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EPA Office of Compliance Sector Notebook Project

Profile of the Lumber and Wood Products Industry

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Cover photograph by Steve Delaney, U.S. EPA.

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EPA/310-R-95-018.	Transportation Equipment Cleaning Industry	Virginia Lathrop	564-7057

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LUMBER AND WOOD PRODUCTS
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LIST OF ACRONYMS

ACZA - Ammoniacal Copper Zinc Arsenate
AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CCA - Chromated Copper Arsenate
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
EPA - United States Environmental Protection Agency
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HB - Hardboard
IDEA - Integrated Data for Enforcement Analysis (Enforcement Database)
LDR - Land Disposal Restrictions (RCRA)
LVL - Laminated Veneer Lumber
MACT - Maximum Achievable Control Technology (CAA)
MDI - Methylenediphenyl Diisocyanate
MDF - Medium density Fiberboard
NAAQS - National Ambient Air Quality Standards (CAA)
NaOH - Sodium Hydroxide
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NESHAP - National Emission Standards for Hazardous Air Pollutants
NSPS - New Source Performance Standards (CAA)
NO_x - Nitrous Oxides
NPDES - National Pollution Discharge Elimination System (CWA)
OAR - Office of Air and Radiation
OPA - Oil Pollution Act
OECA - Office of Enforcement and Compliance Assurance
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSB - Oriented Strand Board
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention

LUMBER AND WOOD PRODUCTS
(SIC 24)
LIST OF ACRONYMS (CONT'D)

PB -	**Particleboard**
PCP -	**Pentachlorophenol**
PCS -	**Permit Compliance System (CWA Database)**
PF -	**Phenol-Formaldehyde**
PM -	**Particulate Matter**
RCRA -	**Resource Conservation and Recovery Act**
RCRIS -	**RCRA Information System**
SDWA -	**Safe Drinking Water Act**
SO_x -	**Sulfur Oxides**
TGNMO	**Total Gaseous Nonmethane Organics**
TRI -	**Toxic Release Inventory**
TRIS -	**Toxic Chemical Release Inventory System**
TSCA -	**Toxic Substances Control Act**
UF -	**Urea-Formaldehyde**
UIC -	**Underground Injection Control (SDWA)**
UST -	**Underground Storage Tanks (RCRA)**
VOCs -	**Volatile Organic Compounds**

LUMBER AND WOOD PRODUCTS (SIC 24)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water, and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, States, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate, and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or States may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages State and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested States may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with State and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE LUMBER AND WOOD PRODUCTS INDUSTRY

II.A. Introduction, Background, and Scope of the Notebook

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the lumber and wood products industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes. Additionally, this section contains a list of the largest companies in terms of sales.

The lumber and wood products industry includes establishments engaged in cutting timber and pulpwood; sawmills, lath mills, shingle mills, cooperage stock mills (wooden casks or tubs), planing mills, plywood mills; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or related materials such as reconstituted wood panel products manufacturers. The categorization corresponds to the Standard Industrial Classification (SIC) code 24 established by Department of Commerce's Bureau of the Census to track the flow of goods and services within the economy. It should be noted that silviculture (development and care of forests) and the preparation of forested areas for logging is covered by SIC 08 (forestry) and is not addressed in this industry profile.

In this profile, the industry's processes are divided into four general groups: logging timber; producing lumber; panel products and wood preserving. The Bureau of the Census estimates that in 1992, employment in these principal categories totaled approximately 306,700 (See Exhibit 1 for facility employment size distribution). This does not include the additional employment generated by the wood container, structure wood member, wood kitchen cabinet, and wood building/mobile home sectors. Shipments increased less than one percent in 1993, to an estimated $78.1 billion. Sawmills and planing mills (SIC 242) accounted for $24.8 billion (31 percent) of industry shipments in 1993. Logging (SIC 241) added an additional $15.6 billion (17.8 percent).

The Department of Commerce provides the following three-digit breakout for lumber and wood products industries in SIC 24:

SIC 241 - Logging
SIC 242 - Sawmills and Planing Mills
SIC 243 - Millwork, Veneer, Plywood, and Structural Wood Members
SIC 244 - Wood Containers
SIC 245 - Wood Buildings and Mobile Homes
SIC 249 - Miscellaneous Wood Products.

