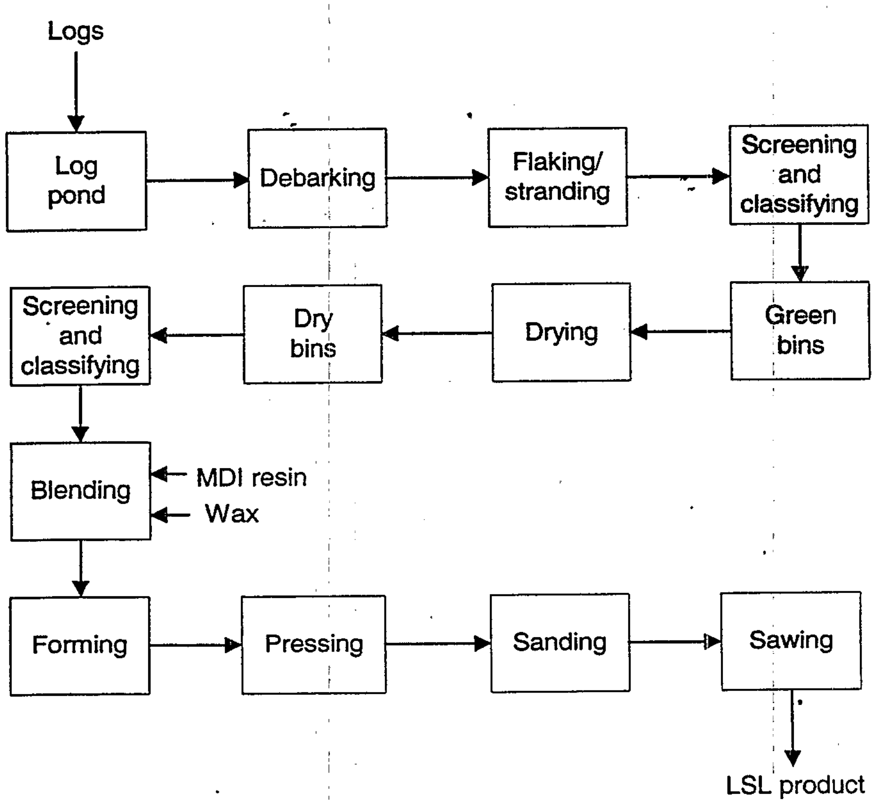

Figure 2-11. Laminated strand lumber manufacturing process.

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 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 min at a temperature of 310°F. Billets may be up to 8 ft wide, 5.5 inches thick, and 48 ft long. The average press throughput for the two LSL plants is 5.2 million ft^3/yr. Once the billets leave the press, they are sanded, cut to specific dimensions, and packaged for shipment.[29]

Laminated strand lumber manufacturing is similar to OSB manufacturing in some regards. The equipment and processes for LSL and OSB manufacturing are similar, with the exception of the press. Oriented strandboard is usually formed into panels used for sheathing in a multi-opening platen press, while LSL is made into a billet (which will be cut-to-size and used for structural framing) in a steam-injection press. As with OSB, the raw material for LSL production is whole debarked logs cut into strands. In the case of LSL, however, the nearly 12-inch strands are significantly longer than the 3- to 6-inch strands used for OSB.[1] The LSL strands are about the same thickness (0.03 to 0.05 inches) as OSB strands. Laminated strand lumber is manufactured from only hardwood species, while OSB is made from a mixture of hardwoods and softwoods.[6,29] The LSL strands are oriented parallel to the length of the finished product (rather than in perpendicular layers as in OSB).

2.9.2 Emission Sources and Controls at LSL Plants

Sources of HAP emissions at LSL plants include strand dryers, blenders, the steam-injection press, and application of edge seals. All of the LSL strand dryers (four conveyor dryers and two rotary dryers) are vented through an EFB. Emissions from the blenders at the two LSL plants are ducted through a baghouse. The two presses are enclosed and ducted through a stack. The edge seal operations are fugitive emission sources.

2.9.3 Nationwide HAP Emissions from LSL Plants

Nationwide baseline total HAP emissions from LSL plants are estimated to be 64 tpy. The average total uncontrolled and baseline HAP emissions per plant is 32 tpy. Table 2-24 presents the average uncontrolled emissions per LSL process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-24. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR LSL PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Rotary strand dyers	27
Conveyor strand dryers	2[a]
Press	<1

[a] Emissions were estimated based rotary dryer emission factors that were scaled down using ratios of rotary dryer and conveyor dryer formaldehyde and total hydrocarbon. See the baseline emissions memo for details.

2.10 PARALLEL STRAND LUMBER

2.10.1 PSL Process Description

Like LSL, PSL is a product manufactured by Trus-Joist MacMillan at two facilities in the United States. Figure 2-12 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 may be used to manufacture PSL.

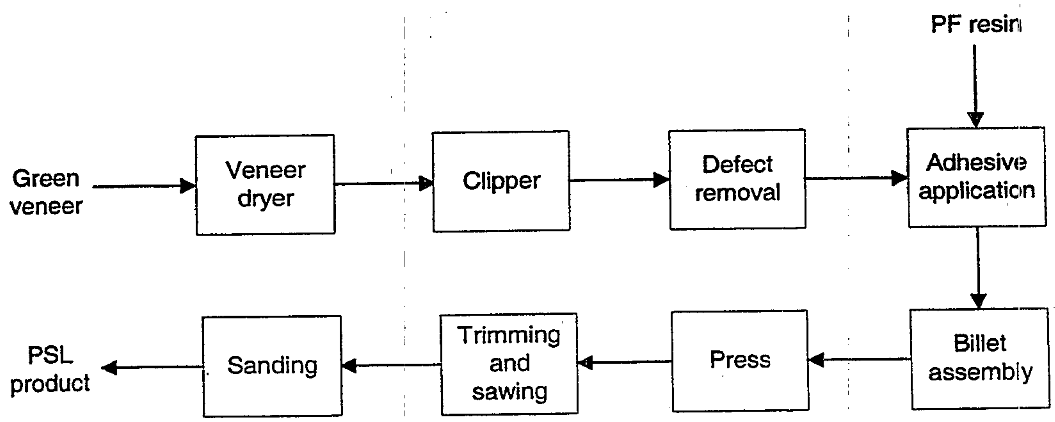

Figure 2-12. Parallel strand lumber manufacturing process.

The manufacturing process begins with rotary-peeling logs into veneer about 0.125 inches thick.[1] The green veneer is clipped into sheets, sorted, and dried in a veneer dryer. The two PSL plants in the United States each have two indirect-heated veneer dryers. One of the plants uses the same veneer dryers for both LVL and PSL production. The veneers are typically dried at around 400°F.[29]

The dried veneer is clipped into strands approximately 0.75 inches 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.[1] A variety of billet dimensions may be produced in the continuous press. Following pressing, the billets are processed into smaller members according to customer specifications and packaged for shipment.

2.10.2 Emission Sources and Controls at PSL Plants

The HAP emission sources at PSL plants include veneer dryers and presses. There are two uncontrolled softwood veneer dryers in operation at PSL plants. (Note that there are two additional uncontrolled hardwood veneer dryers that are shared between LVL and PSL production lines at one plant. These hardwood veneer dryers were included in Table 2-22.)[27,31] There are two uncontrolled presses in use at PSL plants. In addition to drying and pressing, glue application and application of trademarks or grade stamps may also be a source of HAP emissions at PSL plants.

2.10.3 Nationwide HAP Emissions from PSL Plants

Nationwide baseline total HAP emissions from PSL plants are estimated to be 30 tpy. The average total uncontrolled and baseline HAP emissions per plant is 15 tpy. Table 2-25 presents the average uncontrolled emissions per PSL process unit. The average emissions per plant and per process unit were calculated as the average of the total emissions estimated for each plant and for each process unit using the methodology documented in the baseline emissions memo.[13]

TABLE 2-25. AVERAGE UNCONTROLLED TOTAL HAP EMISSIONS FOR PSL PROCESS UNITS

Process unit	Average uncontrolled total HAP emissions (tpy)
Softwood veneer dyers	7
Press	5

2.11 I-JOISTS

2.11.1 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. Figure 2-13 shows the web and flange of a typical I-joist made with OSB and LVL.[32] 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.

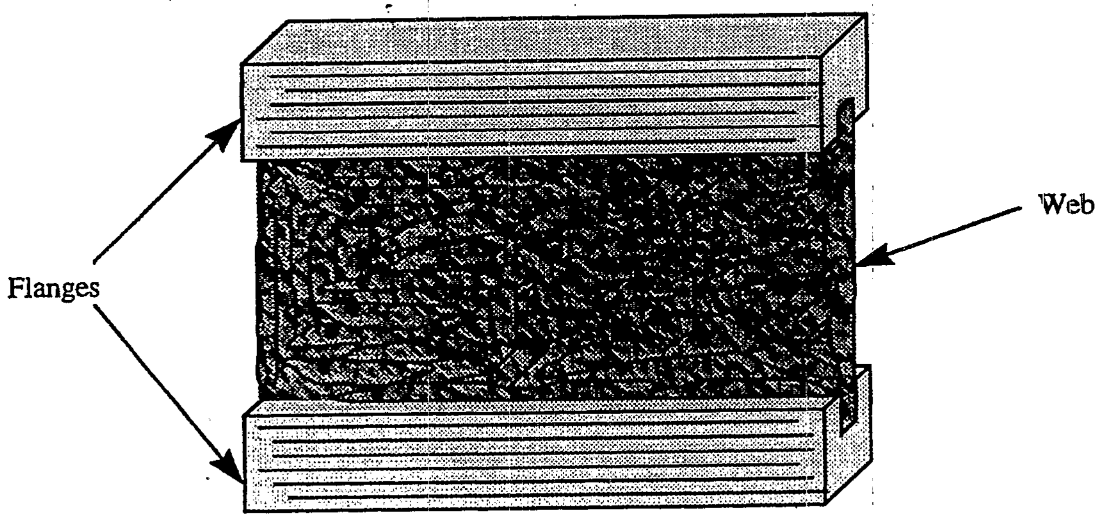

Figure 2-13. View of an I-joist made from an OSB web and LVL flanges.

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 350 linear feet per minute (lf/min).[1] There are also custom hand lay-up processes that are used for heavier commercial 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 2-14a and 2-14b show a typical automated I-joist fabrication process.

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-

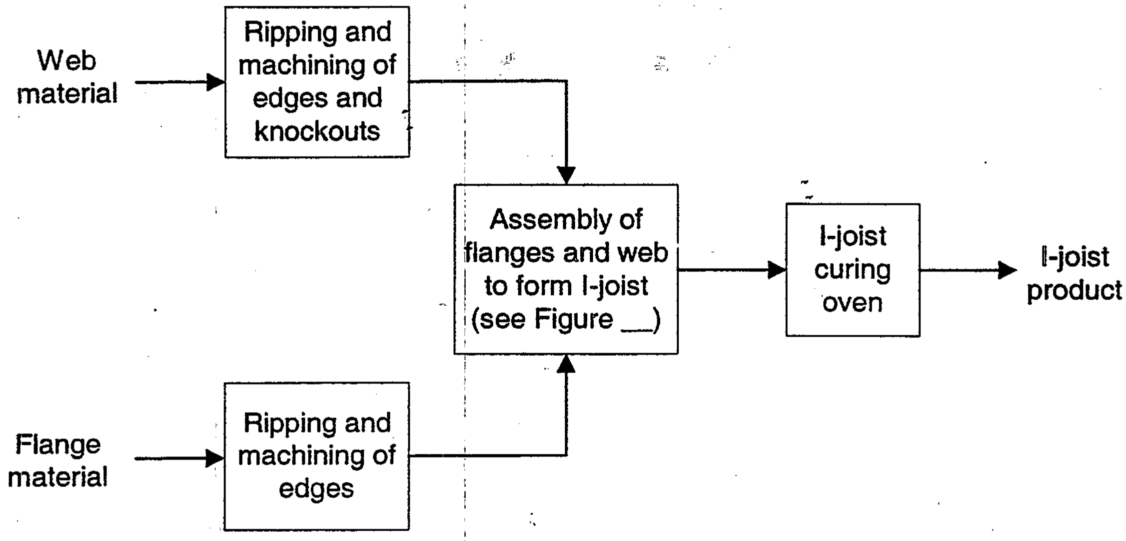

Figure 2-14a. I-joist manufacturing process.

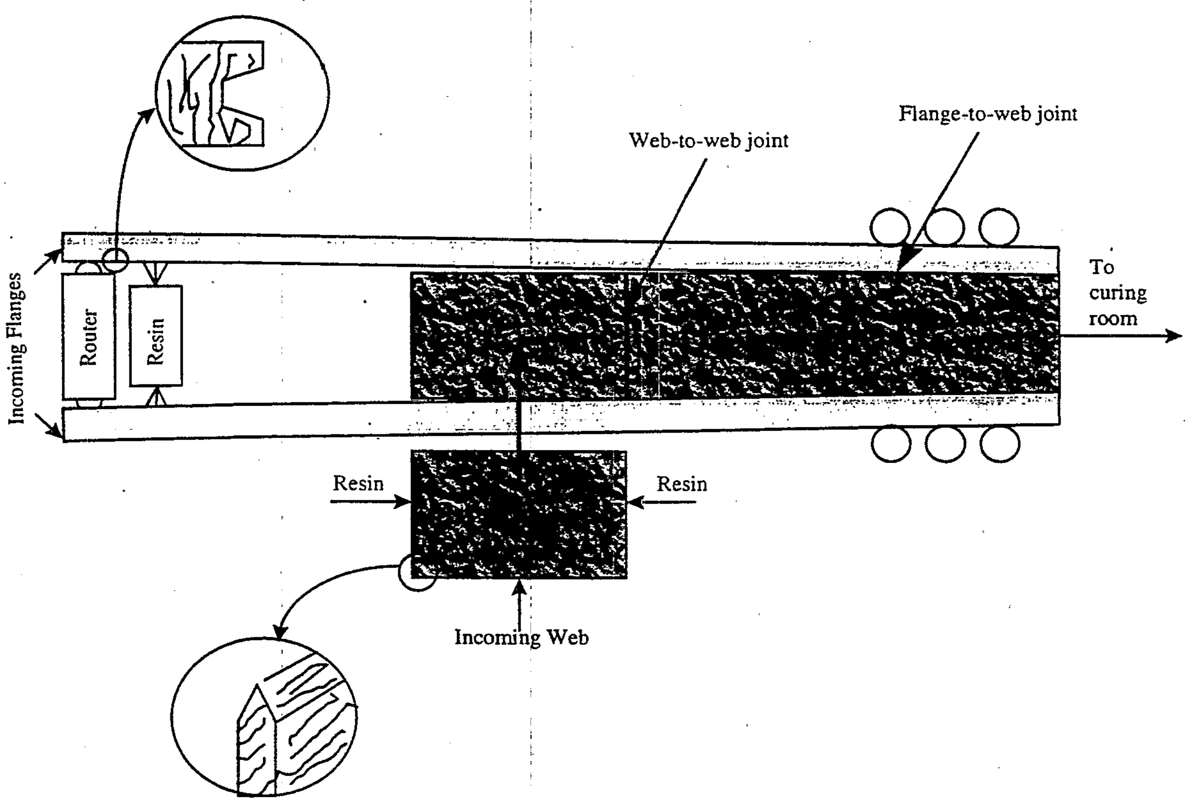

Figure 2-14b. Basic I-joist assembly.

formaldehyde (PRF) finger-jointing resin is applied in 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 adhesive is applied in the flange groove for formation of the flange-to-web joints.[29] The adhesive 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 adhesive. Resin curing chambers may be rooms surrounded by a solid wall or heavy plastic flaps. Curing rooms are typically heated to around 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.[29] Once cured, the finished I-joists are inspected and bundled for shipment.

2.11.2 Emission Sources and Controls at I-Joist Plants

Sources of HAP emissions at I-joist plants include resin application, I-joist assembly, and I-joist curing. Additional sources of HAP emissions may include application of grade stamps or trademarks. Most of the operations at I-joist plants are fugitive sources of HAP emissions. No add-on APCD are used on sources of HAP emissions at I-joist plants. If not vented inside the building, emissions from I-joist curing ovens may be vented through exhaust fans, roof vents, or hoods. There are 17 uncontrolled I-joist curing ovens in use at I-joist plants in the United States.

2.11.3 Nationwide HAP Emissions from I-Joist Plants

Nationwide baseline total HAP emissions from I-joist plants are estimated to be 8 tpy. The average total uncontrolled and baseline HAP emissions per plant is <1 tpy. Because the average emissions per plant are <1 tpy, it follows that the average emissions per I-joist process unit (e.g., curing oven, RF fingerjoint curing tunnel, and cutting operation) are <1 tpy.[13]

2.12 GLUE-LAMINATED BEAMS

2.12.1 Glulam Process Description

Glue-laminated beams are manufactured by gluing lumber 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.

Lumber used to manufacture glulam may be dried onsite at the glulam plant or purchased pre-dried from suppliers. Nearly half of the glulam plants responding to the EPA's engineered wood products survey dry lumber in onsite lumber kilns. The remaining plants purchase dry lumber. 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. 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.[33]

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 1.1 inches long. The finger joints are machined on both ends of the lumber with special cutter heads. A structural adhesive, such as an RF-curing MF or PF adhesive, is applied and the joints in successive boards are mated. The adhesive is cured with the joint under end pressure. Most manufacturers use a continuous RF-curing system to cure end joints.[29]

Just before the face gluing process, the end-jointed lumber is planed on both sides to ensure clean, parallel surfaces for gluing. The adhesive is spread onto the lumber with a glue extruder. Phenol-resorcinol-formaldehyde is the most commonly used adhesive for face gluing. Other adhesives used for face gluing include PF resin or MUF resin.[29]

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.[29] Some of the newer clamping systems combine continuous hydraulic presses and RF curing to accelerate 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 adhesive 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.[33]

2.12.2 Emission Sources and Controls at Glulam Plants

Sources of HAP emissions at glulam plants include lumber drying, RF curing of finger joints, glue application, and pressing. Glue application, RF curing of finger joints, and pressing are fugitive emission sources. Lumber kilns are not fugitive emissions sources. However, lumber kilns have several emission points. Lumber kilns are discussed in Section 2.14 below. There are 22 glulam presses in use at U.S. glulam plants. No add-on controls are used on sources of HAP emissions at glulam plants.

2.12.3 Nationwide HAP Emissions from Glulam Plants

Nationwide baseline total HAP emissions from glulam plants are estimated to be 84 tpy. The average total uncontrolled and baseline HAP emissions per plant is 5 tpy. The average total HAP emissions per glulam press is 4 tpy, based on the resin mass balance calculations described in the baseline emissions memo.[13] Average total HAP emissions for lumber kilns are summarized in Section 2.14.3.

2.13 MISCELLANEOUS ENGINEERED WOOD PRODUCTS

In addition to the engineered wood products discussed in Sections 2.8 to 2.12 above, other miscellaneous engineered wood products are manufactured by individual plants in the United States. These miscellaneous products are manufactured through operations similar to other engineered wood products.

2.13.1 Miscellaneous Engineered Wood Products Process Description

One engineered wood product called "comply" is a composite of a panel (e.g., OSB or particleboard) core overlaid with veneer on its edges or faces. Comply is manufactured as a sheathing panel with veneer faces.[1,34] Comply panels are made in a three- or five-layer arrangement. A three-layer panel has a wood core and a veneer face and back. A five-layer panel also has a veneer crossband in the center. When manufactured in a one-step pressing operation, voids in the veneers are filled automatically by the particles or strands as the panels are pressed.[35]

One I-joist plant manufactures custom I-joist flanges by gluing several 0.75-inch strips of wood together. Pre-dried lumber is purchased and ripped, and scarf joints are cut into the lumber strips. Phenol-resorcinol-formaldehyde resin is applied to the wood strips, and the custom flanges are pressed at room temperature overnight.[36]

Another facility manufactures billets similar to LVL billets for onsite use in I-joist flanges and a product called "glue-laminated veneer beams." The glue-laminated veneer beam billets are manufactured from parallel laminated veneer (PLV) panels of varying thicknesses (5 to 11 ply) obtained from outside facilities. The PLV panels are similar to plywood panels except that the grains of the veneers in the panels are aligned parallel to one another. To manufacture billets, the PLV panels are conditioned to achieve a panel temperature of 100° to 110°F. The ends of the PLV panels are fingerjointed and PRF resin is applied to the jointed edges. The end joints are mechanically forced together and are hot pressed. Following pressing the panels are cut to length and moved to billet layup where MDI resin is applied to the panel faces. The panels are stacked into billets of varying thicknesses and pressed in a room temperature batch press. Glue-laminated veneer beams are made by ripping the pressed billets to customer specifications. I-joist flanges are made from the billets as they would be prepared from LVL billets.[37]

2.13.2 Emission Sources at Miscellaneous Engineered Wood Plants

Sources of HAP emissions at the comply plant include particle drying and panel pressing.[34] Emission sources related to custom flange preparation include glue application and pressing, both of which are fugitive HAP sources. Finger joint hot pressing and billet pressing are fugitive HAP emission sources related to production of billets for glue-laminated veneer and I-joist flange manufacturing.