The main end use market for the industry's products is the new construction and remodeling sectors.

This profile covers logging, sawn lumber production, panel products including veneer and plywood manufacture and reconstituted wood panel manufacture (which includes particleboard (PB), hardboard (HB), medium density fiberboard (MDF), and oriented strand board(OSB)), engineered lumber, and wood preserving. Each of these are discussed in greater detail later in the profile. This profile does not address production processes, pollution outputs, or regulatory information for the following three-digit industries contained in SIC 24: Wood Containers (SIC 244), Wood Buildings and Mobile Homes (SIC 245), and some areas of Miscellaneous Wood Products (SIC 249).

II.B. Characterization of the Lumber and Wood Products Industry

The discussion of the characterization of the lumber and wood products industry is divided into the following topics: industry size and geographic distribution; identification of the largest U.S. facilities in the industry by capacity; and industry economic trends.

II.B.1. Industry Size and Distribution

Variation in facility counts occur across data sources due to many factors, including reporting and definition differences. This document does not attempt to reconcile these differences, but rather reports the data as they are maintained by each source.

Geographic Distribution

Most of the wood products industry is concentrated in the Pacific Northwest and the Southeast. However, concentrations are also found across the Midwest, the Northeast, and in Appalachia (See Exhibits 2 and 3). Approximately 1/3 of the U.S. is forested. Of this forested area, two-thirds (480 million acres) contain at least 20 cubic feet of commercially usable wood per year per acre, the threshold for determining whether timberland could be commercially productive. The area east of the Mississippi still contains a significant amount of forested acreage; 155 million acres are in the Northern States and 195 million acres are in the South. About 130 million acres of forested land is in Western States. Exhibit 4 illustrates the largest lumber and wood products facilities in the U.S. by capacity.

Exhibit 1
Industry Facility Size Distribution - 1992

Type of Facility	Facilities with 1 to 19 employees	Facilities with 20 to 99 employees	Facilities with 100 or more employees	Total
SIC 2411 - Logging	12,283	691	36	13,010
SIC 2421 - Lumber	4,400	1,283	321	6,004
SICs 2435 & 2436 - Hardwood, Softwood Plywood, Veneer	147	208	164	519
SIC 2491 - Wood Preserving	307	168	11	486
SIC 2493 - Reconstituted Wood Products	108	80	100	288

Source: Based on 1992 Bureau of the Census Data.

Exhibit 2
Geographic Distribution of Industry
Total Number of Lumber and Wood Products Facilities per State*

Source: Based on 1987 Bureau of the Census Data. 1992 Bureau of the Census Data on State breakdown was not available at the time of publication.
**Note: Exhibit represents all industries within SIC 24.*

Exhibit 3
Geographic Distribution of Industry
Breakdown of Lumber and Wood Facilities by State

Type of Facility	Number of Facilities Per State
Logging	AL-957, AK-37, AR-403, CA-525, FL-346, GA-796, ID-321, KY-95, LA-413, ME-439, MI-341, MN-176, MS-531, MT-312, NH-130, NH-130, NY-209, NC-677, OH-128, OR-1,293, PA-257, SC-559, TN-128, TX-297, VA-444, WA-597, WV-185, WI-384
Sawmills and Planning Mills	AL-212, AZ-17, AR-218, CA-278, CO-48, CT-34, FL-94, GA-216, ID-100, IL-75, IN-155, KY-185, LA-104, ME-141, MD-58, MA-89, MI-219, MN-96, MS-213, MO-237, MT-68, NH-83, NM-27, NY-231, NC-554, OH-172, OK-50, OR-309, PA-448, SC-126, SD-17, TN-345, TX-116, UT-26, VT-78, VA-370, WA-381, WV-188, WI-206, WY-28
Millwood, Plywood and Structural Members	AL-158, AZ-146, AR-85, CA-1,145, CO-140, CT-122, FL-661, GA-260, ID-66, IL-224, IN-213, IA-54, KS-70, KY-78, LA-77, ME-31, MD-86, MA-172, MI-192, MN-165, MS-73, MO-144, MT-30, NE-47, NV-42, NH-47, NJ-165, NM-62, NY-378, NC-294, OH-225, OK-49, OR-298, PA-315, RI-28, SC-105, SD-21, TN-153, TX-412, UT-82, VT-30, VA-185, WA-273, WV-26, WI-206
Wood Containers	AL-56, AR-39, CA-204, FL-37, GA-69, IL-13, IN-103, KY-71, MI-144, MN-36, MS-39, MO-85, NJ-46, NY-82, NC-80, OH-172, OR-26, PA-155, SC-38, TN-87, TX-85, VA-54, WA-30, WI-83
Wood Buildings and Mobile Homes	AL-46, AZ-20, CA-87, CO-11, DE-2, FL-68, GA-53, ID-13, IL-25, IN-55, KS-12, ME-12, MD-13, MA-18, MI-34, MN-20, MS-12, MO-21, NE-7, NH-20, NY-27, NC-51, OH-36, OR-23, PA-72, TN-32, TX-74, VA-31, WA-18, WI-34
Miscellaneous Wood Products	AL-113, AR-84, CA-432, FL-161, GA-128, ID-43, IL-147, IN-96, IA-27, KY-46, LA-58, ME-91, MD-36, MA-93, MI-141, MN-79, MS-96, MO-102, NH-72, NJ-71, NM-16, NY-210, NC-202, OH-143, OK-26, OR-159, PA-181, SC-68, TN-88, TX-195, VT-115, WA-123, WV-36, WI-119

*Source: Based on 1987 Bureau of the Census Data.**

**1992 Bureau of Census Data on State breakdown was not available at the time of publication.*

Exhibit 4
Largest U.S. Lumber and Wood Products Facilities by Capacity (1993)

	Lumber Production
1.	Weyerhaeuser Co.
2.	Georgia-Pacific Corp.
3.	Louisiana-Pacific Corp.
4.	Sierra Pacific Industries
5.	International Paper Co.
6.	Boise Cascade Corp.
7.	Pope & Talbot Inc.
8.	MacMillan Bloedel Ltd.
9.	WTD Industries Inc.
10.	Simpson Timber Co.

	Softwood Veneer
1.	Scotch Plywood Co. of Alabama
2.	Stone Forest Industries Inc.
3.	Freres Lumber Co. Inc.
4.	Sun Studs Inc.
5.	Plum Creek Manufacturing, L.P.
6.	Hunt Plywood Co. Inc.
7.	Omak Wood Products, Inc.
8.	Roseburg Forest Products
9.	Green Veneer Inc.
10.	WTD Industries Inc.

	Softwood Plywood
1.	Georgia-Pacific Corp.
2.	Willamette Industries Inc.
3.	Boise Cascade Corp.
4.	Louisiana-Pacific Corp.
5.	Roseburg Forest Products Co.
6.	Weyerhaeuser Co.
7.	Champion International
8.	International Paper Co.
9.	Stimson Lumber Co.
10.	Stone Forest Industries Inc.

	OSB/Waferboard
1.	Louisiana-Pacific Corp.
2.	Potlatch Corp.
3.	Georgia-Pacific Corp.
4.	Weyerhaeuser Co.
5.	J.M. Huber Corp.
6.	Norbord Industries
7.	Roy O. Martin Lumber Co. Inc.
8.	International Paper Co.
9.	Langdale Forest Products Co.

	Particleboard
1.	Georgia-Pacific Corp.
2.	Willamette Industries Inc.
3.	Weyerhaeuser Co.
4.	Louisiana-Pacific Corp.
5.	Temple-Inland Forest Products Corp.
6.	Roseburg Forest Products Co.
7.	Masonite Corp.
8.	Allegheny Particleboard Corp.
9.	Boise Cascade Corp.
10.	Timber Products Co.

	Medium-density Fiberboard
1.	Willamette Industries Inc.
2.	Louisiana-Pacific Corp.
3.	Medite Corp.
4.	Masonite Corp.
5.	Plum Creek Manufacturing, L.P.
6.	Georgia-Pacific Corp.
7.	Sierra-Pine, Ltd.
8.	Weyerhaeuser Co.
9.	Norbord Industries
10.	Bassett Industries

Source: American Forest & Paper Association, Wood Technology's 1994-95 North American Factbook.

Exhibit 4 (cont'd)
Largest U.S. Lumber and Wood Products Facilities by Capacity (1993)

	Hardboard
1.	Georgia-Pacific Corp.
2.	Masonite Corp.
3.	Weyerhaeuser Co.
4.	Wood Fiber Industries Inc.
5.	Louisiana-Pacific Corp.
6.	Stimson Lumber Co.
7.	Evanite Fiber Corp.
8.	Dee Forest Products Inc.