2.13.3 Nationwide HAP Emissions from Miscellaneous Engineered Wood Plants

Nationwide uncontrolled and baseline total HAP emissions from miscellaneous engineered wood products plants are estimated to be 18 tpy. The total baseline HAP emissions per plant range from less than 1 tpy to 13 tpy depending on the miscellaneous engineered wood product manufactured. The baseline emission estimates were developed using the methodology described in the baseline emissions memo.[13]

2.14 KILN-DRIED LUMBER

Several PCWP plants are co-located with sawmills. Sawmills can process peeler cores from plywood plants into lumber. Lumber is also produced from logs at some glulam plants for use in glulam production. Lumber may be sold green, or it may be air dried or dried in a lumber kiln. This section discusses drying of lumber in lumber kilns. Lumber kilns are emission sources that contribute to the facility-wide HAP emissions when co-located at PCWP plants.

2.14.1 Co-Located Lumber Kilns

Green lumber is sawed from debarked logs or from plywood peeler cores. Freshly sawn lumber has a high moisture content that must be reduced for many lumber end uses. Prior to kiln drying, green lumber is stacked with stickers (thin strips of wood) in between each layer of the stack. The stickers allow space between the layers of lumber for air flow. The lumber stacks are loaded into the kiln, the kiln runs through the drying cycle, and the dried lumber is removed from the kiln when the drying cycle is complete. After completion of the lumber drying cycle, the dried lumber is removed from the kiln, unstacked (i.e., the stickers are removed), and stored for shipment.

Lumber kilns are batch units. Softwood lumber kiln drying cycles typically last around 24 hours, while hardwood kiln drying cycles can last from several days to weeks. Lumber kilns may be direct-fired or indirect-heated (e.g., steam-heated). Lumber kiln operating temperatures vary during the drying cycle as the humidity in the lumber kiln and lumber moisture content change. Lumber drying temperatures range from around 95° to 260°F and increase as the lumber becomes increasingly dry.[38] The lumber is dried slowly while at a higher moisture content and more severely as the moisture content decreases in order to maintain an adequate drying rate. Green southern yellow pine is dried from about 40 to 100 percent moisture (dry basis) down to below 20 percent moisture (dry basis).[38] The amount and direction of air that is vented from the kiln changes with the relative humidity, dry bulb temperature, and wet bulb temperature inside the kiln. Lumber kilns have multiple vents, which alternate in function. During any given time, one set of vents allows moisture to exhaust from the kiln while the other set of vents brings in dry air. After some time, the direction of air circulation within the kiln is changed, and the kiln vents exchange functions. Because of these changes in air flow patterns, lumber kiln emission streams vary in flow rate, concentration, and mass emission rate throughout the kiln drying cycle. In addition to emissions from lumber kiln vents, considerable amounts of fugitive emissions may be emitted from lumber kilns through crevices in the kiln wall and around doors.

2.14.2 Emission Sources and Controls for Lumber Kilns

Lumber kilns are emission sources. There are a total of 356 uncontrolled lumber kilns co-located at plants in the PCWP industry. Of the 356 kilns, roughly two-thirds are co-located at softwood or hardwood plywood and veneer plants while the remaining kilns are co-located at glulam, OSB, conventional or molded particleboard, and hardboard plants.[6,26,29]

2.14.3 Nationwide HAP Emissions from Co-Located Lumber Kilns

The nationwide baseline total HAP emissions from co-located lumber kilns are included with the nationwide totals presented in the sections on nationwide emissions above for each product. The average total HAP emissions per lumber kiln is 1 tpy, based on the emission estimation methodology documented in the baseline emissions memo.[13]

2.15 REFERENCES FOR CHAPTER 2

1. Smulski, S., et al., Engineered Wood Products – A Guide for Specifiers, Designers, and Users. Madison, WI, PFS Research Foundation. 1997.

2. Memorandum from M. Icenhour, MRI, to Project file. February 28, 2000. Growth projections for the Plywood and Composite Wood Products Industry – Plywood and Composite Wood Products Manufacturing NESHAP.

3. Maloney, T.M. Modern Particleboard and Dry-Process Fiberboard Manufacturing. San Francisco, Miller Freeman, Inc. 1993. pp. 26, 49, 64, 105-107, 284-285, 294, and 573.

4. Emission Factor Documentation for AP-42 Section 10.6.2, Particleboard Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. September 1998.

5. Memorandum from R. Nicholson and K. Hanks, MRI, to P. Lassiter, EPA/ESD. October 28, 1998. Trip report for visit to Roseburg Forest Products plant in Dillard, Oregon.

6. Memorandum from D. Bullock, K. Hanks, and B. Nicholson, MRI to M. Kissell, EPA/ESD. April 28, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – General Survey.

7. Douglass, Todd. Prairie Forest Products Appears To Have Turned the Wheat Straw Corner. Panel World. November 1998.

8. Memorandum from J. Bradfield, Composite Panel Association, to R. Nicholson and K. Hanks, MRI. March 21, 2000. New Plant Update.

9. Louisiana Department of Environmental Quality. Small Source Permit for Acadia Board Company, Inc., New Iberia, LA facility. Undated.

10. Application for a Registration Permit Option D. Prepared for Phenix Biocomposites, Mankato, MN facility, by Braun Intertec Corporation. Project Number CMXX-96-0840. November 14, 1996.

11. Memorandum from K. Hanks, MRI, to Project File 4803-48: Plywood and Composite Wood Products NESHAP. August 24, 2000. Identifying Green and Dry Rotary Dryers Used in The Plywood and Composite Wood Products Industry.

12. Memorandum from K. Hanks, MRI, to CBI Project File. September 21, 2000. Presses and board coolers with permanent total enclosures.

13. Memorandum from K. Hanks and D. Bullock, MRI, to M. Kissell, EPA/ESD. June 9, 2000. Baseline Emission Estimates for the Plywood and Composite Wood Products Industry.

14. North Dakota State Department of Health and Consolidated Laboratories, Environmental Health Section. Air Pollution Control Permit to Construct. Prime Board, Inc., Wahpethon, ND. Undated.

15. Emission Factor Documentation for AP-42 Section 10.6.1, Waferboard/Oriented Strandboard Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. December 1998.

16. Emission Factor Documentation for AP-42 Section 10.6.3, Medium Density Fiberboard Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. September 1998.

17. Letter from T. Peters, MacMillan Bloedel (Temple-Inland Forest Products Corporation), to P. Lassiter, EPA/ESD. Response to information request for Clarion, PA facility.

18. Memorandum from K. Hanks, MRI, to Project File 4803-48: Plywood and Composite Wood Products NESHAP. August 24, 2000. Identifying Primary And Secondary Tube Dryers Used in The Plywood and Composite Wood Products Industry.

19. Memorandum from B. Nicholson, and K. Hanks, MRI, to P. Lassiter, EPA/ESD. May 27, 1998. Site Visit – Medite Division of Sierra Pine Medium Density Fiberboard Plant in Medford, Oregon.

20. Memorandum from K. Hanks, MRI, to CBI Project File. September 25, 2000. Digesters and Refiners at Plywood and Composite Wood Products Plants.

21. Suchsland, O., and G.E. Woodson. Fiberboard Manufacturing Practices in the United States. Forest Products Research Society. 1990. pp. 24-25, 72-80, 131, 151, 168, and 176.

22. Memorandum from R. Nicholson, MRI, to M. Kissell, EPA/ESD. February 24, 1998. Site Visit – ABTco, Inc., Roaring River, NC.

23. Memorandum from D. Bullock and K. Hanks, MRI, to P. Lassiter, EPA/ESD. October 29, 1997. Sits Visit – Temple-Inland Forest Products Corporation, Diboll, TX Complex.

24. Emission Factor Documentation for AP-42 Section 10.5, Plywood Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. September 1997.

25. Memorandum from K. Hanks and D. Bullock, to P. Lassiter, EPA/ESD. December 1, 1997. Site Visit – Champion International Corporation Camden Plywood and Stud Operations, Camden, TX.

26. Memorandum from K. Hanks, B. Threatt, and B. Nicholson, MRI to M. Kissell, EPA/ESD. May 19, 1999. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – Hardwood Plywood and Veneer.

27. Memorandum from K. Hanks, MRI, to CBI Project File. September 21, 2000. Distinctions between hardwood and softwood veneer dryers, veneer kilns, and radio-frequency (RF) veneer dryers.

28. Baldwin, R.F. Plywood and Veneer Based Products - Manufacturing Processes. San Francisco, Miller Freeman, Inc. 1995. pp. 258-259.

29. Memorandum from K. Hanks and B. Threatt, MRI, to M. Kissell, EPA/ESD. January 20, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – Engineered Wood Products.

30. Bowering, C., Raute Wood Ltd. Processing Options for Laminated Veneer Lumber. Presented at The Sixth International Panel and Engineered Wood Technology Conference and Exposition (PETE), Georgia International Convention Center. Atlanta, GA. October 19-22, 1998.

31. Memorandum from K. Hanks, MRI, to Project Files. April 18, 2000. Changes in the population of existing plywood and composite wood products plants and equipment following the information collection request.

32. Memorandum from K. Hanks and B. Nicholson, MRI, to P. Lassiter, EPA/ESD. March 17, 1998. Site Visit – Willamette Industries, Incorporated I-joist Plant in Woodburn, OR.

33. Memorandum from K. Hanks and D. Bullock, MRI, to P. Lassiter, EPA/ESD. December 1, 1997. Site Visit – Willamette Industries, Simsboro Laminated Beam Plant, Simsboro, LA.

34. Oregon Department of Environmental Quality. Air Contaminant Discharge Permit Application Review Report. Permit Number 22-1037, Application Number 14726. April 26, 1995.

35. APA – The Engineered Wood Association, "http://209.20.164.209/products/osb.html," July 12, 1999.

36. C. Wozney, Starwood Rafters, Incorporated, to P. Lassiter, EPA/ESD. Response to information request for Independence, WI facility.

37. R. Strader, Boise Cascade Corporation, to P. Lassiter, EPA/ESD. Response to information request for White City LVL facility in White City, OR.

38. Thompson, A.L. Volatile Organic Compounds Emitted During The Drying of Southern Pine Lumber. A Thesis Submitted to the faculty of Mississippi State University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Forest Products in the Department of Forest Products. Mississippi State University. December 1996.

3.0 EMISSION CONTROL TECHNIQUES

This chapter discusses emission control techniques for reducing HAP emissions from process units, primarily dryers and presses, at PCWP facilities. Emission control techniques include add-on APCD, emission capture systems, and other control techniques (e.g., process modifications). This chapter summarizes the performance of HAP control techniques and discusses the operating parameters that can be monitored to assure proper operation of these control systems.

Add-on control devices traditionally have been applied to process units at PCWP facilities to reduce particulate matter (PM) emissions. Examples of APCD used to control PM emissions from PCWP facilities include multi-cyclones (multiclones), baghouses, electrified filter beds (EFB), wet scrubbers, and WESP. Available control device performance data for multi-cyclones, baghouses (or fabric filters), and EFB show that these control devices have no effect on gaseous HAP or VOC[a] emissions. The performance data for WESP and wet scrubbers installed for PM control also showed no effect on HAP and VOC emissions. These wet systems may achieve short-term reductions in VOC or gaseous HAP emissions, however, the HAP and VOC control efficiency data, which range from slightly positive to negative values, indicate that the ability of these wet systems to absorb water-soluble compounds (such as formaldehyde) diminishes as the recirculating scrubbing liquid becomes saturated with these compounds.[1] Beginning in the 1990s, incineration-based controls and biofilters also were installed at some PCWP facilities to reduce VOC emissions, primarily from dryers and presses. These VOC controls are also effective in reducing gaseous HAP emissions.

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[a]Volatile organic compound (VOC) emissions are often based on total hydrocarbon (THC) measurements. This chapter refers to VOC in discussions of control system design and operation. However, performance data specific to PCWP control systems are presented in terms of THC. The factors that affect control system performance for VOC are the same for THC.

This chapter focuses on those control systems that reduce gaseous HAP emissions. Incineration-based controls are discussed in Section 3.1 and biofiltration is discussed in Section 3.2. Capture devices designed to capture and deliver gaseous HAP emissions from PCWP process units to an APCD are discussed in Section 3.3. Although WESP do not consistently and reliably reduce gaseous HAP emissions, a discussion of WESP is included in Section 3.4 because WESP are often used in conjunction with RTO to protect the media from particulates that would otherwise enter the RTO. Additional control techniques are discussed in Section 3.5. Section 3.6 contains the references cited in this chapter.

3.1 INCINERATION-BASED CONTROLS

Incineration is a highly effective method for destroying hydrocarbon and other organic vapors, gaseous pollutants, and combustible particulate. Incineration-based controls oxidize organic vapors in the process exhaust stream to carbon dioxide (CO_2) and water (H_2O) through combustion reactions. Incineration-based controls used in the PCWP industry include add-on controls such as thermal oxidizers, regenerative catalytic oxidizers (RCO), and thermal catalytic oxidizers (TCO). In addition to add-on incineration-based controls, some PCWP facilities perform "process incineration." Process incineration involves routing 100 percent of the emissions from a process unit to an onsite combustion unit such as a boiler or process heater (e.g., dryer burner). Section 3.1.1 discusses thermal oxidization (i.e., thermal oxidizers, process incineration, and RTO) and Section 3.1.2 discusses catalytic oxidation (i.e., RCO and TCO). The performance of incineration-based controls is discussed in Section 3.1.3. Parameters monitored during operation of incineration-based controls are discussed in Section 3.1.4.

3.1.1 Thermal Oxidization

The vast majority of incineration-based systems used in the PCWP industry are thermal oxidization systems and nearly all of these systems have waste heat recovery to reduce operating costs related to fuel consumption. Thermal oxidation systems include thermal oxidizers (which do not have heat recovery) and recuperative or regenerative thermal oxidizers. Recuperative thermal oxidizers incorporate a heat exchanger at the combustion chamber outlet to recover up to 70 percent of the heat energy in the combustion chamber exhaust. Regenerative thermal oxidizers incorporate ceramic beds at the inlet and outlet of the combustion chamber for up to 95 percent energy recovery.[2] Based on available information, either no heat recovery or only the regenerative heat recovery systems are most commonly used with thermal oxidizers at PCWP facilities.[3] Therefore, this section focuses on describing operation of thermal oxidizers and RTO. Recuperative thermal oxidizers are not discussed.

3.1.1.1 Thermal Oxidizers. Thermal oxidizers are one of the best known methods for industrial waste gas disposal in which the combustible compounds in the waste gas stream are completely destroyed rather than collected. Thermal oxidizers are refractory-lined combustion chambers containing a burner (or set of burners). Figure 3-1 is a schematic of a thermal oxidizer. The burner provides the heat necessary for combustion. Natural gas or propane are typically used as burner auxiliary fuels. The heat from the burner ignites and begins to oxidize the gaseous HAP and/or VOC pollutants in the exhaust once they enter the mixing chamber. Oxidation of the pollutants to combustion products (i.e., CO_2 and H_2O) is completed in the reaction chamber. Heat from combustion of the pollutants in the exhaust gas serves to reduce auxiliary fuel usage. An efficient thermal oxidizer provides: (1) a combustion chamber temperature high enough to completely oxidize the gaseous HAP or VOC; (2) sufficient residence time in the combustion chamber to allow for complete oxidation of gaseous HAP or VOC; and (3) sufficient mixing of combustion products, air, and the process vent streams.[4]

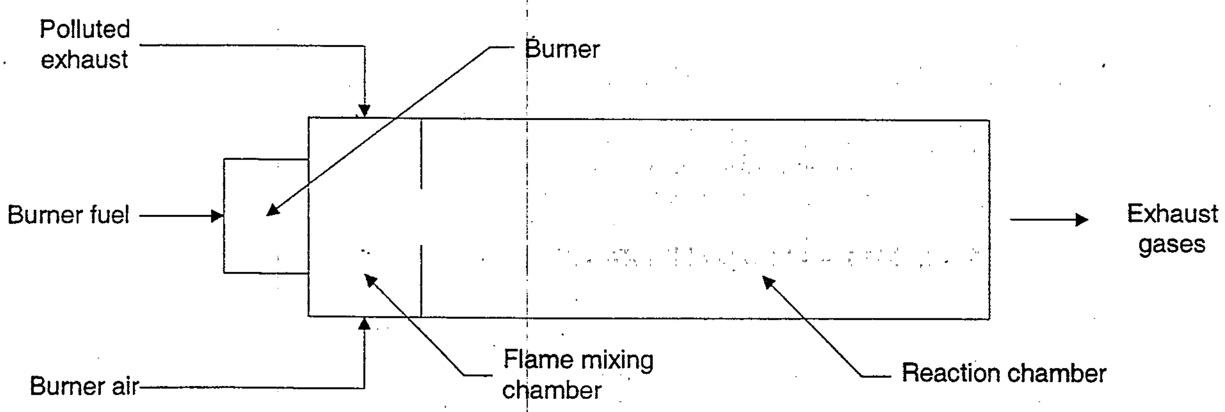

Figure 3-1. Schematic of a thermal oxidizer.

Combustion is greatly affected by the operating temperature of the incinerator. The theoretical temperature required for thermal oxidation depends on the structure of the chemical involved. Some chemicals can be oxidized at a temperature much lower than others. However, a temperature can be identified that will result in the efficient destruction of most exhaust gas streams containing gaseous HAP or VOC. To be efficiently incinerated, exhaust gas streams must be heated to their ignition temperature. If the ignition temperature is not met, then incomplete combustion will occur. Therefore, most thermal oxidizers operate above exhaust gas ignition temperatures. Thermal destruction of most compounds occurs between 1,110° and 1,200°F, while most incinerators operate between 1,300° and 1,500°F.

Thermal oxidizer residence time is the time from when the exhaust gas stream reaches the combustion temperature until the exhaust gas stream leaves the combustion chamber. Therefore, the residence time is determined by the size of the combustion chamber and the flow rate of the exhaust gas stream through the chamber.[5] The incinerator operating temperature directly affects the residence time, and vice versa. If the operating temperature is increased, then the gaseous pollutants can be oxidized more rapidly, therefore, reducing the necessary residence time. Also, if the operating temperature is decreased, then the gaseous pollutants will be oxidized in a longer period of time, requiring a longer residence time.[5]

Turbulence is necessary to achieve the proper amount of mixing, which is important for two reasons. First, every gaseous pollutant molecule must come into contact with an oxygen (O_2) molecule to ensure complete combustion. If gaseous pollutant molecules do not contact O_2 molecules, then the gaseous pollutants may be exhausted from the combustion unit before being oxidized. Secondly, the entire exhaust gas stream must be mixed with the heat source in order to reach the necessary operating temperature.[5]

Relatively few thermal oxidizers without heat recovery are used in the PCWP industry. Nevertheless, the principles of thermal oxidation described above apply to all types of thermal oxidization systems (including process incineration systems and RTO) used at PCWP facilities.

3.1.1.2 Process Incineration. In addition to add-on thermal oxidizers, exhaust gases from PCWP process units may be routed to the combustion chamber of an onsite boiler or process heater. The boiler or process heater operates much like a thermal oxidizer. The organic emissions in the process exhaust are incinerated in the combustion chamber. Hence, this control technique is referred to as "process incineration." As for a thermal oxidizer, the process incineration system must be designed to allow for proper mixing of the pollutants with O_2, have a temperature high enough to ignite the pollutants, and provide adequate residence time.