	Laminated Veneer Lumber, I-joists
1.	Louisiana-Pacific Corp.
2.	Willamette Industries Inc.
3.	Georgia-Pacific Corp.
4.	Tecton Laminates
5.	South Coast Lumber Co.

	Parallel, Laminated Strand Lumber
1.	Trus Joist MacMillian

	Glulam Beams
1.	Willamette Industries Inc.
2.	Anthony Forest Products Co.

	Panelboard
1.	Georgia-Pacific Corp.

	Composite Panels
1.	Oregon Strand Board Co.

Source: American Forest & Paper Association, Wood Technology's 1994-95 North American Factbook.

II.B.2. Economic Trends

The lumber and wood products industry is heavily dependent upon the health of the U.S. residential construction and household furniture industries. Lumber and wood product shipments increased less than one percent in 1993 and this low level of growth is expected to continue in 1994. Domestic wood products shipments over the next five years are expected to remain constant.

Since the mid-1980's, timber harvests from publicly-owned lands have declined by more than 50 percent. The decline is due to new land management policies by the Federal government that have reduced the amount of land available for harvesting.

According to the Hardwood Plywood and Veneer Association, there has been a substantial decline in the use of hardwood plywood prefinished wall paneling due to shifts in consumer preference, a decline in promotion and advertising by major manufacturers, changes in the cost of plywood paneling related to gypsum wallboard, and the public's concern about real or perceived formaldehyde releases from wall paneling. With respect to reconstituted wood panel products shipments of PB, OSB, and MDF are all increasing rapidly. U.S. shipments of MDF were at record levels in 1993.

The engineered lumber sector of the industry (reconstituted wood substitutes for sawn lumber), is currently seeing a rapid rise in production. The production of glulam beams and laminated veneer lumber (LVL), two types of engineered lumber, is increasing rapidly and this increased growth is expected to continue. By 2003, the North American output of LVL is expected to reach 98 million ft^3 (the American Plywood Association's production estimate for LVL in 1995 is 33 million ft^3).

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the lumber and wood products industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the by-products produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

III.A. Industrial Processes in the Lumber and Wood Industry

This section describes the major processes used by the lumber and wood products industry. It is divided into the following sections: logging, sawn lumber, paneling (including veneer and plywood and reconstituted wood panel products), engineered lumber, and wood preserving. Information for these descriptions was obtained from a variety of sources including *Characterization of Manufacturing Processes, Emissions, and Pollution Prevention Options for the Composite Wood Industry* (Martin and Northeim, 1995), *Forest Products and Wood Science* (Haygreen and Bowyer, 1989), and *Guide to Pollution Prevention: Wood Preserving Industry* (U.S. EPA, 1993).

Exhibit 5
Example Flow Diagram For a Lumber Production Facility

Source: Southern Lumber Manufacturing Association, 1995.

Logging

Timber harvesting may be accomplished by either manual or mechanical means. However, the traditional methods of hand sawing or ax use are almost never used. Chain saws powered by gasoline engines or large felling machines are currently used to cut down standing trees. The felling machines use hydraulically-activated shears that cut the tree at its base and transport it to a collection point. The logs are transported by motorized cable or by tractor to larger collection areas for transportation (usually by motor trucks or water) to the sawmill.

Sawn Lumber

Sawn lumber is softwood or hardwood trimmed at a sawmill and destined for a future use such as construction, industrial, or furniture products. Most of the commercially important softwood species such as Southern Yellow Pine, Western Pines, Western Hemlock, Spruce, and Douglas Fir grow in the South or West. Softwood boards are used primarily for framing light construction such as homes, schools, churches, and farm buildings. Hardwood species such as Maple and Oak, are grown and processed mainly in the Eastern portion of the U.S. and are used for flooring, furniture, and crating.

Exhibit 5 illustrates the lumber production process. Logs are delivered to sawmills from the forest and stored in ponds or on land. Most wood is stored on land. Logs are sometimes stored at intermediate points between the forest and the sawmill. If stored on land, the logs are usually sprayed with water to keep them moist and prevent cracking. The raw logs are debarked and then cut into cants (partially cut lumber), which are trimmed into raw lumber. As the logs are debarked, bark is used as hog fuel for boilers or sold as mulch. Shavings, sawdust, and chips can also be used at paper mills and reconstituted wood panel manufacturing plants.

The cants are cut to specific lengths or finished further depending on the final destination of the lumber product. Most lumber is dried to a specific moisture content (conditioned) through air or kiln drying. Air drying, which entails stickering (spacing) and stacking the cut lumber in open storage areas, usually requires several months to a few years. Kiln drying is more time efficient because it uses controlled air flow within a vented closed chamber to quickly dry the lumber to a specified moisture content. Whether lumber is air- or kiln-dried depends upon variables such as the moisture content of the species and the humidity of the region.

Sawmills frequently perform surface protection operations to protect lumber against sapstaining that may occur during temporary storage. Sapstains do not attack the structural components of the wood but do affect the surface, coloring it with dark blue or black stains. This discoloration is often objectionable to the buyer and may decrease the value of the wood and its acceptance of finishes.

Surface protection is typically conducted at mills that process hardwoods; however, softwoods cut for export may also be surface protected. Plants typically treat their lumber with surface protectants only during humid months, depending on the region of the country in which they operate. Wood that is kiln-dried is not normally surface-protected. All green wood to be exported is protected. The most popular surface protectant currently used by approximately 85% of all major U.S. mills who treat lumber is a solution composed of 3-iodo-z-propynyl butyl carbamate (IPBC), didecyl dimethyl ammonium chloride (DDAC), and inert ingredients. The solution is diluted with water to a ratio of 35-1 for spray box application and 100-1 for dip tank applications.

Three major processes are used by sawmills to apply surface protectant to wood: the dip process, the spray process, and the green chain process. Typically the sawmill will use only one process to surface protect; however, some plants use a combination of processes to protect lumber at different locations throughout a mill. Dipping is a batch process; green chain and spray operations are continuous processes. The process used influences the amount of control a plant has over the waste it generates during the surface protection process.

Dip operations offer the best opportunity to control drippage since an owner or operator has the ability to keep the wood over the tank until it stops dripping. Dipping operations can lead to uncontrolled drippage when mills do not allow the treated loads to stop dripping before the next load is dipped. Lumber is dipped in horizontal bundles, and as a result, liquid is often trapped between pieces of wood. When forklifts remove the lumber, large quantities of protectant can drip from the wood onto the ground if the lumber is tipped.

Unlike dipping, the spray operation is a continuous process. Individual pieces of lumber are fed end-to-end by chain, roller, or conveyor belt through a spray box. The spray box is often equipped with flexible brushes or curtains at both ends to isolate the formulation spray and minimize drippage. A drip pan is usually incorporated into the design of the spray box allowing formulation to return to the work tank.

Green-chain systems represent another type of continuous operation. The green-chain is so-named because chains drag fresh cut (or "green") lumber through a tank of protectant formulation and back out again for sorting and grading. A dip vat containing anti-stain formulation is typically located at the head of the green chain and the wood falls into this vat from the cutting operations. Some systems utilize wheels or rollers just above the formulation surface to force the wood pieces into the solution. As the wood is drawn from the vat and along the green chain, excess formulation is released from the wood onto the return drip pan. Green-chain operations are typically the least controllable with respect to drippage.

Panel Products

This section describes two classes of panel products: (1) hardwood veneer, softwood veneer, and plywood; and (2) reconstituted wood products.

Hardwood Veneer and Softwood Veneer and Plywood

Veneer is a thin sheet of wood peeled or sliced from blocks of lumber called flitches or logs. Veneer is glued together to form plywood. Hardwood found in the Western and Southern U.S. is generally used to manufacture hardwood plywood. Softwood logs from the Northwest and Eastern U.S. are used to make softwood plywood. Softwood plywood is primarily used for construction. Softwood veneer and plywood is typically used for structural and industrial applications and represents over 90 percent, by volume, of U.S. production. Hardwood veneer and plywood is used typically for decorative applications and for making interior paneling, components for furniture and cabinets, and specialty products. There are several other important differences between softwood plywood and hardwood plywood: softwood plywood is generally made with relatively thick faces (1/10” and thicker) and with exterior or intermediate glue (for protected construction and industrial uses where moderate delays in providing protection might be expected or conditions of high humidity and water leakage may exist). Hardwood plywood is made with face veneers generally 1/32” and thinner. Because of its nature and the use of decorative thin face veneers, the glues used for hardwood plywood tend to be colorless or light in color so as not to discolor the surfaces if the adhesive bleeds into and through the thin faces. While most hardwood plywood is all veneer, some is made with particleboard and medium density fiberboard core.