Some OSB facilities use a heat/energy system for process incineration. This technology uses an oversized combustion unit that accommodates recirculation of 100 percent of the volumetric flow of dryer exhaust gases. The recirculated dryer exhaust is mixed with combustion air and exposed directly to the burner flame. The gaseous HAP/VOC emissions are incinerated at the high temperatures inside the combustion unit. A urea solution may be injected near the outlet of the combustion chamber to help lower NO_X emissions (i.e., by chemically reducing a portion of the NO_X to nitrogen [N_2]). High temperature exhaust from the combustion unit passes through a heat exchanger, which provides heat for dryer inlet air, and then through an add-on device for PM emission control. Plants that use exhaust gas recycle to control dryer emissions are generally designed from the ground up (i.e., exhaust gas recycle systems cannot be easily retrofitted).[6]

3.1.1.3 Regenerative Thermal Oxidizers. The type of thermal oxidization system most commonly used in the PCWP industry is the RTO. Regenerative heat recovery systems use direct contact with a heat-tolerant ceramic material. The inlet gas first passes through a hot bed or "canister" of ceramic media which heats the gas stream to or above its ignition temperature typically, 1,400° to 1,800°F. If the desired temperature is not attainable, then a small amount of auxiliary fuel is added in the combustion chamber. The hot gases react (i.e., oxidize to CO_2 and H_2O) in the combustion chamber, and then pass through a second canister of ceramic media, heating the media to the combustion chamber outlet temperature. Thus, while one canister absorbs heat from the hot (cleaned) gas stream, another canister transfers its stored heat to the incoming (polluted) gas stream. When the heat absorbing canister reaches its heat storage capacity, and the other canister becomes heat depleted, a series of valves redirects the gas flow so the roles of the two canisters reverse.[7] This cyclic process allows exhaust gas streams to be nearly self-sustaining.[2] Figure 3-2 shows this regenerative heat recovery process.

The RTO used in the PCWP industry incorporate two to eight canisters.[3] The number of heat recovery canisters is dictated by the flow rate to be controlled. Some RTO with odd numbers of canisters incorporate a purge canister to ensure that untreated exhaust in the plenum beneath the RTO is not exhausted to the atmosphere (resulting in reduced control efficiency) as the flow is reversed from canister to canister. For example, in a five-canister system, at any

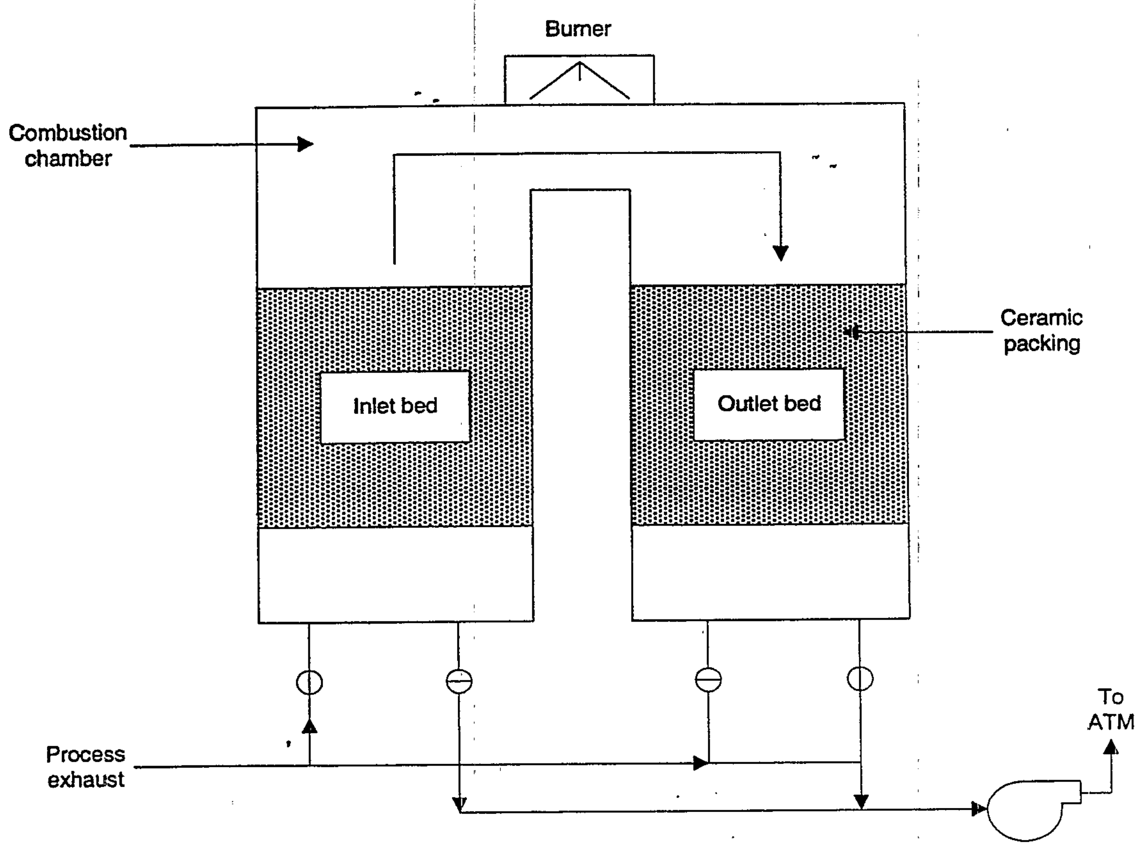

Figure 3-2. Regenerative heat recovery process.

given point in system operation, two canisters will be functioning as inlet beds and two are functioning as outlet beds, while the remaining regenerator bed is being purged.[8]

The ceramic bedding of an RTO typically consists of either structured packing in the form of a honeycomb ceramic monolith or random packing consisting of 1 inch porcelain "saddles." Porcelain saddles are much cheaper to manufacture and therefore cost less than the structured packing. However, structured packing has advantages including lower pressure drop and laminar flow characteristics.[9]

The preheat temperatures achieved in the inlet canister are generally higher than the ignition temperatures for most gaseous HAP or VOC. Thus, some oxidation of pollutants will begin to occur in the ceramic packed beds before the preheated gases are discharged from the inlet bed to the combustion chamber. A burner system fires into the combustion chamber between the ceramic beds to automatically maintain a preset oxidation temperature.[8] Most RTO are operated with combustion chamber temperatures of around 1,500°F.[3] The combustion chamber is sized for a pre-determined retention time with the oxidizer operating at normal design temperature and handling the maximum flow rate of process exhausts. The canister and combustion chamber designs are such that relatively high linear velocities of the oxidizing gases are typical. These velocities and the vertical gas flow patterns in the combustion chamber are sufficient to provide satisfactory gas phase mixing (turbulence).[8]

Natural gas injection (NGI) is a technique used with RTO to boost the hydrocarbon concentration in the incoming air stream to a level necessary for self-sustaining combustion. Typically, a natural gas burner system is used to make up the heat energy that is not recovered by the RTO. If the incoming air stream is highly concentrated, the hydrocarbons will ignite and the process will become self-sustaining (i.e., require no auxiliary fuel usage). However, emission streams at PCWP plants typically are high volume, low concentration streams. Natural gas injection is performed when the heat exchange media is saturated and hot enough to bring the gas stream above ignition levels. At that point, the burner and combustion blower are turned off, and natural gas or methane is injected into the incoming gas stream, enriching it to the concentration level necessary for self-sustaining combustion. The NGI reportedly improves the RTO thermal efficiency by 1 percent or more, overall.[7]

As mentioned above, the exhaust streams from PCWP process units are relatively dilute (i.e., contain air which is comprised primarily of N_2 and O_2). Thermal NO_X is formed when N_2 is exposed to high temperatures in the presence of O_2. In addition, fuel NO_X is formed when N_2 in the fuel is oxidized to NO_X. As temperature increases, the kinetics of NO_X formation accelerate, and more NO_X is formed. Thus, NO_X formation must be considered in the design of incineration systems. Low NO_X burners and NGI can be used to reduce formation of NO_X in combustion units such as RTO. Low NO_X burners inhibit NO_X formation by controlling the mixing of fuel and air.[4] Use of NGI results in a decrease in NO_X emissions because it reduces the need for burner operation. The burner is the major contributor to NO_X emissions from the RTO due to the high flame temperatures.[7,10]

Several facilities in the wood products industry have noted trouble with buildup of particulates or salts in the heat recovery beds of RTO. The salts include submicron particles of sodium and potassium oxides which originate from wood ash that passes through direct wood-fired dryers. The salts can penetrate deep into the RTO media, where they melt and fuse to the media. In the liquid state, these salts react with the ceramic media causing the media to weaken and crumble, which eventually leads to restriction of air flow and unacceptable pressure drop through the RTO system.[11,12] When air flow through the RTO packing is restricted, the air flow through the dryers is also restricted resulting in dryer plugging and the potential for dryer fires. "Bakeouts" and "washouts" are two methods used to combat the buildup of particulates and salts in the RTO media. Glazing of the RTO media by salts occurs most rapidly at the top of the RTO media bed where temperatures are the hottest.[13] A particulate prefilter, such as a WESP, may be used upstream of an RTO to remove some of the particulates or salts before they enter the RTO.

During a bakeout, the RTO temperature is increased to burn the residue off of the media. Online bakeout features have been incorporated into the design of some RTO to allow bakeouts without shutdown of the RTO or production line. Once bakeouts are no longer effective in removing buildup on the RTO media, washouts may be performed. During a washout, residue is rinsed from the media beds by manually spraying water over the media. The RTO must be shut down and cooled prior to washout. Most facilities must perform bakeouts from time to time. However, there are some facilities that perform washouts rather than bakeouts. In addition, there are some facilities that perform bakeouts but do not perform washouts. The frequency at which bakeouts and/or washouts must be performed depends on the source controlled and site-specific conditions but generally ranges from monthly to annually. Frequent bakeouts and washouts of the RTO can be costly due to lost production.[3]

3.1.2 Catalytic Oxidization

A number of catalytic oxidation systems, including RCO and TCO, are used to control PCWP process unit emissions. All of these systems have regenerative heat recovery to reduce operating costs related to fuel consumption. The primary difference between catalytic oxidation systems and thermal oxidation systems is that catalytic systems employ a catalyst to increase the rate of the combustion reaction by allowing oxidation to occur at lower operating temperatures. The use of lower reaction temperatures results in substantial auxiliary fuel savings and, therefore, reduced operating costs.

An RCO is designed much like an RTO, except that a layer of precious metal catalyst is impregnated on the ceramic media. Typical operating temperatures for RCO are around 800°F.[3]

Another type of catalytic oxidizer, the TCO, is a combination between an RTO and a RCO. The TCO runs at a temperature of around 900°F and contains catalytic media. However, the canisters and fans on the TCO are sized large enough so that the TCO can be operated like an RTO if catalyst replacement costs become overly expensive. Natural gas can be injected into the TCO to reduce NO_X emissions.[6]

A catalyst is a substance that causes or speeds up a chemical reaction without undergoing any change itself.[5] In catalytic ozidizers, the active catalyst is impregnated on the surface of temperature-resistant substrate such as ceramic pellets, cylinders, or a monolithic honeycomb.[8] Even when using a catalyst, the incoming exhaust gas must be preheated to a temperature sufficiently high (usually from 300° to 900°F) to initiate the oxidation reactions in the catalytic oxidizer.[2] The specific reaction initiation temperature depends on the type of catalyst and the specific pollutants in the exhaust gas. The reaction between the O_2 in the gas stream and the gaseous pollutants takes place at the catalyst surface. As the polluted process exhaust passes though the catalyst bed and is oxidized, there is an increase in temperature proportional to the amount of organics contained in the exhaust.[8]

Catalysts have a finite life in terms of catalytic activity. "Catalytic activity" refers to the degree to which a chemical reaction rate is increased compared with the same reaction without the catalyst.[4] Catalyst replacement is necessary when loss of catalytic activity causes the oxidizer's HAP/VOC reduction efficiency to fall to unacceptable levels. The basic factors affecting catalyst life are temperature and deactivation (e.g., poisoning, masking, or fouling).

Each type of catalyst has a required minimum activation temperature and a maximum operating temperature above which catalyst performance is impaired or destroyed. Thus, each catalyst type therefore has a "temperature window" for satisfactory operation. Because the temperature increase across the catalyst bed is proportional to the organic concentration in the process exhaust, there is a maximum organic loading that corresponds with the maximum catalyst operating temperature. Generally, the "temperature window" is greater for precious metal catalysts than for base metal catalysts.[8]

Exposure of catalysts to certain chemical compounds can result in deactivation (i.e., a loss of efficiency for destruction of hydrocarbons). Deactivation can be caused by poisoning of the catalyst by compounds containing heavy metals, sulfur, or phosphorous. Deactivation can also result from masking or fouling of the catalyst by silicon compounds (which convert to silica on the catalyst surface), PM, or resinous material which may coat the catalyst surface. The loss of catalyst activity is irreversible when poisoning occurs. Catalyst activity can often be restored following masking or fouling by techniques such as washing of the catalyst.[8]

Precious metal (e.g., platinum and platinum group metals) and base metal (e.g., manganese dioxide and related oxides) catalysts are commonly used in catalytic oxidizers.[8] Precious metal catalysts are more resistant to poisoning and fouling than base metal catalysts.[7] Dryers with high moisture and particulate content in the dryer exhaust could potentially foul catalytic media. Thus, RTO are most commonly used to control emissions from wood strand and particle rotary dryers and tube dryers. However, RCO or TCO, as well as RTO, are used to control emissions from presses or veneer dryers.[6,8]

Tradeoffs exist between thermal and catalytic oxidizers. Thermal oxidizers generally require more auxiliary fuel than catalytic oxidizers and operate at temperatures that are several hundred degrees higher than in catalytic oxidizers. However, deactivation of the catalyst and catalytic system is a possibility. Catalytic media is much more expensive than ceramic media (if ceramic media is used in a thermal oxidizer to recover heat). Thus, catalytic oxidizers have higher capital and media replacement costs than do thermal oxidizers. However, thermal oxidizers have higher operating costs than do catalytic oxidizers.

3.1.3 Performance of Incineration-Based Controls

Incineration-based controls are an applicable control technology for a wide range of exhaust streams containing gaseous organic compounds. Thermal oxidizers generally can be designed to achieve 95 to 99 percent reduction for most VOC and an outlet concentration of 20 ppmv.[8,14] Catalytic oxidizers are also frequently designed to achieve 95 to 99 percent reduction.[8] The control efficiency of process incineration systems is expected to be equivalent to that of a thermal oxidizer. The inlet concentration of combustible organic compounds affects the achievable percent reduction. For example, a 98 percent reduction is more easily achieved when there is a high concentration (e.g., 1,000 ppm) of organics. However, a 98 percent reduction may be more difficult to achieve for low inlet concentrations (e.g., < 100 ppm).

Tables 3-1 and 3-2 summarize the range and average of the inlet and outlet concentrations and achievable percent reductions for formaldehyde, methanol, and THC for RTO and RCO.

The performance data for individual control systems summarized in Tables 3-1 and 3-2 are presented in a separate memorandum on control efficiency.[1] Examination of the performance data for individual control systems shows that RTO and RCO used in the PCWP industry can reduce methanol and formaldehyde emissions by at least 90 percent except when the pollutant loadings of the emission stream entering the control devices are very low. Examination of the performance data for THC reveals that RTO and RCO can reduce THC emissions by at least 90 percent. As shown in Tables 3-1 and 3-2, low concentrations (generally less than 100 ppmdv) of methanol and formaldehyde are present at the inlet of PCWP RTO and RCO. Thus, it is reasonable that the average pollutant reduction efficiency for these compounds is less than the typical design VOC destruction efficiency for RTO and RCO (i.e., 95 to 99 percent).

TABLE 3-1. SUMMARY OF RTO PERFORMANCE FOR FORMALDEHYDE, METHANOL, AND THC[a]

Pollutant	No. of tests	Minimum-maximum (average) concentration, ppmvd		Control efficiency, %[b]
		RTO Inlet	RTO Outlet	
Formaldehyde	17	1.0-45 (13)	0.067-13 (1.4)	51-99.8 (89)
Methanol	15	4.0-109 (25)	0.25-4.6 (0.75)	78-99.7 (94)
THC (as carbon, minus methane)[c]	25	51-5,090 (613)	0.5-130 (17)	90-99.9 (97)

[a] This table presents the range and average of the available inlet and outlet concentration and control efficiency data for RTO used in the PCWP industry. Lower control efficiencies generally correspond with lower inlet concentrations and higher control efficiencies generally correspond with higher inlet concentrations.
[b] Control efficiencies are calculated based on mass rates (inlet vs. outlet) which are not shown in the table.
[c] Excludes one data set not corrected for methane and one data set measured during process upsets.

TABLE 3-2. SUMMARY OF RCO PERFORMANCE FOR FORMALDEHYDE, METHANOL, AND THC[a]

Pollutant	No. of tests	Minimum-maximum (average) concentration, ppmvd		Control efficiency, %[b]
		RCO Inlet	RCO Outlet	
Formaldehyde	2	3.5-21	2.6-7.9	18-51
Methanol	2	9.3-13	0.94-3.9	67-87
THC (as carbon, minus methane)	3	44-1,831 (674)	15-153 (64)	89-99 (94[c])

[a] This table presents the range and average of the available inlet and outlet concentration and control efficiency data for RCO used in the PCWP industry. Lower control efficiencies generally correspond with lower inlet concentrations and higher control efficiencies generally correspond with higher inlet concentrations.
[b] Control efficiencies are calculated based on mass rates (inlet vs. outlet) which are not shown in the table.
[c] Excludes one control efficiency not corrected for methane.

No specific inlet and outlet test data are available to determine the control efficiency achieved by thermal oxidizers (without heat recovery) and TCO used in the PCWP industry. However, it is expected that thermal oxidizers and TCO can achieve the same level of control as RTO and RCO, respectively. Furthermore, no inlet and outlet test data are available for process incineration systems. However, test data for one process incineration system (a heat/energy exhaust gas recirculation system at an OSB plant used to control emissions from rotary strand dryers) shows that THC and formaldehyde emissions from the system on a pounds per oven dried ton (lb/ODT) basis are comparable to or lower than emissions at the outlet of an RTO used to control similar dryers.[15,16]

Incineration-based controls currently used in the PCWP industry include 2 thermal oxidizers, 82 RTO, 8 RCO, 8 TCO, and 9 process incineration systems. The thermal oxidizers are used to control tube dryers and veneer dryers. The RTO, which by far are the most commonly used incineration-based control systems in the PCWP industry, are used to control various types of dryers, presses, board coolers, and hardboard process units. The RCO control OSB presses and dryers, veneer dryers, and hardboard process units. One of the TCO controls an OSB press and the other TCO is used to control the combined exhaust from an MDF press and tube dryers. The process incineration systems are used to control OSB rotary and conveyor dryers, MDF dryers and an MDF press, and veneer dryers. Although a variety of process units are controlled with incineration-based control systems, the performance data for incineration-based controls show that the same level of control (e.g., outlet concentration and/or control efficiency) can be achieved regardless of the type of process unit controlled.[1]

3.1.4 Monitoring of Incineration-Based Controls

Operating parameters monitored for incineration-based controls may include temperature, flow rate, system pressure, catalyst activity for catalytic systems, and valve timing for regenerative systems. Monitoring of these operating parameters is discussed below. In addition to operating parameters, some facilities may continuously monitor VOC (or THC), CO, or stack opacity, depending on the process units controlled by the control system and the applicable regulatory requirements.[3]

Combustion chamber (or "firebox") temperature is a key operating parameter monitored for thermal oxidizers. Monitoring and controlling firebox temperature is a good method for ensuring that the oxidizer achieves the necessary ignition temperature required for pollutant destruction. In catalytic oxidizers, temperatures at the inlet and/or outlet of the catalyst bed may be monitored to indicate catalyst activity (shown by a temperature increase across the catalyst bed) or to control operation of the oxidizer.

Exhaust gas flow rates may be monitored directly with a flow meter or through use of a flow indicator such as fan power or static pressure. Pressure drop varies as gas flow rate through the control system varies. An increase in pressure drop or change in static pressure can indicate problems with plugging of the heat recovery media.

As discussed in Section 3.1.2, catalyst material life is impacted by poisons, masking agents, and thermal or physical degradation. Annual sampling and testing of the catalyst in a catalytic oxidizer can be performed to determine catalyst activity.