The general processes for making softwood and hardwood plywood are the same: log debarking, log steaming and or soaking, veneer cutting, veneer drying, veneer preparation, glue application, pressing, panel trimming, and panel sanding. These basic processes are illustrated in Exhibit 7. Nevertheless, there are differences in details in these softwood and hardwood plywood processes. Because of its greater volume, this section primarily describes softwood veneer and plywood manufacturing. However, it is noted where details of the manufacturing process are substantially different for hardwood plywood.

Most softwood plywood plants also produce veneer. Most hardwood plywood plants purchase components for making plywood from outside sources. Logs received at the plant are debarked and cut into lengths appropriate for the plant's processing equipment. Almost all hardwood and many softwood blocks are heated prior to cutting or peeling the veneer to soften the wood. The cut logs are heated by steaming, soaking in hot water, spraying with hot water, or combinations of these methods. The heating time required depends on the diameter of the log, specific gravity, moisture content, and the temperature needed to properly peel that particular species of wood.

The major methods for producing veneer are slicing and peeling. The majority of veneer is produced by peeling (rotary cutting) on a veneer lathe into sheets of uniform thickness. Slicing is used to produce hardwood decorative veneers from a flitch generally in thicknesses of 1/24” and thinner, and is seldom used with softwood. In either case, the wood is forced under a pressure bar that slightly compresses the wood as it hits the cutting edge of a knife. On a rotary lathe, the block, or log section, continuously rotates against the knife and the pressure bar and peels a sheet of veneer from the heated block.

The veneer is peeled at a rate of 300 to 800 lineal feet/min. A series of 120-foot long trays is used in many softwood plywood plants to gently handle these long sheets of wood as they are peeled from the chuck. In softwood mills and some hardwood mills, high-speed clippers automatically chop the veneer ribbons to usable widths at speeds of 1500 lineal feet/min. In hardwood mills, clipping may be done manually to obtain the maximum amount of clear material from the flitch.

After the veneer is peeled and clipped, it must be dried. Two types of dryers are used in softwood veneer mills: roller resistant dryers, heated by forced air; and platen dryers, heated by steam. In older roller dryers, also still widely used for hardwood veneer, air is circulated through a zone parallel to the veneer (see Exhibit 6). Most plants built in recent years use jet dryers (also called impingement dryers) that direct a current of air, at a velocity of 2,000 to 4,000 feet/min., through small tubes on the surface of the veneer.

Veneer dryers may be heated indirectly with steam, generated by a separate boiler, which is circulated through internal coils in contact with dryer air. Dryers may also be heated directly by the combustion gases of a gas- or wood-fired burner. The gas-fired burner is located inside the dryer, whereas combustion gases from a wood-fired burner are mixed with recirculating dryer air in a blend box outside the dryer and then transported into the dryer. Veneer dryers tend to release organic aerosols, gaseous organic compounds, and small amounts of wood fiber into the atmosphere.

Exhibit 6
Veneer Dryer (Longitudinal)

Source: <u>Basic Plywood Processing</u>.

From the dryer, the sheets of veneer travel to a glue application station. Narrow pieces of hardwood veneers are often joined with an adhesive and/or string to maximize recovery. In the gluing process, also known as layup, adhesive is applied to the individual sheets of veneer which are later assembled into plywood. Various adhesive application systems are used including hard rolls, sponge rolls, curtain coaters, sprayers, and foam extruders. The most common application for softwood plywood is an air or airless spray system, which generally uses a fixed-head applicator capable of a 10-foot wide spray at a nozzle pressure of 300 pounds per square inch (psi). Roller applications are most common in the manufacture of hardwood plywood.

With spray systems, control of glue spreads is achieved by adjusting the veneer conveyor speed, or by changing the size of the spray nozzle orifice. Wastes generated in the layup process include adhesive waste (typically overspray), and off-spec plywood.