Operation and maintenance of the valve system for switching between heat recovery canisters can affect the performance of regenerative systems (i.e., RTO, RCO, or TCO). Leaking valves or valve timing that is off could allow a small portion of untreated exhaust gases to bypass the oxidation chamber. Periodic inspection of the valves and verification of the valve timing could be done periodically to guard against reduced system performance.

3.2 BIOFILTRATION

3.2.1 Description of Biofiltration

Biofiltration systems are currently used to control emissions of HAP and VOC from PCWP presses and board coolers in the United States. Biofiltration systems consist of a vacuum system, a humidification system, and the biofilter. Figure 3-3 presents a schematic of a biofiltration system. The vacuum system moves process unit exhaust through the humidification system and biofilter. The humidification system uses water sprays to cool and saturate the air entering the biofilter. The humidification system also removes excess particulates from the air stream. Pre-humidification of the gas stream entering the biofilter also helps to prevent the constant flow of gas from drying the biofilter media. Humidification may be accomplished with water spray nozzles in the biofilter inlet duct, with spray chambers in enlarged sections of the inlet duct, or through use of a wet scrubber or packed bed upstream of the biofilter.[17,18]

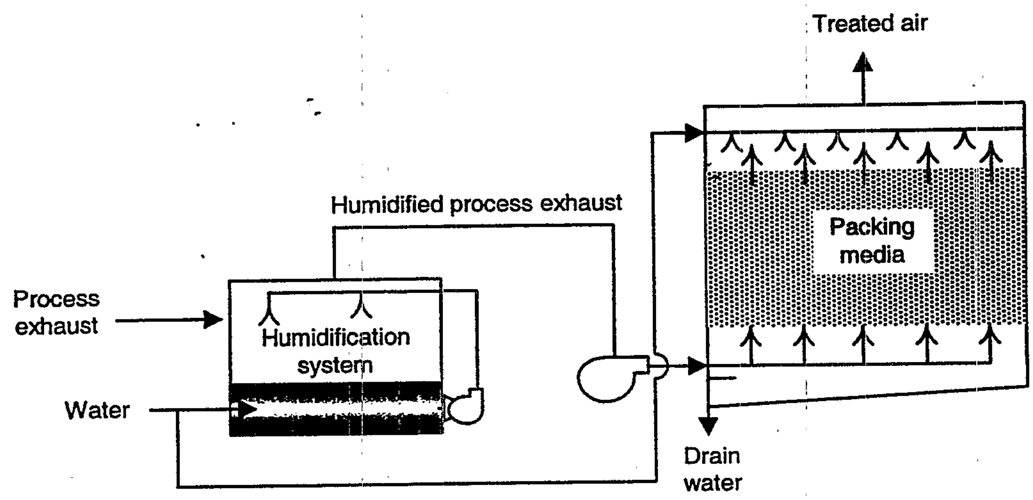

Figure 3-3. Schematic of a biofiltration system.

The biofilter contains porous packing such as bark, wood chips, peat, or synthetic media. The media provides a large surface area for the absorption and adsorption of contaminants. The life span of bark varies from 6 months to 2 years depending on the properties of the gases being treated. Composted wood chips may last up to 7 years.[19,20] A structural component may be added to the media to prevent compaction which would result in excessive pressure drop across the filter bed.[17] The filter media naturally contains some microorganisms and is inoculated with additional microorganisms that are well suited for the environment in the biofilter and the exhaust gas to be treated. Acclimation of the microorganisms to the biofilter environment and gases to be treated may take weeks or months.[20] The microorganisms are immobilized in an aqueous layer or "biofilm" on the packing material. Typical biofilter design consists of a 3- to 6-foot-deep bed of media suspended over an air distribution plenum.

The vacuum system draws the humidified gases into the plenum under the biofilter where the gases are evenly distributed under the media. The exhaust gases are forced upward through the moist biofilter media. As the contaminated exhaust stream passes through the biofilter media, pollutants are transferred from the vapor phase to the biofilm. Once in the biofilm, the pollutants are oxidized by microbiological activity to CO_2, water, and mineral salts. The biological oxidation process can de described as follows:

$$\text{organic pollutants} + O_2 \rightarrow CO_2 + H_2O + \text{heat} + \text{biomass}$$

Microorganisms require a carbon source, water, and nutrients (e.g., N_2 and phosphorous) to carry out metabolic processes necessary for the microorganisms' growth, reproduction, and survival. In biofiltration systems, the carbon source is the hydrocarbon pollutants from the exhaust gas. The biofilter media is also a source of carbon and nutrients for the microorganisms. Water and nutrients are added to the biofiltration system through water sprays over the biofilter media and by humidification of the incoming exhaust gases. A media moisture of 30 to 60 percent is generally maintained.[17,20] Water and condensate flowing through the biofilter media is collected in the plenum underneath the biofilter which slopes so the water drains away to the wastewater handling system.

Microorganisms also thrive within specific temperature and pH ranges. Outside of those ranges, the microorganisms become less active; therefore, the pollutant reduction efficiency of the biofilter can decrease if appropriate temperature and pH conditions are not maintained in the media bed. The optimal temperature range for the types of microorganisms used in biofilters (i.e., mesophilic microorganisms) is around 70° and 95°F.[17] The upper limit of temperature for activity of mesophilic microorganisms is about 105°F.[19,21] Most microorganisms grow best in a relatively neutral pH range (i.e., pH 6 to 8).[20,22]

There are two main biofilter designs used, including the completely open system and the totally enclosed system. Completely open systems are less expensive than totally enclosed systems, however, the performance of an open system can be affected significantly by outside influences (e.g., rain, wind, and sun). Completely open systems are used primarily for odor control of dilute and cool exhaust streams. A totally enclosed system is necessary for exhaust streams with higher concentrations of organic compounds and increased monitoring requirements (e.g., systems used to comply with emission limits rather than for odor control).[17] All of the biofilters currently used to control emissions from presses and board coolers in the PCWP industry are fully enclosed.

There are three general types of totally enclosed systems, including: building enclosures, cellular systems, and modular units. Building enclosures are simple to construct and can include multiple chambers. The spray nozzles can be attached to the roof in order to thoroughly irrigate the media. Because the roof is an integral part of the building enclosure design, the only way to enter the biofilter and remove the media is through small doors and hatches (i.e., confined spaces). Cellular systems are subterranean compartments that can be designed and constructed prior to delivery and assembled on-site. With the cellular design, the roof is easily removed, which makes access for media replacement more convenient. Modular units are similar to cellular systems, except that the modules include self-contained gratings, media, and irrigation systems. The entire module can easily be removed and replaced with an entirely new module without interrupting the whole biofiltration system. The modular design is accommodating to facilities with future expansion plans.

Onsite pilot-scale tests using a slip-stream of the actual gas stream targeted for control are often conducted prior to design of a full-scale biofiltration system. Such tests reveal fluctuations in off-gas conditions, such as pollutant concentration and temperature, and the presence of contaminants or particulates. Pilot tests are valuable for tailoring the biofilter media, microbes, and operating parameters to site-specific conditions.[17]

3.2.2 Performance of Biofilters

Biofiltration systems are effective for treating low concentrations (e.g., <1,000 ppm) of organic compounds with organic loading rates between 300 to 500 ft^3/ft^2-hr.[20] Biofilters perform best when a steady flow of gaseous HAP or VOC must be treated, because fluctuations in emissions make the biological reactions more difficult to control.[23] The size of the biofilter increases as the flow rate and organic concentration increases in order to provide sufficient residence time for treatment of the organic loading. Biofiltration is most effective on water soluble and biodegradable organic contaminants. Formaldehyde, phenol, and methanol meet these criteria.[17] However, some VOC compounds emitted from PCWP process units (such as pinenes) are less water soluble. Biofiltration cannot successfully treat some organic compounds, such as chlorinated VOC, which have low adsorption or degradation rates.[20]

Five biofilters are being used to reduce emissions from presses or board coolers at four wood products plants. Table.3-3 summarizes the inlet and outlet concentrations of formaldehyde, methanol, and THC in the PCWP exhaust streams treated using biofilters.[1] Table 3-3 also summarizes the control efficiency achieved by biofilters for these pollutants.

TABLE 3-3. SUMMARY OF BIOFILTER PERFORMANCE FOR FORMALDEHYDE, METHANOL, AND THC[a]

Pollutant	No. of tests	Minimum-maximum (average) concentration, ppmvd		Control efficiency, %[b]
		Biofilter Inlet	Biofilter Outlet	
Formaldehyde	3	2.9-13 (8.1)	0.07-0.22 (0.15)	97-98 (98)
Methanol	2	19-90	0.32-18	79-98
THC (as C, minus methane)	3	84-130 (110)	7.1-27 (19.2)	73-90 (81)

[a] This table presents the range and average of the available inlet and outlet concentration and control efficiency data for biofilters used in the PCWP industry.

[b] Control efficiencies are calculated based on mass rates (inlet vs. outlet) which are not shown in the table.

3.2.3 Monitoring of Biofilters

The health of the microorganism population and the ability of the biofilter to destroy pollutants depends on the amount of moisture in the biofilter, pH of the biofilter media, bed temperature, and nutrient levels. Adequate moisture is needed to ensure survival of the microorganisms, to ensure that pollutants are transferred to the biofilm, and to prevent drying and channeling of the biofilter media. Over-watered and/or poorly drained media may also cause problems such as development of wet spots and anaerobic zones, and reduction in the active surface contributing to pollutant transfer. Over-watered media is also prone to channeling.[18] The microorganisms become acclimated to certain pH, temperature, and nutrient level ranges, and large swings in these ranges can slow uptake and degradation of pollutants by the microorganisms. Severe changes in pH or temperature could destroy the microorganisms. Particulate buildup in the system, which is indicated by increased system pressure, also affects the performance of the biofilter. A reduction in the activity of the microorganism population can be indicated through routine or continuous monitoring of VOC (e.g., with the THC analyzer). Alternatively, bacteria counts could be monitored by collecting samples of the biofilter media or effluent and analyzing the samples in a laboratory. Nutrient levels and pH could be checked by monitoring the effluent from the biofilter. Pressure drop and bed temperature (or gas stream temperature) are biofilter parameters that are routinely monitored.[3,24,25]

3.3 CAPTURE DEVICES

Sections 3.1 and 3.2 discussed two types of control devices (incineration-based controls and biofilters) used for destruction of gaseous HAP emissions. The reduction in gaseous HAP emissions from a process unit depends not only on the destruction efficiency of the control device, but also on the percentage of the process unit exhaust routed to the control device. Therefore, this section discusses capture devices used to capture and route process unit exhaust to a control device. "Capture efficiency" refers to the fraction of emissions from a process unit that is captured and routed to the control device. The total HAP reduction efficiency of a control system (i.e., capture device and control device) is the product of the capture efficiency and control device destruction efficiency.

Most process units at PCWP plants exhaust through stacks or duct work; therefore, 100 percent of the exhaust from the process unit is routed to the control device. However, emissions from PCWP presses and board coolers do not exhaust directly through stacks. Gaseous HAP emissions are released directly into the press or cooling area. These emissions typically are drawn through the roof vents above the press or cooler. The emissions that are not drawn through the roof vents dissipate inside the building (and are eventually emitted through the building ventilation system). Several PCWP plants have hoods or other partial capture devices above the press area to aid in collection of the press and board cooler emissions. The capture efficiency achieved by such devices is not known and is difficult to measure.

Permanent total enclosures, as defined by EPA in Method 204 (40 CFR 51, Appendix M), are presumed to achieve 100 percent capture. Thus, the capture efficiency of PTEs does not require measurement. To be considered a PTE (and qualify for the presumption of 100 percent capture), a total enclosure must meet the five design criteria summarized below:[26,27]

1. All emission points inside the enclosure must be at least 4 equivalent diameters from any openings;
2. The total area of all openings (doors, windows, etc.) must not exceed 5 percent of the enclosure's surface area (walls, floor, and ceiling);
3. Air must flow into the enclosure at all openings with an average face velocity of at least 200 ft/min (which is equivalent to approximately 0.007 inches of water column);

4. All windows and doors not counted in the 5-percent of area rule must be closed during normal operation; and
5. All exhaust streams must be discharged through a control device.

Capture devices (e.g., hoods or partial enclosures) that do not meet the PTE design criteria are not considered to be total enclosures and the capture efficiency of such devices must be measured. To measure the capture efficiency for an unenclosed or partially enclosed process unit, a temporary total enclosure (TTE) must be constructed and EPA Methods 204 and 204A through 204F in 40 CFR 51, Appendix M must be used to measure the capture efficiency of the TTE. An existing building can be used as either a PTE or TTE, provided it meets the applicable criteria in EPA Method 204.

Some PCWP facilities have constructed PTE around presses and/or board coolers. The PTEs are usually made of corrugated sheet metal extending from the roof of the press area to the floor. Existing walls of the press building may be used as part of the enclosure. The press unloader is generally included inside the enclosure with the press; however, the press loader may or may not also be included within the enclosure. The openings in the enclosure walls for the unpressed mats to enter and for the pressed boards to exit may have heavy plastic flaps to minimize in-leakage of ambient air. At some plants, the board cooler exhaust is ducted into the press enclosure.[3]

The key to maintaining PTE performance is maintaining the integrity of the enclosure and the airflow through the system. Techniques for ensuring the integrity of the enclosure may include periodic inspections (e.g., to ensure plastic strips have not been knocked off) and use of self-closing mechanisms on doors. An indicator such as duct static pressure or fan amperage can be monitored to ensure that the system airflow from the enclosure to the control device is maintained.

3.4 WET ELECTROSTATIC PRECIPITATORS

Wet electrostatic precipitators are commonly used in the PCWP industry to reduce PM (including PM_{10} and $PM_{2.5}$) from dryer exhausts. Wet electrostatic precipitators are often used upstream of RTO in the PCWP industry to protect the RTO from long-term media degradation caused by fine particulates and salts. As discussed in Section 3.1.1.3, the salts originate from wood ash that passes through direct wood-fired dryers. Bakeouts and washouts of the RTO media can combat this buildup to some degree; however, the RTO media may require frequent replacement.[11,12] Thus, many PCWP plants choose to install a WESP to reduce the effects of buildup and the frequency of RTO maintenance. However, depending on company philosophy, some plants may elect not to install a WESP or to use a less efficient PM control device (e.g., a multiclone) upstream of the RTO to avoid the operating costs associated with WESP although more frequent replacement of RTO media may be necessary.

According to industry survey data, over two-thirds of OSB rotary dryers with incineration-based controls (including RTO, RCO, or TCO) have a WESP as a prefilter prior to the incineration-based device. Five of the nine (just over half) of the particleboard rotary dryers with RTO have WESP. One third of the tube dryers with incineration-based controls (RTO or TCO) have WESP. However, no WESP dedicated to press emissions are operated upstream of press controls and no WESP are operated upstream of incineration-based controls (RTO or RCO) on veneer dryers.[3] Based on the survey data, it appears that exhaust streams from rotary particle dryers, tube dryers, veneer dryers, and presses generally do not have the high fine particulate or salt loadings that can necessitate use of a WESP. Prefiltering of exhaust from particle and tube dryers can be accomplished using lower-cost PM control devices. Prefiltering of exhaust from veneer dryers and presses is usually not necessary.[28,29]

Wet electrostatic precipitators are effective on effluent gas streams when there is a potential for explosion, when the particulates are sticky or are liquid droplets, or when the dry dust has an extremely high resistivity. Thus, WESP are well suited for PCWP dryer exhausts because these exhausts are quite humid and contain wood particles and sticky organic compounds. Particulate removal efficiency for WESP varies from about 90 to 99.9 percent, depending on the system design. New WESP are commonly designed to achieve 99 percent or greater PM removal.[30]

A low energy wet scrubber (or prequench) is used upstream of the WESP to cool and saturate gases before they enter the precipitator. The prequench sprays water into the incoming gas stream. The amount of cooling required depends on the characteristics of the exhaust air stream exiting the dryer. The prequench water, which flows at around 275 gallons per minute (gpm), is typically recirculated for conservation. Caustic may be added to the prequench water for pH control.[3] The prequench removes relatively large particles (>2 um) from the incoming gas stream to reduce the load on the WESP.[30] Some of the hydrocarbon vapors produced by the drying process are condensed in the prequench and enter the precipitator as droplets.[31] In addition, some fraction of the highly water-soluble compounds, such as formaldehyde and methanol, may be scrubbed by the prequench. However, as discussed above, the ability of the prequench water to absorb water-soluble compounds diminishes as the water becomes saturated.

The WESP uses electrical forces to move particles or droplets entrained in the exhaust stream onto collection surfaces. The entrained particles are given an electrical charge when they pass through a corona, a region where gaseous ions flow. Electrodes in the center of the flow lane are maintained at high voltage and generate the electrical field that forces the particles to the collector walls. In WESP, the collectors are either intermittently or continuously washed by a water spray.[30]

In a wire-pipe WESP, also called a tubular WESP, the exhaust gas flows vertically through parallel conductive tubes. The high voltage electrodes are long wires or rigid "masts" that run through the axis of each tube. The electrodes are generally supported by both an upper and lower frame of the WESP. Sharp points may be added to the electrodes, either at the entrance to a tube or along the entire length in the form of stars, to provide additional ionization sites.[30]

Wet electrostatic precipitators require a source of wash water to be injected or sprayed near the top of the collector pipes either continuously or at timed intervals. The water flows with the collected particles into a sump from which the fluid is pumped or drained. A portion of the fluid may be recycled through the prequench to reduce the total amount of water required. The remainder is usually pumped into a settling pond.[30]

Parameters typically monitored for WESP include amperage, voltage, or current; inlet or outlet exhaust temperature; spark rate; and washing frequency.[3]

3.5 OTHER CONTROL TECHNIQUES

This chapter has focused on APCD that are already commonly used in the PCWP industry. However, any pollution control technique that achieves the emission limits required by the PCWP standards can be used to comply with the standards. New APCD and lower-emitting process equipment are continually under development. For example, one engineering firm has developed a regenerative vapor recovery system (RVRS) applicable to low concentration, high flow, and high humidity exhausts. The RVRS adsorbs VOC onto polymeric adsorbents and uses a microwave desorption system followed by condensation of the desorbed VOC.[32]

Catalytic infrared drying of wood strands is an example of a new drying technology under development. With catalytic infrared drying, an energy source such as natural gas or propane is oxidized in the presence of a catalyst to produce infrared energy, CO_2, and water. The wood strands absorb the infrared energy which heats the strands to around 250°F and dries them. Because of the lower drying temperature and absence of combustion in the catalytic infrared drying system, emissions of NO_X, CO, and VOC from catalytic infrared drying are lower than from rotary wood strand dryers.[33]

Low temperature conveyor drying is a drying technology that has already been employed to dry wood strands at PCWP plants. Emissions of HAP, VOC, PM, and NO_X are lower with the conveyor dryer than with rotary strand dryers because drying occurs at lower temperatures and conveyors (as opposed to pneumatic conveyance) are used to move the wood strands through the dryer.[16,34]

Another technology under development is a rotary concentrator that could be used to concentrate dilute press exhaust streams. The rotary concentrator is applicable for press exhaust streams because the inlet temperature of the gas stream entering the concentrator must be less than 120°F. The pollutant-laden press exhaust gas is drawn through a rotary adsorber where the pollutants are adsorbed onto the adsorbent media affixed to the rotor. The purified air flowing from the adsorber is directed to the atmosphere. The pollutants adsorbed on the rotor are continuously desorbed by a high temperature, low-volume desorption air stream. The desorption air stream exits the rotor containing the pollutants and may be directed to a thermal oxidizer or other control device. Test results reportedly show rotary concentrator efficiencies of up to 98 percent.[35]

3.6 REFERENCES FOR CHAPTER 3

1. Memorandum from R. Nicholson, MRI, to M. Kissell, EPA/ESD. May 26, 2000. Control Device Efficiency Data for Add-on Control Devices at PCWP Plants.

2. OAQPS Control Cost Manual (Fifth Edition), Chapter 3 – Thermal and Catalytic Incinerators. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Publication No. EPA 453/B-96-001. February 1996.

3. Memorandum from D. Bullock, K. Hanks, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. April 28, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – General Survey.

4. Cooper C.D. and F.C. Alley. Air Pollution Control: A Design Approach. 2nd edition. Prospect Heights, IL, Waveland Press, Inc. 1994. pp. 354, 360, 488-504.

5. Beachler, D., Jahnke, J., Joseph, G. and M. Peterson. APTI Course SI: 431, Air Pollution Control Systems for Selected Industries – Self Instructional Guidebook. U. S. Environmental Protection Agency. Publication No. EPA 450/2-82-006. June 1983.

6. Memorandum from Hanks, K. and Bullock, D., MRI, to Lassiter, P., EPA/ESD. May 27, 1998 (Finalized March 1, 1999). Site Visit – Georgia-Pacific Oriented Strandboard Plant in Brookneal, VA. EPA.

7. McMahon, A., Dürr Environmental Incorporated. Minimizing RTO Operating Costs in OSB Mills. Panel World. September 1998. pp. 52-54.

8. Seiwert, J., Smith Engineering Company. Untitled paper presented at the American Institute of Chemical Engineers (AIChE) Meeting in Denver, CO. August, 1994. Printed from www.smitheng.com/techaich/techaich.htm on September 1, 2000.

9. Cloud, R., Huntington Environmental Systems. Thermal Treatment Systems for Volatile Organic Control. Printed from www.huntington1.com/hes_cas3.html on June 4, 1999.

10. Kirkland, J., Smith Environmental Corporation. VOC Control for the Panel Industry. Panel World. September 1998. pp. 56-57.

11. Jaasund, S., Geoenergy International Corporation. Proper Care Saves Money In Dryer Emission Control Systems. Panel World. September 1999. p. 13.

12. Jaasund, S., Geoenergy International Corporation. Upstream Particulate Removal for RTOs on Direct-Fired Dryers: How Much Is Enough? Panel World. September 2000. pp. 50-51.

13. Memorandum from K. Hanks and D. Bullock, MRI, to P. Lassiter, EPA/ESD. December 1, 1997. Site Visit – Willamette Industries, Arcadia Oriented Strandboard (OSB) Plant, Arcadia, LA.

14. Memorandum and attachments from J. Farmer, EPA, to distribution. August 22, 1980. Thermal Incinerators and Flares.

15. Stationary Source Sampling Report for Georgia Pacific Corporation, Mt. Hope, WV, Wellons Energy Unit, Press Vent, Test Dates August 7-8, 1996. Prepared for Georgia Pacific Corporation, by Trigon Engineering Consultants, Inc. Project No. 047-96-004. August 1996.

16. Memorandum from D. Bullock and K. Hanks, MRI, to M. Kissell, EPA/ESD. April 27, 2000. Documentation of Emission Factor Development for the Plywood and Composite Wood Products Manufacturing NESHAP.

17. Pond, R.L. Biofiltration to reduce VOC and HAP emissions in the board industry. TAPPI Journal. Volume 82, No. 8. August 1999.

18. Standefer, S. and R. Willingham, PPC Biofilter. Experience with Pilot-and Full-scale Biofilter Operations. Printed from www.ppcbio.com/biopr4.html on August 28, 2000.

19. AirScience Technologies Technological Fact Sheet – Biofiltration of gaseous effluents (F2-04-96B). Printed from www.enviroaccess.ca/fiches_2/F2-04-96ba.html on June 21, 1999.

20. Anit, S. and R. Artuz. Biofiltration of Air. Printed from www.rpi.edu/dept/chem-eng/Biotech-Environ/.../biofiltration.html on June 21, 1999.

21. Mohseni, M. and D. Allen, Biofiltration of α-Pinene and Its Application to the Treatment of Pulp and Paper Air Emissions. 1997 Environmental Conference & Exhibit.

22. LaGrega, M., P. Buckingham, and J. Evans. Hazardous Waste Management. New York, McGraw-Hill, Inc. 1994. pp. 562-569.

23. Biedell, E. Pollution Engineering. VOCs Pose a Sticky Situation for Industry. Autumn 1997 Pollution Engineering International. Printed from Pollution Engineering Online (http://www.pollutionengineering.com) on June 21, 1999.

24. Proposed Monitoring Protocol for Biofiltration Systems From the Forest Products Industry, report by G. McGinnis, M. Connell, and A. Nadeau, submitted to the U. S. Environmental Protection Agency. May 5, 2000.

25. Memorandum from T. Holloway, MRI, to W. Schrock, EPA/ESD. October 14, 1998. Minutes of the August 5, 1998 meeting with Envirogen, Inc.

26. Method 204 – Criteria for Verification of a Permanent or Temporary Total Enclosure. 40 CFR 51, Appendix M.

27. Bemi, D., Permanent Total Enclosures Used to Capture VOCs in Process Air Streams.' EM. April 1999.

28. Telecon. R. Nicholson, MRI, with R. Grzanka, Smith Engineering. March 23, 2000. Discussion of use of RTOs in the wood products industry.

29. Donnel, R. (editor). Geoenergy Principles Have Been Pushing the Right Buttons. Panel World. September 1999. pp. 10-12.

30. Fact Sheet: U. S. Environmental Protection Agency, EPA-CICA Air Pollution Technology Fact Sheet for Wire-Pipe Type Wet Electrostatic Precipitators.

31. Raemhild, G., Geoenergy International Corporation. Balancing Wet ESP, RTO Application. Panel World. September 1998. p. 51.

32. Product literature from American Purification, Inc. Presented to the U. S. Environmental Protection Agency. June 30, 2000.

33. Macaluso, V., Catalytic Industrial Group (Independence, KS), and R. Davis, Cat-Tec Industries, Inc. (Eden Prairie, MN). Preliminary Report and Findings on the Drying of OSB Flakes and Fines Through the use of Catalytic Infrared Energy. Funding provided by: U.S. Department of Energy, Catalytic Industrial Group, Cat-Tec Industries, Inc., Potlatch Corporation, and The Institute of Paper Science and Technology. February 1999.

34. Dexter, J. Low Temp, Conveyorized Strand Drying Recognized By State and B.A.C.T. Panel World. March 1998. p. 34.

35. Blocki, S., Durr Industries, Inc. Rotary Concentrator for Controlling VOC Emissions from Press Exhaust. Abstract for presentation at the Washington State University Particleboard and Composite Materials Symposium. 1995.

4.0 CONTROL AND TESTING/MONITORING COSTS

This chapter presents the estimated nationwide capital and annualized costs for compliance with the PCWP rule. Compliance costs include the costs of installing and operating air pollution control equipment and the costs associated with demonstrating ongoing compliance (i.e., emissions testing, monitoring, reporting, and recordkeeping costs). Section 4.1 discusses the estimated air pollution control costs. Cost estimates associated with testing, monitoring, reporting, and recordkeeping are discussed in the Paperwork Reduction Act submission for the proposed PCWP standards and are summarized in Section 4.2.

4.1 BASIS FOR CONTROL COSTS

As discussed in Section 3.1, add-on APCD most likely to be used to comply with the PCWP rule include incineration-based controls (e.g., RTO, RCO, and process incineration) or biofilters. The control device most commonly used to control emissions from PCWP plants is the RTO. Therefore, for costing purposes, it was assumed that most plants would install RTO to comply with the rule. A number of RCO and biofilters are also presently used by PCWP plants. In addition, several plants with large capacity heat energy systems currently use process incineration. However, the applicability of process incineration is limited to those plants that have, or may later install, large onsite heat energy systems. There may be cost advantages to using RCO, biofilters, process incineration, other add-on control devices, or pollution prevention measures instead of RTO for some plants. Plants may elect to use any of these technologies to comply with the rule, provided the technology limits HAP emissions to the levels specified in the rule. However, the cost analyses described in this chapter focus on use of RTO due to their prevalence in the industry, to minimize the number of cost algorithms developed, and to avoid judgments regarding which plants may choose a particular technology.

Oriented strandboard plants typically install WESP upstream of rotary dryer RTO to protect the RTO media from plugging. Thus, the capital and annualized costs associated with WESP were modeled for rotary strand dryers. As discussed in Chapter 3, available information indicates that WESP are not necessary for protecting RTO installed on other types of dryers (e.g., tube dryers) or on presses.[1] Therefore, with the noted exception of OSB dryers without WESP, the existing particulate abatement equipment on process units was assumed to be sufficient for protecting the RTO media.[2]

Enclosures must be installed around presses to ensure complete capture of the press emissions before routing these emissions to a control device. Thus, the capital costs of permanent total enclosures (PTE) were included in the costing analyses. Annualized costs associated with PTE were assumed to be minimal and were not included in the cost analyses.

The following sections (4.1.1 through 4.1.3) discuss the RTO, WESP, and PTE costs. Section 4.1.4 describes how plant-by-plant control costs were estimated, and Section 4.1.5 summarizes the nationwide control costs.

4.1.1 RTO Costs

An RTO cost algorithm was developed based on: (1) information from an RTO vendor with numerous RTO installations at PCWP plants, and (2) the costing methodology described in the Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual.[3,4] The RTO cost algorithm was used to determine RTO total capital investment (TCI) and total annualized cost (TAC) based on the exhaust flow to be controlled and annual operating hours. The RTO cost algorithm is presented in Appendix A. Development of the algorithm is discussed in Sections 4.1.1.1 and 4.1.1.2.

4.1.1.1 RTO Total Capital Investment.[3,4] Equipment costs (including equipment, installation, and freight) were provided by the RTO vendor for four sizes of RTO. The 1997 equipment costs were not escalated because the Vatavuk Air Pollution Control Cost Index (VAPCCI) for 1997 (107.9) was slightly greater than the preliminary VAPCCI for RTO in fourth quarter 1999 (107.8).[5] According to the OAQPS Control Cost Manual, instrumentation is typically 10 percent of equipment cost (RTO and auxillary equipment); sales tax is typically 3 percent of the equipment cost; and freight is typically 5 percent of the equipment cost. Figure 4-1 presents the purchased equipment costs (PEC) supplied by the RTO vendor (minus freight), and shows that the equipment costs vary linearly with gas flow rate. The regression equation presented in Figure 4-1 was included in the RTO cost algorithm to calculate the equipment cost for the oxidizer and auxiliary equipment for various gas flow rates. Instrumentation, sales tax, and freight were added to the calculated equipment costs to obtain the total PEC.

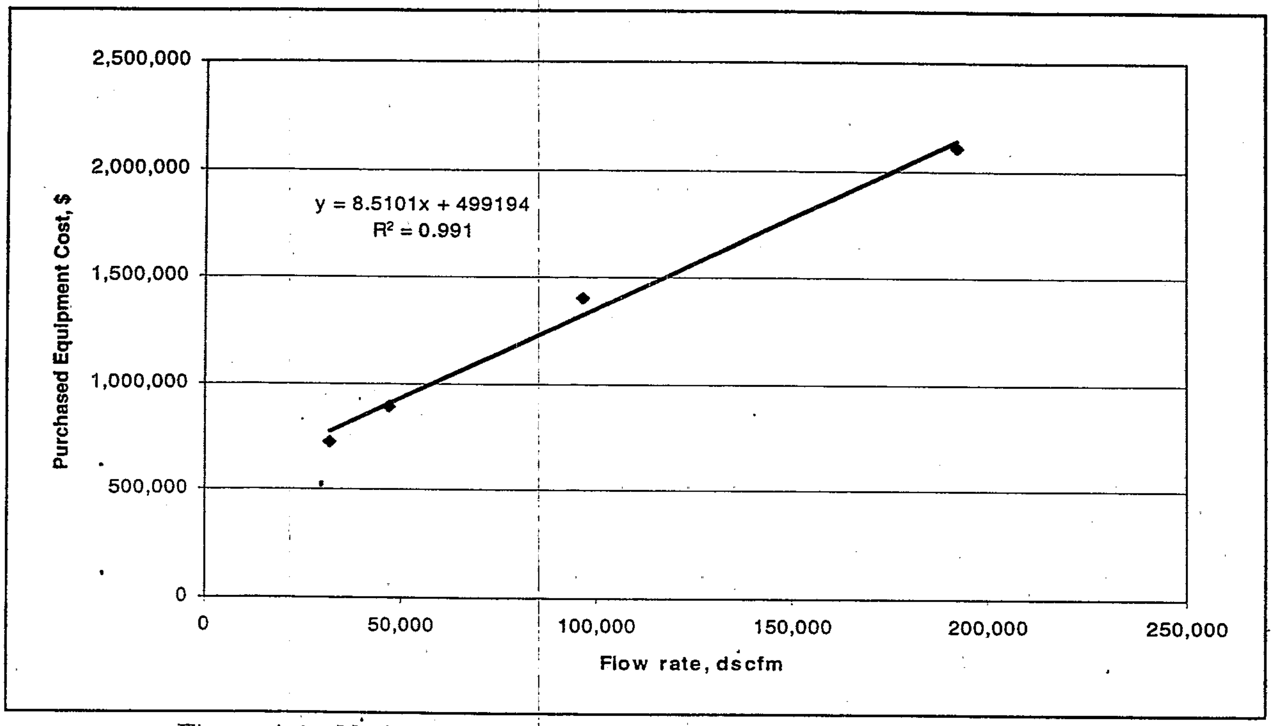

Figure 4-1. Variation in RTO purchased equipment cost with flow rate.

Direct installation costs for handling and erection, electrical, and piping were included in the equipment cost provided by the RTO vendor. Start-up costs were also included in the equipment cost provided by the RTO vendor. These costs are typically 22 percent of the PEC. Thus, these costs were subtracted from the PEC before further calculations based on the PEC were performed. Direct installation costs including foundation and support, insulation for ductwork, and painting were estimated according to the procedures in the OAQPS Control Cost Manual. Because PTE were costed separately, no enclosure building was costed in the RTO algorithm. Site preparation costs and indirect installation costs (e.g., engineering, field expense, contractor fees, performance tests, and contingencies) were estimated according to the procedures in the OAQPS Control Cost Manual. The TCI was calculated by summing the PEC, direct and indirect installation costs, and site preparation cost.

4.1.1.2 RTO Total Annualized Cost. Total annualized costs consist of operating and maintenance labor and material costs, utility costs, and indirect operating costs (including capital recovery). Operating and maintenance labor and material costs were estimated based on the RTO vendor information because the RTO vendor assumptions led to higher costs than the OAQPS Control Cost Manual and were assumed to be more representative of the PCWP industry. The operator labor rate supplied by the RTO vendor was $19.50 per hour.

The RTO electricity use and natural gas use was provided by the RTO vendor for the four RTO sizes. Figures 4-2 and 4-3 present the relationships between flow rate and electricity and flow rate and natural gas use, respectively. As shown in the figures, there is a linear relationship between RTO electricity consumption and flow rate, and an exponential relationship between RTO fuel consumption and flow rate.

Electricity costs were estimated by the RTO vendor at $0.045 per kilowatt-hour (kWh). The RTO vendor estimated natural gas costs at $3 per million British thermal units (MMBtu). Both of these energy prices match closely with currently published nationwide average prices.[6,7] Thus, the electricity and natural gas prices supplied by the RTO vendor were used in the cost algorithm.

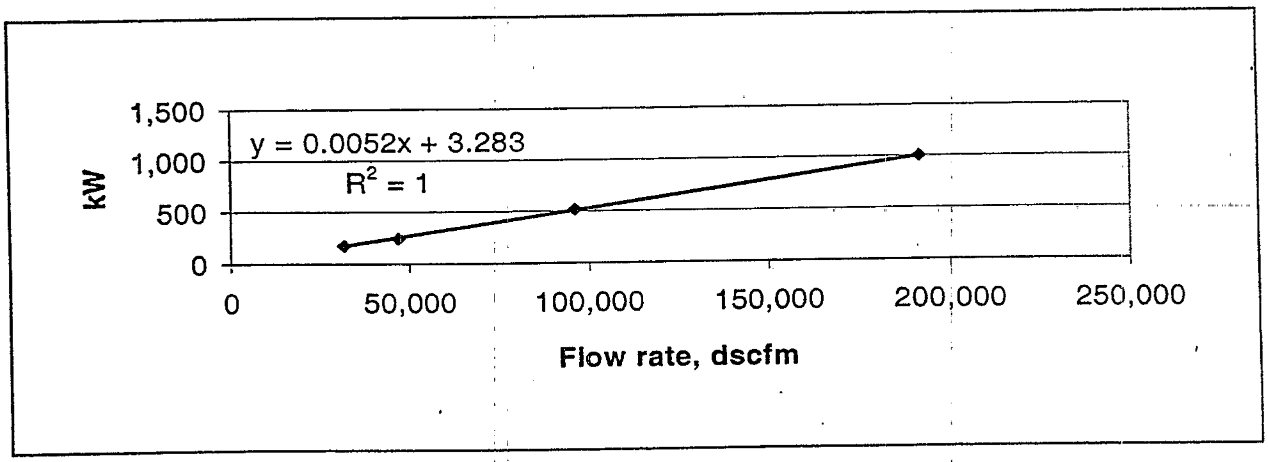

Figure 4-2. Relationship between RTO electricity consumption and flow rate.

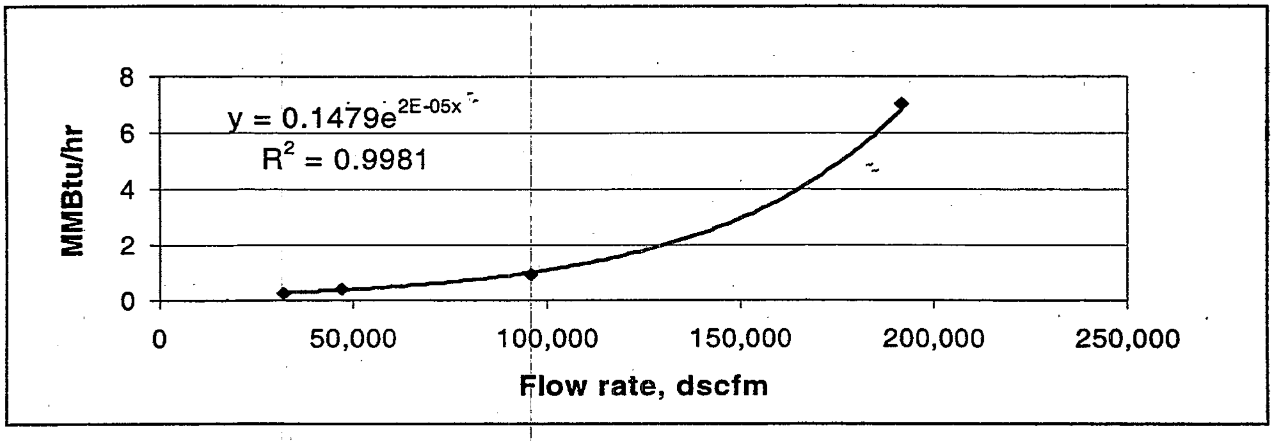

Figure 4-3. Relationship between RTO natural gas consumption and flow rate.

Indirect operating costs were estimated using the methodology described in the OAQPS Control Cost Manual. The capital recovery cost was estimated assuming an RTO equipment life of 15 years (based on the RTO vendor information) and a 7-percent interest rate. The TAC was calculated by summing the direct and indirect annual operating costs.

4.1.1.3 Application of the RTO Cost Algorithm to Estimate Capital and Annualized Costs. The complete RTO cost algorithm, which predicts RTO capital and annualized costs as a function of operating hours and flow rate, was run several times assuming 8,000 operating hours per year and various flow rates. The 8,000-hr operating time was selected based on the results of the EPA's MACT survey, which show industry average operating hours of slightly less than 8,000 hr/yr.[1] Although several plants operate process lines more than 8,000 hr/yr, their equipment and control devices may or may not be operated for more than 8,000 hr/yr. Thus, 8,000 hr/yr was selected as the control device operating time for purposes of costing.

The TCI and TAC values generated for each flow rate using the RTO cost algorithm are presented in Appendix A. A regression equation was developed based on the calculated TCI and TAC for each flow rate. Figures 4-4 and 4-5 present the relationships between flow rate and RTO capital costs and flow rate and annualized costs, respectively, and the associated regression equations.