The phenol-formaldehyde (PF) typical in softwood plywood manufacturing and urea-formaldehyde (UF) adhesions typically used in hardwood plywood are made from resins synthesized in regional plants and shipped to individual plywood mills. At the mills, the resins are combined with extenders, fillers, catalysts, and caustic to make a glue mixture. The addition of these ingredients modifies the viscosity of the adhesive and allows it to be compatible with the glue application method (curtain, roll, spray, foam); allows for better adhesive distribution; increases the cure rate; and lowers cost.

Following the application of glue, the panels must be pressed. The purpose of the press is to bring the veneers into close contact so that the glue layer is very thin. At this point, resin is heated to the temperature required for the glue to bond. Most plywood plants prepress the panels in a cold press at lower pressure prior to final pressing in the hot press. This allows the wet adhesive to "tack" the veneers together, permits easier loading of the hot-press, and prevents shifting of the veneers during loading. Pressing is usually performed in multiopening presses, which can produce 20 to 40 4x8-foot panels in each two to seven minute pressing cycle.

One of the goals of the pressing process is to use enough pressure to bring the veneer surfaces together without overcompressing the wood. Less pressure is required if the lathe has cut smooth veneer of a uniform thickness.

After pressing, stationary circular saws trim up to one inch from each side of the pressed plywood to produce square-edged sheets. Approximately 20 percent of annual softwood plywood production is then sanded. Over 90 percent of the hardwood plywood production is sanded. As sheets move through enclosed automatic sanders, pneumatic collectors above and below the plywood continuously remove the sanderdust. Sawdust in trimming operations is also removed by pneumatic collectors. The plywood trim and sawdust are burned as fuel or sold to reconstituted panel plants. Exhibit 7 illustrates the veneer and plywood manufacturing process.

Exhibit 7
Flow Diagram of Veneer and Plywood Production

Source: Estimating Chemical Releases from Presswood and Laminated Wood Products Manufacturing, U.S. EPA, Office of Pesticides and Toxic Substances, March 1988.

Note: Many veneer and plywood plants are dry.

Reconstituted Wood Products

Reconstituted wood products, such as particleboard (PB), medium density fiberboard (MDF), hardboard (HB), and oriented strand board (OSB), is composed of furnish, or raw wood, that is combined with resins and other additives and formed into a mat, which is then pressed into a board. The manufacturing processes of these boards differ, as do the raw materials used. For example, the furnish (raw materials) used for particleboard consists of finely ground wood particles of various sizes, while OSB is manufactured using specially-prepared strands of wood. In general, the manufacturing processes involve wood size reduction followed by drying (except for wet process boards), adhesive application, pressing at elevated temperatures. Because these products are based on use of all parts of the sawn log, very little solid waste is generated. Instead, air emissions from dryers and presses tend to be the principal environmental concern stemming from the production of these products. Exhibit 8 compares the process flows for some reconstituted wood product manufacturing processes.

Particleboard (PB)

Particleboard is a panel product made from wood particles of various sizes that are bonded together with a synthetic resin such as urea-formaldehyde (UF). The raw materials, or "furnish," that are used to manufacture PB can be either green or dry wood residues. Green residues include planer shavings from green lumber, and green sawdust. Dry process residues include shavings from planing kiln-dried lumber, sawdust, sanderdust and plywood trim. The wood residues are ground into particles of varying sizes using flakers, mechanical refiners, and hammermills. The material may be screened prior to refining.

The furnish is dried to a low moisture content (two to six percent) to allow for moisture that will be gained by the adding of resins and other additives during "blending." Furnishes are generally no warmer than 100_F when blended to avoid precuring and the drying out of the resin.

Most dryers currently in operation in PB and other reconstituted wood panel manufacturing plants use large volumes of air to convey material of varied size through one or more passes within the dryer. Rotating drum dryers requiring one to three passes of the furnish are most common. The use of triple-pass dryers predominates in the United States (see Exhibit 9). Dryer temperatures may be as high as 1100 - 1200_F with a wet furnish. However, dry planer shavings require that dryer temperatures be no higher than 500_F because the ignition point

Exhibit 8
Reconstituted Wood Panel Process Flow

Source: Characterization of Manufacturing Processes, Emissions, and Pollution Prevention - Options for the Composite Wood Industry; Martin and Northeim, Research Triangle Institute Center for Environmental Analysis, 1995.

of dry wood is 446_F. Dry material is the predominant furnish in particleboard. Many dryers are directly heated by dry fuel suspension burners. Others are heated by burning oil or natural gas.