4.1.2 WESP Costs

A WESP cost model was developed based on: (1) information from a WESP vendor with many WESP installations at wood products plants, and (2) the costing methodology described in

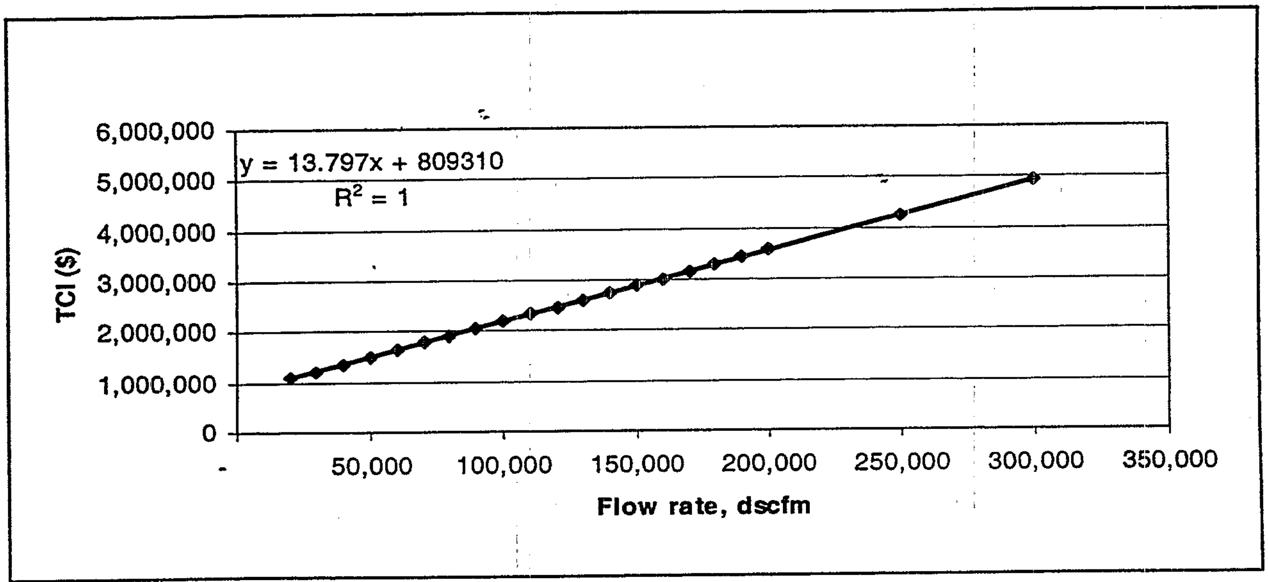

Figure 4-4. Variation in RTO total capital investment with flow.

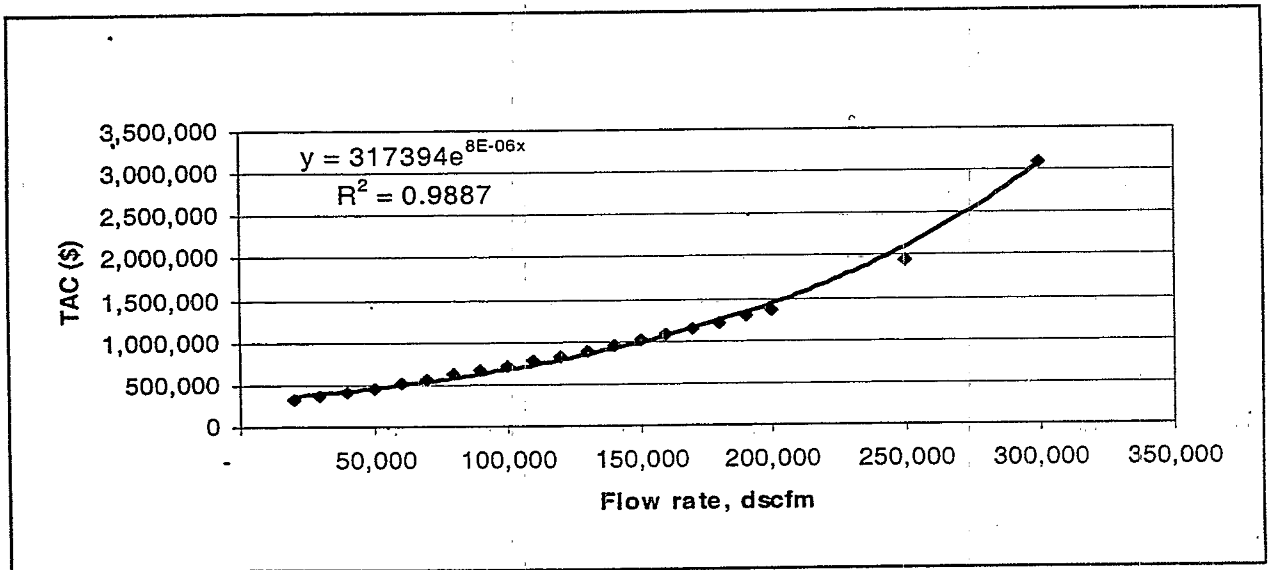

Figure 4-5. Variation in RTO total annualized cost with flow.

the OAQPS Control Cost Manual for electrostatic precipitators (ESP).[4,8] The cost model was used to determine TCI and TAC for WESP used to control particulate emissions from OSB rotary dryers. The WESP vendor provided cost information for a WESP sized to treat 27,650 dry standard cubic feet per minute (dscfm) of OSB rotary dryer exhaust. This flow rate matches closely with the flow rates for uncontrolled OSB. Thus, the model TCI and TAC could be applied for each dryer to be controlled (i.e., the model need not calculate different costs for varying flow rates). The WESP cost model is presented in Appendix A. Development of the model is discussed in Sections 4.1.2.1 and 4.1.2.2.

4.1.2.1 WESP Total Capital Investment. The WESP and auxiliary equipment costs (which makeup the PEC) were provided by the WESP vendor. These PEC include the cost of the WESP; pumps, piping, and tanks; ducting (including the quench); fans; and a 1-gpm blowdown solids removal system. Instrumentation costs were also provided by the WESP vendor. Sales tax and freight were added into the total PEC based on the methodology described in the OAQPS Control Cost Manual.

The direct installation costs such as foundation and support, handling and erection, electrical, piping, insulation for ductwork, and painting were included in the PEC provided by the WESP vendor. It was assumed that no building would be necessary for the WESP and that there would be no additional site preparation costs. Several indirect costs were also included in the equipment cost supplied by the WESP vendor, including engineering, construction and field expense, start-up, and contingencies. Because WESP are already widely used at OSB plants, it was assumed that no model study would be necessary for the WESP although the OAQPS Control Cost Manual mentions model-study costs for ESP.

The cost of a performance test was included in the WESP cost model. According to the OAQPS Control Cost Manual, the performance test is typically 1 percent of the PEC. Thus, 1 percent of the model PEC (minus the direct and indirect installation costs included in the PEC) was used as the cost of the performance test. The direct and indirect costs were summed to arrive at the WESP TCI.

4.1.2.2 WESP Total Annualized Cost. The direct annualized costs include operating and maintenance labor and materials, utilities, and waste disposal. The operating labor cost was based on 1,146 hr/yr (provided by the WESP vendor) at $19.50/hr (the labor rate used in the RTO cost algorithm). The annual cost of operating materials, including caustic and defoamer, was provided by the WESP vendor. The maintenance labor rate was estimated as 110 percent of the operating labor rate. The maintenance hours per year were estimated based on information supplied by the WESP vendor. The cost of maintenance materials (including replacement of one pump seal per year, and one voltage controller every 4 years, and miscellaneous materials) was supplied by the WESP vendor.

The electricity necessary to power the WESP components (approximately 2,076,000 kWh/yr for all WESP components) was based on information provided by the WESP vendor. An electricity cost of $0.045/kWh was used (the same as used in the RTO cost algorithm). A $0.20/gal cost for makeup water was used based on the OAQPS Control Cost Manual. The WESP water recirculation rate, makeup water addition rate, and blowdown generation rates were provided by the WESP vendor. The OAQPS Control Cost Manual indicated that wastewater treatment costs may range from $1.30 to $2.15 /1,000 gallons. Methods of WESP wastewater treatment and disposal could include evaporation from settling ponds, discharge to a municipal water treatment facility, or spray irrigation. The wastewater treatment and disposal cost for the blowdown was assumed to be $2.15 per gallon. The wastewater percent solids of 7.6 percent was based on the average from the MACT survey responses.[1] It was assumed that the solids would ultimately be disposed in a landfill (although they could be burned onsite or used for soil amendment). The trucking cost for hauling sludge to a landfill was estimated to be $0.20 per cubic yard per mile ($\$/yd^3$-mi).[9] The landfill was assumed to be 20 miles away, and a $20/ton landfill tipping fee was used.[4] The density of the solids was assumed to be 0.5 ton/yd^3 for wet wood particulate (given that the density of water is 0.84 ton/yd^3 and the density of wood is from 30 to 50 percent of the density of water).

The indirect operating costs were estimated based on the methodology described in the OAQPS Control Cost Manual. The capital recovery cost was estimated assuming a WESP equipment life of 20 years (based on the OAQPS Control Cost Manual and WESP vendor information) and a 7-percent interest rate. The TAC was calculated by summing the direct and indirect annual operating costs.

4.1.3 Permanent Total Enclosure (PTE) Costs

The capital costs associated with installation of a PTE were based on available information in the project files on the capital cost of PTE for particleboard, MDF, and OSB presses.[10] These costs included the following elements:

- installed cost of the PTE (including fan system)
- ductwork

- instrumentation and wiring
- fire suppression (in some cases)
- site supervision
- start-up and testing

Based on the available cost information, the following algorithm was developed to estimate the PTE costs for various exhaust flowrates:

$$TCI_{PTE} = 1.2031 \times Q_{dscfm} + 425{,}760$$

where:

TCI_{PTE} = the total capital cost of the permanent total enclosure, \$

Q_{dscfm} = design exhaust flow rate from PTE, dry standard cubic feet per minute

Available information on actual exhaust flow rates from PTE installed around reconstituted wood product presses was used to develop model flow rates for the various press applications.[1,11] Information on press vent flow rates from unenclosed presses was available, but not used, because unenclosed press flow rates are altered when a PTE is installed around a press.[12] The cost algorithm was then applied to the model flow rates to estimate the capital costs of the model PTE as shown in Table 4-1. The costs were rounded to the nearest $1,000. In the case of the particleboard press PTE, the cost was set at $485,000 (instead of $481,000, which is the value derived from the cost algorithm) because the PTE model flow rate was similar to those for the MDF and hardboard presses, and applying the same cost to all three types of press PTE simplified the costing analyses. Annualized costs were not developed for PTE because the annualized cost of the fans is already accounted for in the estimated costs of the RTO.

TABLE 4-1. PRESS ENCLOSURE EXHAUST FLOW RATES AND CAPITAL COSTS

Equipment type	Flow rate, dscfm	PTE capital cost
Particleboard press	45,524	$485,000
OSB press	97,509	$543,000
MDF or dry/dry hardboard press	49,413	$485,000
Wet/dry or wet/wet hardboard press	49,209	$485,000

4.1.4 Plant-by-Plant Costing Approach

The control costs associated with the PCWP standards were estimated for each plant and were summed to arrive at a nationwide estimate of control costs. The PCWP standards apply only to major sources of HAP emissions. Therefore, cost estimates were developed for only those plants that were estimated to be major sources.[13] Sections 4.1.4.1 and 4.1.4.2 describe the information used to estimate the plant-by-plant control costs. Section 4.1.4.3 describes how the nationwide control cost estimates were developed from the plant-by-plant estimates.

4.1.4.1 Application of Control Costs to Process Units. The cost models discussed in Sections 4.1.1 through 4.1.3 were applied to each plant that would likely need to install air pollution controls in order to meet the PCWP standards. Plant-specific information on process units (e.g., dryers, presses) and controls was taken from the MACT survey responses.[1,14,15] In addition, information about the presence of PTE on presses was taken from the MACT survey responses.[1] If information about press enclosures was not provided in the MACT survey responses, or was claimed confidential, the press was assumed to be unenclosed if it was uncontrolled or enclosed if it was controlled for purposes of costing.

Some plants have begun operation and other plants have added equipment or controls since EPA conducted the MACT survey. Such changes were accounted for in the nationwide cost estimates. A separate memorandum summarizes the changes to plants that have occurred following the EPA's MACT survey. The nationwide cost estimates reflect the equipment and controls in place as of April 2000.[16]

The process units and controls present at each plant were reviewed to determine what control equipment (i.e., RTO, WESP, or PTE) the plant would need to install to meet the PCWP standards based on the MACT floor control levels. The MACT floor control levels are based on the information presented in Chapters 2 and 3 of this document and are documented in a separate memorandum.[17] Table 4-2 summarizes the process units for which control equipment would be required to meet the MACT floor and the control equipment costed for these process units. At each plant, the exhaust gas flow rates from the applicable uncontrolled process units listed in Table 4-2 were summed to yield a plant-wide uncontrolled exhaust gas flow rate. Process units already equipped with controls to meet the MACT floor were not included in the plant-wide uncontrolled gas flow rate estimates. The procedures for estimating the uncontrolled gas flow rates from process units and the application of the cost algorithms is discussed in the following section.

TABLE 4-2. CONTROL EQUIPMENT COSTED FOR PROCESS UNITS WITH CONTROLLED MACT FLOOR

Existing process units with control requirements	Control equipment costed	Notes
Tube dryers (primary and secondary)	RTO	Tube dryers are located at particleboard, MDF, and hardboard plants
Rotary strand dryers	WESP and RTO	Rotary strand dryers are located at OSB and LSL plants. Assumed that the WESP is not needed for plants that already have an RTO without a WESP. Assumed that plants that currently operate an EFB or multiclone alone (i.e., with no RTO) would install a WESP with the RTO.
Conveyor-type strand dryers	RTO	Conveyor strand dryers are located at OSB and LSL plants.
Rotary green particle dryers	RTO	Rotary green particle dryers are located at particleboard, MDF, or hardboard plants and process furnish with >30% (dry basis) inlet moisture content at dryer inlet temperature of >600°F
Hardboard ovens	RTO	Includes bake and tempering ovens
Softwood veneer dryers	RTO	Softwood veneer dryers are located at softwood plywood, hardwood plywood, LVL, and PSL plants and dry ≥30% (by volume, annually) softwood veneer
Pressurized refiners	None	The exhaust from pressurized refiners typically passes through a tube dryer and exits through the tube dryer control device. Therefore, it was not necessary to cost separate control equipment for pressurized refiners. Pressurized refiners are located at MDF and hardboard plants.
Reconstituted wood products presses	PTE and RTO	Reconstituted wood products presses are located at hardboard, MDF, OSB, and particleboard plants

4.1.4.2 <u>Exhaust Flow Rate to Be Controlled</u>. If provided in the non-confidential MACT survey responses, process-unit specific exhaust flow rate, temperature, and percent moisture were used to determine the dry standard flow rate for each process unit. If sufficient information was not provided in the MACT survey response to determine dry standard flow rates (or the information was claimed confidential), then default values were used for the flow rate. The default values were based on the average value for other similar process units at plants that provided enough non-confidential information to calculate the dry standard flow rate. Table 4-3 summarizes the default flow rates used in the costing analyses. The average flow rates from press enclosures are described in Section 4.1.3 and were used for all presses.

TABLE 4-3. DEFAULT FLOW RATES

Process line	Equipment type	Flow rate (dscfm)
Particleboard	Rotary green particle dryer	35,731
	Tube dryer	14,955
OSB	Rotary strand dryer	32,478
	Conveyor-type strand dryer	37,810
MDF	Primary tube dryer (single-stage or first stage of staged dryer)	79,173
	Secondary tube dryer (second stage of staged dryer)	18,195
Plywood	Softwood veneer dryer	12,062
Hardboard	Bake oven	4,742
	Tempering oven	4,055
	Primary tube dryer (single-stage or first stage of staged dryer)	37,436
	Secondary tube dryer (second stage of staged dryer)	31,728

Several plants have multiple process units requiring controls. The flow rates for these process units were summed and divided across control equipment as necessary. In most cases, the total dryer flow was assumed to be routed to one or more RTO dedicated to controlling dryer exhaust, and the total press flow was assumed to be routed to one or more RTO dedicated to controlling press exhaust. Because RTO fuel costs increase exponentially with gas flow rate, RTO sizes were assumed to remain less than about 150,000 dscfm. (The largest RTO mentioned in the MACT survey responses was around 150,000 dscfm.)

In some cases, dryers and presses were assumed to be routed to the same RTO, provided that the total dryer and press flow remained under 150,000 dscfm. For example, two RTO (103,500 dscfm each) would be costed for a MDF plant with 2 dryers (79,000 dscfm each) and

1 press (49,000 dscfm) assuming that the flow for both dryers and the press could be combined and split equally across the two RTO. This approach seems reasonable given that several MDF plants currently route dryer and press exhaust to the same RTO.

4.1.4.3 Calculation of Nationwide Control Costs. The total plant-by-plant control cost was calculated by summing the control cost associated with each RTO, WESP, and PTE costed for each plant. The number of control devices at each plant depended on the number of process units and the exhaust flow to be controlled at the plant. In some cases, only one control device was costed, while in other cases, multiple control devices were costed for a plant.

Some plants claimed all relevant portions of their MACT survey responses confidential. In addition, a MACT survey response was not available for a few plants likely to be impacted by the PCWP standards. Without a non-confidential MACT survey response, information was not available to develop plant-specific cost estimates. Therefore, the average cost for all other plants manufacturing the same product was used to approximate the costs for plants for which there was no non-confidential plant-specific information.

The nationwide capital and annualized control costs were determined by summing the total plant-specific costs.

4.1.5 Summary of Nationwide Control Costs. Table 4-4 summarizes the nationwide control costs for different product types. The nationwide total capital cost for control equipment is estimated to be $473 million and the nationwide total annual cost for control equipment is estimated as $136 million.

TABLE 4-4. ESTIMATED NATIONWIDE CONTROL COSTS FOR THE PCWP INDUSTRY[a]

Product type	No. of plants[b]	No. of plants impacted[b,c]	Process units impacted	Control equipment	Total capital costs, $MM	Total annual costs, $MM
Softwood plywood/veneer	105	66	softwood veneer dryers	RTO	$87.1	$28.4
Hardwood plywood/veneer	166	0	N/A	no control	$0.0	$0.0
Medium density fiberboard	24	18	dryers, presses	RTO for dryers and PTE/RTO for presses	$71.3	$21.5
Oriented Strandboard	37	23	dryers, presses	WESP/RTO for dryers and PTE/RTO for presses	$94.6	$25.5
Particleboard (conventional and molded)	51	38	green rotary particle dryers, presses	RTO for dryers and PTE/RTO for presses	$125.2	$34.2
Particleboard (agriboard)	5	0	N/A	no control	$0.0	$0.0
Hardboard	18	18	tube dryers, presses, ovens	RTO for dryers and PTE/RTO for presses	$84.4	$23.5
Fiberboard	7	0	N/A	no control	$0.0	$0.0
Engineered wood products	41	3	softwood veneer dryers, strand dryers	RTO for veneer dryers and WESP/RTO for strand dryers	$10.3	$3.2
TOTAL:	454	166			$473	$136

[a] Nationwide costs are for control equipment only; costs do not include testing, monitoring, reporting, and recordkeeping costs.

[b] Some plants manufacture more than one product type. These plants are listed once for each product type manufactured.

[c] The number of plants impacted may be different from the number of plants nationwide for one of the following reasons: (1) some plants are not major sources; (2) some plants already have all of the necessary control equipment; or (3) a few plants are major sources but do not operate any process units for which there are control requirements (e.g., glu-lam plants).

4.2 TESTING, MONITORING, REPORTING, AND RECORDKEEPING COSTS

Compliance with the PCWP standards must be demonstrated through performance testing, ongoing monitoring of process or control device operating parameters or emissions, periodic reporting to the government agency that implements the PCWP rule, and recordkeeping. There are capital and annualized costs associated with these testing, monitoring, reporting, and recordkeeping activities. These costs, which are estimated and documented in the supporting statement for the Paperwork Reduction Act submission, are summarized in this section.[18]

The annual costs associated with testing, monitoring, reporting, and recordkeeping activities include reporting and recordkeeping labor; annualized capital for monitoring equipment, file cabinets, and performance tests; and the operation and maintenance costs associated with monitoring equipment. The capital costs include capital for monitoring equipment, file cabinets and performance tests. Performance tests are considered to be capital costs because plants will typically hire a testing contractor to conduct the performance tests.

The total nationwide capital cost associated with testing, monitoring, reporting, and record keeping is estimated to be $5.8 million and the total nationwide annualized cost is estimated to be $5.6 million. These costs were developed based on the information presented in the Paperwork Reduction Act submission for the first 3 years following the effective date of the PCWP rule. The costs apply for the 223 PCWP plants that are expected to be major sources.

4.3 REFERENCES FOR CHAPTER 4

1. Memorandum from D. Bullock, K. Hanks, and B. Nicholson, MRI to M. Kissell, EPA/ESD. April 28, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – General Survey.

2. Telecon. R. Nicholson, MRI, with R. Grzanka, Smith Engineering. March 23, 2000. Discussion of control equipment used in the plywood and composite wood products industry.

3. Facsimile from J. Seiwert, Smith Environmental Corporation, to L. Kesari, EPA/OECA. October 31, 1997. Revised emissions abatement systems RTO pricing (Smith Proposal BO7-95-156-1, Trinity Consultants).

4. OAQPS Control Cost Manual (Fifth Edition), U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA Publication No. 453/B-96-001. February 1996.

5. Vatavuk Air Pollution Control Cost Indexes (VAPCCI). Chemical Engineering. March 2000. p. 150.

6. Energy Information Administration, Form EIA-826. Monthly Electric Utility Sales and Revenue Report with State Distributions.

7. Energy Information Administration. Natural Gas Monthly. February 2000. p. 60.

8. Letter and attachments from S. Jaasund, Geoenergy International Corporation, to B. Nicholson, MRI. March 28, 2000. Geoenergy WESP Capital and Operating Costs.

9. Vatavuk, W.M. Estimating Costs of Air Pollution Control. Chelsea, MI, Lewis Publishers. 1991. p. 139.

10. Memorandum from B. Nicholson, MRI, to Plywood and Composite Wood Products Project File. July 31, 2000. Cost of Permanent Total Enclosures. (Confidential Business Information)

11. Memorandum from B. Nicholson, MRI, to Plywood and Composite Wood Products Project File. July 31, 2000. Exhaust Gas Flowrate Information for Enclosed Presses. (Confidential Business Information)

12. Memorandum from D. Bullock and K. Hanks, MRI, to P. Lassiter, EPA/ESD. October 27, 1998. Trip report for visit to Temple-Inland Forest Products plant in Diboll, TX.

13. Memorandum from K. Hanks and D. Bullock, MRI, to M. Kissell, EPA/ESD. June 9, 2000. Baseline Emission Estimates for the Plywood and Composite Wood Products Industry.

14. K. Hanks, B. Threatt, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. May 19, 1999. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – Hardwood Plywood and Veneer.

15. K. Hanks, B. Threatt, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. January 20, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – Engineered Wood Products.

16. Memorandum from K. Hanks, MRI, to Project Files. April 18, 2000. Changes in the population of existing plywood and composite wood products plants and equipment following the information collection request.

17. Memorandum from B. Nicholson and K. Hanks, MRI, to M. Kissell, EPA/ESD. July 13, 2000. Determination of MACT floors and MACT for the Plywood and Composite Wood Products Industry.

18. Paperwork Reduction Act Submission, Supporting Statement. Plywood and Composite Wood Products. 2000.

5.0 ENVIRONMENTAL AND ENERGY IMPACTS

This chapter presents the nationwide environmental and energy impacts estimated to result from compliance with the PCWP standards. Environmental impacts include air impacts, wastewater impacts, and solid waste impacts. Energy impacts include the increased consumption of fuel and electricity to power air pollution control equipment. Section 5.1 discusses the methodology used to calculate the air impacts. Section 5.2 discusses the wastewater impact estimates, Section 5.3 discusses the solid waste impact estimates, and Section 5.4 discusses the energy impact estimates. The nationwide environmental and energy impacts are summarized in Section 5.5 and the references used are presented in Section 5.6.

The environmental and energy impacts were estimated using the same plant-by-plant approach that was employed to estimate the nationwide cost impacts in Chapter 4. This plant-by-plant approach to estimating nationwide impacts is described in detail in Section 4.1.4 of this document. The impacts associated with the PCWP standards were estimated for each plant and were summed to arrive at nationwide impacts estimates. Impact estimates were developed only for those plants that were determined to be major sources.[1] The impact estimates were developed based on the control equipment (e.g., RTO or WESP/RTO) that plants would likely install to comply with the PCWP standards at the MACT floor control level. Impact estimates were not developed for process units that already have the necessary control equipment. The impact estimates represent a worst-case estimate of impacts because the use of RTO results in greater energy usage and secondary air impacts relative to other control technologies such as RCO and biofilters.

Table 4-2 in Chapter 4 summarizes the control equipment assumed to be installed in order to meet the MACT floor control levels for various process units.[2] Section 4.1.4.2 of Chapter 4 describes how the exhaust flow rate to be treated by each control device was approximated. An 8,000 hr/yr operating time (the same time used for the cost estimates in Chapter 4) was assumed for calculation of the environmental and energy impact estimates.

5.1 AIR IMPACTS

The air impacts associated with the PCWP standards include a reduction in nationwide HAP emissions, reduction in THC emissions, changes in emissions of primary criteria air pollutants, and secondary air impacts associated with increased electricity generation at power plants. The reduction in HAP and THC emissions is discussed in Section 5.1.1. Section 5.1.2 discusses the changes in emissions of criteria air pollutants and Section 5.1.3 discusses the secondary air impacts.

5.1.1 Reduction in Total HAP and THC

The reduction in emissions of total HAP and THC is the difference between baseline emissions and the emissions expected to remain following implementation of the MACT floor level of control identified for the PCWP standards. Baseline emissions reflect the level of air pollution control that is currently used at PCWP plants. The MACT floor control level reflects the level of control that will be used following implementation of the PCWP standards. Baseline emissions are presented in Chapter 2 for each PCWP.

The same plant-by-plant approach used to estimate baseline emissions was used to estimate the emissions at the MACT floor control level. This approach incorporates specific information on process units (e.g., throughput, emission controls) from the MACT survey responses and the emission factors developed for those process units. This approach is documented in detail in a separate memorandum on baseline emissions.[1]

As for all of the environmental and energy impacts presented in this chapter, the following assumptions were used when estimating emissions at the MACT floor control level: (1) plants will install RTO on all process units that require controls to meet the MACT floor; (2) presses at conventional particleboard, MDF, OSB, and hardboard plants will be fully enclosed by a PTE that captures and routes 100 percent of the emissions from the press area to an RTO; and (3) WESP will be installed upstream of RTO for new RTO installations on rotary strand dryers.

Following the procedure outlined in the baseline emissions memorandum, the HAP and THC reduction associated with RTO was taken to be 95 percent.[1] Thus, for each process unit that would likely need an RTO to meet the MACT floor control level, uncontrolled HAP and THC emissions from the process unit were reduced by 95 percent to approximate the average emissions remaining following installation of an RTO. No HAP or THC reduction was associated with WESP.

The emission estimates at the MACT floor control level were summed for each plant. The plant totals were summed to arrive at a nationwide estimate of the emissions remaining following implementation of the MACT floor control level. The nationwide HAP and THC emission reduction was calculated by subtracting the emissions remaining at the MACT floor control level from the baseline emissions. Section 5.5 summarizes the nationwide HAP and THC emission reductions.

5.1.2 Effect of Standards on Criteria Pollutants

In addition to reducing HAP and THC, the PCWP standards will affect emissions of primary criteria pollutants (i.e., criteria pollutants emitted directly from an emission source). The primary criteria pollutants are PM less than 10 micrometers in aerodynamic diameter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and lead (Pb). Of these pollutants, PM_{10}, CO, and nitrogen oxides (NO_X) are the most prevalent pollutants emitted from PCWP processes. Emissions of SO_2 are not prevalent and are not expected to change greatly due to the PCWP standards because RTO do not destroy or alter SO_2 emitted from PCWP process units, and RTO are not suspected of generating appreciable amounts of SO_2 (because there is little, if any, sulfur in the process exhaust or in the natural gas burned by the RTO). No information is available for use in evaluating emissions of Pb from PCWP processes. Lead is not expected to be a pollutant of concern for PCWP processes, and emissions of Pb (if any) are not expected to change as a result of the PCWP rulemaking. The changes in PM_{10}, NO_X (as NO_2), and CO emissions expected to result from the PCWP standards were estimated using the methodology described in the following subsections.

5.1.2.1 PM-10 Emissions. Plywood and composite wood products process unit exhausts include solid PM (including PM less than 10 micrometers) and condensible PM. The condensible PM leaves the process unit as vapor but may condense at normal atmospheric temperatures to form liquid particles or aerosols. Condensible PM consists primarily of compounds evaporated from the wood. Fabric filters, cyclones, multicyclones, electrified filter beds, and other dry particulate control devices are commonly used to reduce solid PM, but these control devices are often not as effective for controlling condensible PM. Wet electrostatic precipitators are often used on effluent gas streams containing sticky, condensible organics. The

WESP collects only particles and droplets that can be electrostatically changed; vaporous components of the gas stream that do not condense are not collected by the device. Thermal oxidizers destroy condensible organics by burning them at high temperatures.[3]

Information needed to estimate the reduction in PM_{10} associated with the PCWP standards includes the RTO inlet PM_{10} loading and PM_{10} percent reduction achievable with an RTO. The RTO inlet PM_{10} loading depends on whether there is a particulate control device or "prefilter" upstream of the RTO. Many plants already operate particulate controls on process units that will be subject to the PCWP standards. Thus, the additional particulate reduction achieved by the standards will be only the PM reduction across the RTO (regardless of whether the particulate control device already in place continues to be used upstream of the RTO installed to meet the standards).

Emission factors are available for uncontrolled filterable PM, filterable PM_{10}, and condensible PM for many PCWP process units.[4] These emission factors were used to approximate the inlet PM loading for RTO on different types of process units. The EPA test methods 201 and 201A suggest adding filterable PM_{10} and total condensible PM together to get total PM_{10}. Thus, total PM_{10} was calculated as the sum of filterable PM_{10} and total condensible PM.

Table 5-1 presents available information on the percent reduction in total PM_{10} achieved across combined prefilter and RTO systems. Using the information in Table 5-1, it was determined that a combined prefilter and RTO control system can achieve about a 90 percent reduction in PM_{10}.

TABLE 5-1. PERCENT REDUCTION IN TOTAL PM_{10} ACROSS COMBINED PREFILTER AND RTO CONTROL SYSTEMS

Process unit and control system description	PM_{10} reduction, %	Reference[a]
Multiple MDF process units with WESP and RTO	86	5
Particleboard process units with unspecified prefilter and control	95	6
OSB rotary dryer with multiclone and RTO	90.4	7
MDF tube dryer with WESP and RTO	90	8
Average	90	

[a] See Section 5.6 for a list of references.

Table 5-2 presents several reported total PM_{10} reductions across RTO without a prefilter or following a prefilter (i.e., PM reduction across the RTO only). Using the information in Table 5-2, it was determined that an RTO alone can achieve approximately an 80 percent reduction in PM_{10}.

TABLE 5-2. TOTAL PM_{10} REDUCTION ACROSS RTO

Process unit	PM_{10} reduction, %	Reference[a]
MDF dryer with knockout	81.5	9
MDF dryer with cyclone	81.4	9
OSB dryer with WESP	72.7	9
OSB dryer with multiclone	89	9
OSB press	75	7
MDF press	87.4	9
Multiple MDF process units with baghouse	60	5
Average	Approx. 80	

[a] See Section 5.6 for a list of references.

Given that the approximate PM_{10} reduction across a combined prefilter and RTO system is about 90 percent, and the reduction in PM_{10} across the RTO alone is about 80 percent, it was determined that the typical percent reduction in PM_{10} across a prefilter alone is about 70 percent. The actual percent reduction in PM_{10} achieved by a prefilter depends on the type of prefilter and the inlet PM loading into the prefilter (e.g., amount and fraction of filterable PM_{10} and condensible PM). However, for purposes of this analysis, specific PM_{10} reductions achieved by various types of particulate controls were not determined.

The annual PM_{10} reductions were calculated for process units that would likely need controls to meet the PCWP standards using the available emission factors and the percent reductions presented above. Table 5-3 shows the calculated PM_{10} reductions. A PM_{10} reduction was not estimated for hardboard ovens or secondary tube dryers because no information was available for estimating uncontrolled PM_{10} emissions from these sources.

TABLE 5-3. CALCULATION OF PM_{10} REDUCTION ASSOCIATED WITH THE PCWP STANDARDS FOR VARIOUS PROCESS UNITS

Process unit	Average throughput[a]	Throughput units	Filterable PM_{10} emission factor[b]	Condensible PM emission factor[b]	Emission factor units	Total uncontrolled PM_{10} (tpy)[c]	PM_{10} reduction if particulate controls already used (tpy)[f]	PM_{10} reduction if particulate controls not already used (tpy)[g]	Note
MDF tube dryer	87,000	ODT/yr	1.6	0.59	lb/ODT	95	23	76	
Hardboard tube dryer	58,000	ODT/yr	1.6	0.59	lb/ODT	64	15	51	
Softwood veneer dryer	71,000	MSF/yr 3/8"	0.35	1	lb/MSF 3/8"	48	12	38	d
OSB rotary dryer	65,000	ODT/yr	4.2	1.9	lb/ODT	198	48	159	d
Green particle rotary dryer	70,000	ODT/yr	0.69	0.83	lb/ODT	53	13	43	e
OSB conveyor dryer	88,000	ODT/yr	0.062	0.028	lb/ODT	4.0	1.0	3.2	
Hardboard press	163,000	MSF/yr 1/8"	0.086	0.12	lb/MSF 1/8"	17	4.0	13	
MDF press	71,000	MSF/yr 3/4"	0.15	0.2	lb/MSF 3/4"	12	3.0	10	
OSB press	284,000	MSF/yr 3/8"	0.11	0.15	lb/MSF 3/8"	37	8.9	30	
PB press	85,000	MSF/yr 3/4"	0.016	0.23	lb/MSF 3/4"	10	2.5	8.4	

a Average through puts are documented in reference 1.
b Emission factors were selected for the types of units most commonly used for which emission factors were available in reference 4.
c Total uncontrolled PM_{10} is calculated as follows: Total PM_{10} = (filterable PM_{10} + condensible PM) x (average throughput) / 2000.
d The filterable PM emission factor was used instead of an emission factor for filterable PM_{10} because no PM_{10} factor was available. Use of the filterable PM emission factor overestimates PM_{10} emissions.
e The filterable PM_{10} emission factor used is for a dry rotary dryer because no emission factor was available for the green rotary dryer.
f PM_{10} reduction if particulate controls are already in place was calculated as follows: PM reduction = total uncontrolled PM_{10} x (1 - 0.7) x 0.8.
g PM_{10} reduction if particulate controls are not already in place was calculated as follows: PM reduction = total uncontrolled PM_{10} x 0.8.

As mentioned earlier, a plant-by-plant approach was used to estimate environmental impacts. The PM_{10} reductions presented in Table 5-3 were applied to each process unit that would likely need controls to meet the PCWP standards based on the MACT floor control level. The PM_{10} reduction for process units with particulate controls already in place was applied for process units with controls such as baghouses, sand filters, scrubbers, EFB, wet or dry ESP, multiclones, or semi-incineration. The PM_{10} reduction for units without particulate controls was applied to units with no particulate controls or cyclones only. The PM_{10} reduction associated with two veneer dryers was assumed for the plywood plants that claimed the number of process units confidential. The plant-specific PM_{10} reduction associated with the PCWP standards was calculated by summing the PM_{10} reductions for all process units. The nationwide PM_{10} reduction was calculated by summing the reductions for each plant. Section 5.5 summarizes the estimated nationwide PM_{10} reduction.

5.1.2.2 <u>NO_X Emissions</u>. As discussed in Chapter 3, NO_X is formed when nitrogen (from ambient air or fuel) is exposed the high temperatures in the presence of oxygen (i.e., through combustion processes). Nitrogen oxides are present in the exhaust streams from PCWP process units that incorporate combustion units (e.g., direct-fired dyers). Because RTO use combustion to destroy pollutants, they may also generate some NO_X.. The total amount of NO_X emitted includes the NO_X emissions from the PCWP process unit plus the NO_X generated in the RTO.

The NO_X air impacts associated with the PCWP standards result from the increase in NO_X emissions across the RTO. Vendor literature indicates that the typical NO_X increase across an RTO can range up to 10 ppmv.[7,9,10] The following equation was used to estimate the annual increase in NO_X (as NO_2) for RTO:

$$NO_X \text{ increase (ton/yr)} = (8{,}000 \text{ hr/yr}) \times (10 \text{ ppm}) \times (10^{-6}) \times (46.01 \text{ lb } NO_2/\text{lbmole}) \times (\text{dscfm}) \times (60 \text{ min/hr}) / (385.3 \text{ ft}^3/\text{lbmole ideal gas at } 528°\text{R}) / (2000 \text{ lb/ton})$$

The above equation was applied to estimate the NO_X increase for each RTO expected to be installed as a result of the PCWP standards. The plant-specific NO_X increase was calculated by summing the NO_X increase for each RTO, and the nationwide NO_X increase was calculated by summing the plant-specific NO_X increases. Section 5.5 summarizes the estimated nationwide NO_X increase associated with the use of RTO. The NO_X emission estimates presented in Section 5.5 do not account for the baseline NO_X emissions generated by PCWP process units.

5.1.2.3 CO Emissions. By combusting process exhaust, RTO can either generate or destroy emissions of CO depending on the process unit controlled. Whether there is a net increase or decrease in CO across an RTO depends on the amount of CO entering the RTO. Carbon monoxide is a product of incomplete combustion formed when there is not sufficient time at high enough temperature to allow for complete oxidation of the CO to carbon dioxide (CO_2). Although combustion systems are designed to minimize formation of CO, a small amount of CO will always be formed. Carbon monoxide is present in the exhaust from direct-fired PCWP process units. As the exhausts from direct-fired process units enter an RTO, most of the CO in the process exhaust is easily oxidized to CO_2 under the RTO combustion temperatures. For direct-fired process units, much more CO is destroyed than is formed in an RTO, resulting in a net decrease in CO emissions. There is much less CO in the exhausts from indirect-heated PCWP process units (e.g., veneer dryers, presses) than there is in the exhausts from direct-fired process units. For indirect-heated PCWP process units, it appears that an RTO can form more CO than it destroys, resulting in a net increase in CO emissions. Table 5-4 presents increases in CO across RTO documented in vendor literature for veneer dryers and presses.

TABLE 5-4. CO INCREASES ACROSS RTO

Process unit	Increase in CO across RTO, ppmv	Reference[a]
Veneer dryer	30	9
MDF press	3	8
OSB press	11	6

[a] See Section 5.6 for a list of references.

The following equation was used to estimate the annual increase in CO for RTO used to control the sources listed in Table 5-4:

CO increase (ton/yr) = (8,000 hr/yr) x (ppm increase from Table 5-4) x (10^{-6}) x (28 lb CO/lbmole) x (dscfm) x (60 min/hr) / (385.3 ft^3/lbmole ideal gas at 528°R) / (2000 lb/ton)

The CO concentration increase for MDF presses was also applied for particleboard presses because particleboard presses operate at temperatures similar to those for MDF presses.

Likewise, the OSB press CO concentration increase was also applied to hardboard presses because hardboard presses operate at temperatures similar to OSB presses.

Table 5-5 presents several reported percent reductions in CO across RTO. Using the information in Table 5-5, it was determined that RTO reduce CO emissions from direct-fired dryers by 80 percent on average.

TABLE 5-5. PERCENT REDUCTION IN CO EMISSIONS ACROSS DIRECT-FIRED DRYER RTO

Dryer type	% reduction	Reference[a]
OSB	31	3
OSB	95	3
OSB	88	3
OSB	80	3
OSB	78	3
OSB	83	3
OSB	91	3
OSB	90	3
OSB	58	7
MDF	88.3	9
MDF	80	9
OSB	95	9
OSB	88	9
Average	80	

[a] See Section 5.6 for a list of references.

Table 5-6 shows the calculated CO reductions for various types of process units. A CO reduction was not estimated for conveyor-type strand dryers, hardboard ovens, or secondary tube dryers because no information was available for estimating uncontrolled CO emissions from these sources. For RTO that are shared by dryers and presses, the increase in CO associated with the press exhaust was summed with the decrease in CO associated with the dryer exhaust.

Using a plant-by plant approach, the CO increases described above and the reductions presented in Table 5-6 were applied to each process unit that would likely install an RTO to meet the PCWP standards. The nationwide change in CO emissions associated with the PCWP standards was calculated as the total of the CO increases and reductions for all process units. Section 5.5 summarizes the estimated nationwide change (net reduction) in CO emissions.

TABLE 5-6. CALCULATION OF CO REDUCTION ASSOCIATED WITH THE PCWP STANDARDS FOR VARIOUS PROCESS UNITS

Process unit	Average throughput[a]	Throughput units	CO emission factor[b]	Emission factor units	Uncontrolled CO (tpy)[c]	CO reduction (tpy)[d]
MDF tube dryer	87,000	ODT/yr	0.11	lb/ODT	5	3.8
Hardboard tube dryer	58,000	ODT/yr	0.067	lb/ODT	2	1.6
OSB rotary dryers	65,000	ODT/yr	5.4	lb/ODT	176	140
Green particle rotary dryer	70,000	ODT/yr	3.5	lb/ODT	123	98

[a] Average throughputs are documented in reference 1.
[b] Emission factors were selected for the types of units most commonly used for which emission factors were available in reference 4.
[c] The uncontrolled CO emissions were calculated as follows: Uncontrolled CO = (average throughput) x (CO emission factor) / 2000.
[d] The CO reduction was calculated as follows: CO reduction = uncontrolled CO x 0.8.

5.1.3 Secondary Air Impacts

Emissions of criteria air pollutants are produced from generation of the electricity necessary to power control devices. The secondary air impacts associated with increased electricity consumption were estimated. Energy Information Administration statistics indicate that most of the existing U.S. electric utility capacity uses coal as the energy source.[11] Therefore, electricity was assumed to be generated at coal-fired utility plants built since 1978. Utility plants built since 1978 are subject to the new source performance standards (NSPS) in 40 CFR part 60, subpart Da.[12] The NSPS were used to estimate the SO_2, PM_{10}, and NO_X (as NO_2) emissions from coal combustion. The CO emissions were estimated using an AP-42 emission factor because CO emissions are not covered by the NSPS.[13] The power plant thermal efficiency (i.e., the efficiency with which coal is converted into electricity) was taken to be one-third, based on a typical value for fossil fuel power plants reported in literature.[14] The heating value for bituminous coal (the type of coal most commonly used for electricity generation) was taken to be 12,750 Btu/lb coal, as fired.[13,15]

The NSPS emission limits for coal-fired utilities for SO_2, PM, and NO_X (as NO_2) are, respectively, 1.20, 0.03, and 0.60 lb pollutant per MMBtu heat input. (Note: Use of the NSPS emission limit for PM overstates the secondary air pollutant emissions for PM_{10}. According to AP-42, PM_{10} is about 37 percent of the total PM.[13]) The following equation was used to calculate the annual secondary air emissions of SO_2, PM, and NO_X:

$$EM = EL \times 10^{-6} \times E / TE \times (3{,}415\ \text{Btu/kWh}) / (2{,}000\ \text{lb/ton})$$

where:

EM = emissions, tons per year

EL = NSPS emission limit, lb pollutant per million Btu heat input (1.20 for SO_2, 0.03 for PM, and 0.60 for NO_X as NO_2)

TE = thermal efficiency of power plant (33 percent)

E = plant-specific RTO and/or WESP electricity consumption calculated as described in Section 5.4, kWh/yr

The following equation was used to calculate the annual secondary CO emissions:

$$EM = EF \times E / TE / (12{,}750\ \text{Btu/lb coal fired}) \times (3415\ \text{Btu/kWh}) / (2{,}000\ \text{lb/ton})^2$$

where:

EM = emissions, tons per year

EF = 0.5 lb CO per ton coal fired

E = plant-specific RTO and/or WESP electricity consumption calculated as described in Section 5.4, kWh/yr

The plant-specific secondary air impacts associated with the PCWP standards were calculated by summing the impacts estimated for each RTO and/or WESP expected to be installed at each plant. The nationwide secondary air impacts were calculated by summing the plant-specific impacts. Section 5.5 summarizes the estimated nationwide secondary air impacts.

5.2 WASTEWATER IMPACTS

Potential wastewater impacts associated with the use of RTO and WESP include disposal of the washwater generated during RTO washouts and disposal of WESP blowdown. The WESP blowdown is the fraction of the recirculated WESP water that is purged from the WESP system. Wastewater impacts were based on use of RTO, although other control devices, such as biofilters, are also sources of wastewater. The wastewater impacts for RTO and WESP were estimated using information from the MACT survey responses and WESP vendor information.

Some facilities wash out RTO media beds to prevent buildup of particulates in the RTO. Other facilities can remove the particulates with routine bakeouts of the RTO beds without having to perform periodic washouts. The amount of wastewater generated during washout of an RTO depends on the size of the RTO and the extent of the particulate buildup. The MACT survey responses contain information on the frequency of RTO washouts and the amount of wastewater generated during the washouts. This information was used to determine the annual wastewater used by plants that perform washouts. Table 5-7 summarizes the annual wastewater generation rates for different process units.[16]

TABLE 5-7. ANNUAL WASTEWATER GENERATION RATES FOR RTO WASHOUTS[16]

Process unit	Annual RTO washwater generated, gal/yr
Rotary dryers (particle or strand)	39,000
Particleboard and OSB presses	15,000
Multiple hardboard process units	21,000
Average from all MACT survey responses that included information for RTO washwater volume	32,000

To approximate the annual amount of wastewater generated during washing out of RTO, it was assumed that washouts would be performed on all RTO. The average annual wastewater generation rates were applied according to the process units controlled by each RTO. If the RTO would control emissions from both a rotary dryer and a press, then the rotary dryer washwater amount (39,000 gpy) was applied. For RTO on sources for which no average waste water generation rate was available (e.g., veneer dryers or MDF process units), the industry average (32,000 gal/yr) was applied.

The annual amount of WESP blowdown was determined based on the 1-gpm blowdown system described by the WESP vendor that supplied inputs for the cost algorithm described in

Chapter 4, Section 4.1.2.1. Using 8,000 hr/yr, a 1-gpm blowdown system would produce 480,000 gal/yr wastewater. This wastewater is typically routed to a settling pond for solids removal and is disposed of by evaporation or spray irrigation or is sent to a municipal wastewater treatment plant. Because OSB mills are generally designated as zero discharge facilities, they must treat their own spray water and/or consume it internally. Mills that operate boilers or other wet cell burners can apply some of the spent spray water to the fuel. Some or all of the remaining spray water may be used as makeup water in hot ponds or in debarkers for dust control.[3]

The total amount of wastewater expected to be generated by each plant as a result of the PCWP standards was calculated as the sum of the wastewater generated from each control device. The nationwide wastewater impacts were calculated by summing the wastewater impacts for each plant. Section 5.5 summarizes the nationwide wastewater impacts.

5.3 SOLID WASTE IMPACTS

Potential solid waste impacts associated with the use of RTO and WESP include disposal of the RTO packing media and disposal of WESP wastewater solids or sludge. The solid waste impacts were estimated for RTO and WESP using information from the MACT survey responses and State permits.

The responses to EPA's MACT survey from plants operating RTO indicate that RTO packing media is typically replaced after 1 to 4 years of use. The packing media is generally disposed of in a landfill or is reused on the plant site (e.g., as aggregate in roadbeds).[16] For purposes of estimating RTO solid waste impacts, it was assumed that the RTO packing media would be replaced every 2 years. No information on the volume or mass of RTO packing media was requested in the EPA's MACT survey. Therefore, the mass of RTO media to be replaced was approximated based on drawings of an RTO in a State permit. The RTO described in the permit has 47,322 scfm cylindrical towers that are 12-ft high with an 11-ft inside diameter. Thus, the volume of each tower is 1,140 ft^3.[17] Ceramic saddles are commonly used as RTO packing media. The weight of 1 to 1-1/2-inch ceramic saddles is about 40 lb/ft^3.[18] Thus, a factor relating mass of RTO media to RTO flow was developed as follows:

$$(1{,}140\ ft^3/47{,}322\ scfm) \times (40\ lb/ft^3) \times (ton/2{,}000\ lb) = 4.82E\text{-}04\ tons\ packing\ media/scfm$$

This factor was divided by 2 (because media replacement was assumed to occur every 2 years) and applied to each RTO to approximate the annual mass of RTO media to be disposed.

The mass of WESP solids to be disposed was estimated as described in Chapter 4, Section 4.1.2.2. As described in Section 4.1.2.2, the wastewater percent solids was assumed to be 7.6 percent (by volume) based on the average from the MACT survey responses. The density of the solids was assumed to be 0.5 ton/yd^3. For a 1-gpm blowdown system, the mass of WESP solids generated was estimated as follows:

$$(1 \text{ gal/min}) \times (60 \text{ min/hr}) \times (8{,}000 \text{ hr/yr}) \times (0.076 \text{ volume \% solids}) / (7.481 \text{ gal/ft}^3) / (27 \text{ ft}^3/\text{yd}^3) \times (0.5 \text{ ton/yd}^3) = 90 \text{ tons solids/year}$$

Thus, for each WESP likely to be installed on a rotary strand dryer as a result of the PCWP standards, it was assumed that 90 tons of solids per year would require disposal. It was assumed that the solids would ultimately be disposed of in a landfill (although they could be burned onsite or used for soil amendment).

The plant-specific amount of solid waste expected to be generated as a result of the PCWP standards was calculated as the sum of the solid waste generated from each RTO or WESP. The nationwide solid waste impacts were calculated by summing the solid waste impacts for each plant. Section 5.5 summarizes the nationwide solid waste impacts.

5.4 ENERGY IMPACTS

Energy impacts associated with the PCWP rulemaking include fuel and electricity use by control devices such as RTO or WESP. Natural gas is the most common fuel used in RTO. The RTO natural gas and electricity consumption was determined using the relationships presented in Figures 4-3 and 4-4 in Chapter 4, Section 4.1.1.2 and assuming 8,000 hr/yr of operation. The relationships were applied to each of the RTO likely to be installed as a result of the PCWP standards. The annual WESP electricity consumption (2,076,000 kWh/yr) presented in Section 4.1.2.2 was used for each WESP to be installed. The control device energy consumption was totaled for each plant, and the plant totals were summed to calculate the nationwide energy impacts associated with the PCWP standards. Section 5.5 summarizes the nationwide energy impacts.

5.5 SUMMARY OF NATIONWIDE ENVIRONMENTAL AND ENERGY IMPACTS

Table 5-8 summarizes the nationwide reduction in total HAP and THC estimated to result from the PCWP standards at the MACT floor control level. Table 5-9 summarizes the nationwide change in emissions of primary criteria air pollutants and the secondary air impacts associated with the MACT floor control level. Table 5-10 summarizes the nationwide wastewater and solid waste impacts, and Table 5-11 summarizes the nationwide energy impacts. Each of the tables present the nationwide environmental and energy impacts by product type. See Table 4-4 in Chapter 4, Section 4.1.5 for a summary of the number of plants, number of plants impacted, and process units controlled for each product type.

TABLE 5-8. ESTIMATED NATIONWIDE REDUCTION IN TOTAL HAP AND THC

Product type	Total HAP (ton/yr)			THC (ton/yr)		
	Baseline	MACT floor	Reduction	Baseline	MACT floor	Reduction
Softwood plywood/veneer	3,700	3,043	657	19,631	9,709	9,922
Hardwood plywood/veneer	161	161	0[b]	640	640	0[b]
Medium density fiberboard	2,469	345	2,124	4,763	572	4,191
Oriented strandboard	3,513	753	2,760	5,362	1,755	3,607
Particleboard (molded and conventional)	5,377	2,787	2,590	12,632	6,724	5,908
Particleboard (agriboard)	not estimated[a]	not estimated[a]	0[b]	not estimated[a]	not estimated[a]	0[b]
Hardboard	3,291	752	2,539	5,478	2,103	3,374
Fiberboard	78	78	0[b]	398	398	0[b]
Engineered wood products	298	230	68	793	617	176
TOTAL	18,933	8,196	10,737	49,706	22,529	27,178

[a] Baseline emissions were not estimated for agriboard plants because sufficient data was not available to estimate the baseline emissions. However, agriboard plants are not impacted by the PCWP standards because none are believed to be major sources of HAP emissions. Because agriboard plants are not impacted by the PCWP standards, there are no environmental or energy impacts for agriboard plants resulting from the standards.

[b] There is no impact because no plants are impacted by the PCWP standards at the MACT floor control level.

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TABLE 5-9. ESTIMATED NATIONWIDE CHANGE IN NOX, CO, AND PM_{10} EMISSIONS AND ESTIMATED NATIONWIDE SECONDARY AIR IMPACTS

Product type	Criteria Pollutant Impacts (ton/yr)			Secondary Air Impacts (ton/yr)			
	NO_X	CO[a]	PM_{10}[a]	NO_X	CO	PM_{10}	SO_2
Softwood plywood/veneer	700	1,278	(5,070)	321	10	16	642
Hardwood plywood/veneer	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
Medium density fiberboard	855	(162)	(1,823)	388	13	19	775
Oriented strandboard	880	(4,386)	(2,214)	457	15	23	914
Particleboard (molded and conventional)	1,304	(7,253)	(2,044)	592	19	30	1,183
Particleboard (agriboard)	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
Hardboard	926	17	(1,357)	420	14	21	839
Fiberboard	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
Engineered wood products	86	(267)	(176)	52	2	3	104
TOTAL	4,751	(10,772)	(12,684)	2,229	73	111	4,457

[a] Negative numbers representing emission reductions are presented in parentheses. Numbers outside of parentheses represent emissions increases.

[b] There is no impact because no plants are impacted by the PCWP standards at the MACT floor control level.

TABLE 5-10. ESTIMATED NATIONWIDE SOLID WASTE AND WASTEWATER IMPACTS

Product type	Solid Waste Impacts (ton/yr)		Wastewater Impacts (1,000 gal/yr)	
	RTO media	WESP wastewater solids[a]	RTO washwater	WESP blowdown[a]
Softwood plywood/veneer	589	NA	2,112	NA
Hardwood plywood/veneer	0[b]	0[b]	0[b]	0[b]
Medium density fiberboard	719	NA	832	NA
Oriented strandboard	740	810	768	4,320
Particleboard (molded and conventional)	1,096	NA	1,677	NA
Particleboard (agriboard)	0[b]	0[b]	0[b]	0[b]
Hardboard	779	NA	630	NA
Fiberboard	0[b]	0[b]	0[b]	0[b]
Engineered wood products	72	180	156	960
TOTAL	3,995	990	6,175	5,280

[a] WESP wastewater solids and blowdown are only estimated for plants with rotary strand dryers (i.e., OSB and engineered wood products plants)
[b] There is no impact because no plants are impacted by the PCWP standards at the MACT floor control level.

TABLE 5-11. ESTIMATED NATIONWIDE ENERGY IMPACTS

Product type	RTO natural gas comsumption (Billion Btu/yr)	RTO electricity consumption (GWh/yr)	WESP electricity consumption (GWh/yr)[b]
Softwood plywood/veneer	175	103	NA
Hardwood plywood/veneer	0[c]	0[c]	0[c]
Medium density fiberboard	346	125	NA
Oriented strandboard	269	129	19
Particleboard (molded and conventional)	434	191	NA
Particleboard (agriboard)	0[c]	0[c]	0[c]
Hardboard	385	135	NA
Fiberboard	0[c]	0[c]	0[c]
Engineered wood products	29	13	4
TOTAL[a]	1,638	695	23

[a] Totals may not sum exactly due to rounding.
[b] WESP electricity consumption is only estimated for plants with rotary strand dryers (i.e., OSB and engineered wood products plants).
[c] There is no impact because no plants are impacted by the PCWP standards at the MACT floor control level.

5.6 REFERENCES FOR CHAPTER 5

1. Memorandum from K. Hanks and D. Bullock, MRI, to M. Kissell, EPA/ESD. June 9, 2000. Baseline Emission Estimates for the Plywood and Composite Wood Products Industry.

2. Memorandum from B. Nicholson and K. Hanks, MRI, to M. Kissell, EPA/ESD. July 13, 2000. Determination of MACT floors and MACT for the Plywood and Composite Wood Products Industry.

3. Emission Factor Documentation for AP-42 Section 10.6.1, Waferboard/Oriented Strandboard Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. December 1998.

4. Memorandum from D. Bullock and K. Hanks, MRI, to M. Kissell, EPA/ESD. April 27, 2000. Documentation of Emission Factor Development for the Plywood and Composite Wood Products Manufacturing NESHAP.

5. Report for 1996 PM_{10} Emission Measurements for Emission Reduction Credits, SierraPine, Ltd., Rocklin, CA, Test Dates November 19-26, 1996. Prepared for SierraPine, Ltd., by Carnot. April 1997.

6. Emission Factor Documentation for AP-42 Section 10.6.2, Particleboard Manufacturing. Prepared for the U. S. Environmental Protection Agency, OAQPS/EFIG, by Midwest Research Institute. Cary, NC. September 1998.

7. Smith Environmental Corporation. Environmental Newsletter for the Wood Industry. August 1994.

8. Air Permit Application Review/Preliminary Determination for Hominant USA, Incorporated thin high density fiberboard (THDF) greenfield facility in Mount Gilead, NC. Application No. 6200061.99A. March 6, 2000.

9. Smith Engineering Corporation. Wood Industry Environmental Newsletter. March 1994.

10. R. Grzanka, REECO. An Engineered Solution for Fugitive Emissions Control from Three Veneer Dryers at a Plywood Plant. Undated.

11. Energy Information Administration, Form EIA-860A. Annual Electric Generator Report – Utility.

12. 40 CFR Part 60. Subpart Da.

13. Compilation of Air Pollutant Emission Factors, AP-42, 5th Edition, Supplement E. U. S. Environmental Protection Agency. Research Triangle Park, NC. Volume I: Stationary Point and Area Sources. Section 1.1: Bituminous and Subbituminous Coal Combustion. September 1998.

14. Carbon Dioxide Emissions from the Generation of Electric Power in the United States. Washington, DC, U.S. Department of Energy and U. S. Environmental Protection Agency, Washington, D.C. October 15, 1999.

15. R.H. Perry and D.W. Green, Eds. Perry's Chemical Engineers' Handbook. 6th Edition. New York, McGraw-Hill. 1984. pp. 9-18.

16. Memorandum from D. Bullock, K. Hanks, and B. Nicholson, MRI, to M. Kissell, EPA/ESD. April 28, 2000. Summary of Responses to the 1998 EPA Information Collection Request (MACT Survey) – General Survey.

17. Letter from C. Parham, J.M. Huber Corporation, to E. Cornwell, Georgia Department of Natural Resources, Environmental Protection Division, Air Protection Branch. February 23, 1996. Permit Application for the RTO on the Board Press Exhaust – Permit No. 2493-078-10583.

18. Rauschert Process Technologies. Webpage for ceramic tower packing: http://208.24.91.247/process_technologies/stpk.html, May 15, 2000.

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16. ABSTRACT This background information document (BID) was prepared to support development of national emission standards for hazardous air pollutants (NESHAP) for the plywood and composite wood products (PCWP) manufacturing industry. Plywood and composite wood products include particleboard, oriented strandboard (OSB), medium density fiberboard (MDF), fiberboard, hardboard, softwood plywood, softwood veneer, hardwood plywood, hardwood veneer, laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), wood I-joists, glue-laminated beams, and other engineered wood products. These PCWP are generally manufactured by adhering wood pieces (e.g., particles, fibers, flakes, veneers, or lumber) with glue or other binder and pressing into a consolidated product.

The purpose of this document is to present information on PCWP manufacturing related to the hazardous air pollutants (HAP) emitted from PCWP processes and HAP control strategies. This document contains the following: (1) description of PCWP manufacturing processes and process units; (2) description of the air pollution control devices (APCD) used to reduce HAP emissions; (3) summary of nationwide counts of process units and APCD; (4) summary of nationwide and per-process-unit average HAP emission estimates; (5) summary of the HAP reduction capabilities of APCD; (6) nationwide costs associated with the PCWP rulemaking; and (7) nationwide environmental and energy impacts associated with the PCWP rulemaking.

Much of the information presented in this document is based on detailed information documented in supporting memoranda. Section 1.2 describes the information sources used to develop this document and introduces the additional supporting memoranda.

17. KEY WORDS AND DOCUMENT ANALYSIS		
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Proposed Rule - Clean Air Plywood and Composite Wood Products	Air Pollution control, particleboard, oriented strandboard (OSB), medium density fiberboard (MDF), fiberboard, hardboard, softwood plywood, softwood veneer, hardwood plywood, hardwood veneer, laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), wood I-joists, glue-laminated beams, engineered wood products, hazardous air pollutants	
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