Exhibit 9
Schematic of a Triple Pass Drum Dryer

Source: Characterization of Manufacturing Processes, Emissions, and Pollution Prevention - Options for the Composite Wood Industry; Martin and Northeim, Research Triangle Institute Center for Environmental Analysis, 1995.

Direct-fired rotary drum dryers release emissions such as wood dust, combustion products, fly ash, and organic compounds evaporated from the extractable portion of the wood. Steam-heated and natural gas-filled dryers will have no fly ash.

Air classifiers, which separate particles by surface area and weight, may be used alone or in conjunction with screening equipment. Air classifiers perform best if the feed is limited to particles with uniform widths and lengths. The classifier can then efficiently separate particles of different thicknesses due to the weight difference among particles of approximately equal surface area. Undesired material is usually used as fuel for the dryer burner. The screened particles are stored in dry bins until they are conveyed to the blender. Air classifiers have limited use in the industry. Screening systems are typically used to separate fine from coarse material.

The furnish is then blended with a synthetic adhesives, wax, and other additives distributed via spray nozzles, simple tubes, or atomizers. Resin may be added as received (usually an aqueous solution); mixed with water, wax emulsion, catalyst, or other additives. Waxes are added to impart water repellency and dimensional stability to the boards upon wetting.

Particles for PB are mixed with the additive in short retention time blenders in through which the furnish passes in seconds. The blenders consist of a small horizontal drum with high-speed, high shear impellers and glue injection tubes. As the furnish enters the drum, resin is injected, and the impellers hurl the furnish at high speeds to mix it with the resin.

The furnish and resin mixture is then formed into mats using a dry process. This procedure uses air or a mechanical system to distribute the furnish onto a moving caul (tray), belt, or screen. Particleboard mats are often formed of layers of different sized particles, with the larger particles in the core, and the finer particles on the outside of the board.

The mats are hot pressed to increase their density and to cure the resin.
Most plants use multiopening platen presses, which typically have 14 to 18 openings (see Exhibit 10). The last ten years has seen the introduction of the

continuous press. Though more popular in Europe, the continuous press is currently being used in two PB plants in the United States. Steam generated by a boiler that burns plant residuals runs through a platen passageway to provide the heat in most hot presses. Hot oil and hot water can also be used to heat the platens.

Primary finishing steps for all reconstituted wood panels include cooling or hot stacking, grading, trimming/cutting, and sanding. Cooling is important for UF-resin-cured boards since the resin degrades at high temperatures after curing. Boards bonded using PF resins may be hot-stacked to provide additional curing time. Secondary finishing steps include filling, painting, laminating, and edge finishing. The vast majority of reconstituted panel manufacturers do not apply secondary finishes to their panels; panels are finished primarily by end-users such as cabinet and furniture manufacturers. Panels are also finished by laminators who then sell the finished panels to furniture and cabinet manufacturers.

Exhibit 10
Schematic of a Multi-Opening Board Press

Source: Characterization of Manufacturing Processes, Emissions, and Pollution Prevention - Options for the Composite Wood Industry; Martin and Northeim, Research Triangle Institute Center for Environmental Analysis, 1995.

Medium Density Fiberboard (MDF)

The uses for this type of composite wood product are similar to those of PB. The furnish used to manufacture MDF consists of the same type of green or dry wood residues used to manufacture PB and hardboard. Fibers and fiber bundels are generated by first steam-heating the wood, then passing it through a refiner. During this step the wood changes both chemically and physically; becoming less susceptible to the influences of moisture and less brittle as the lignin in the wood softens. This semi-plastic wood is then "rubbed" apart into fibers and fiber bundles in a refiner instead of being mechanically "broken" apart as in the PB manufacturing process.

The furnish is dried to a very low moisture content to allow for moisture to be gained by the addition of resins and other additives. Most MDF furnish is dried in tube dryers.

The blending process for MDF differs from that of PB in that it typically occurs before drying. After refining, the fibers are discharged through a valve known as the blowvalve into the blowline, a larger continuous chamber where the UF resins are mixed with the wood fiber. In the blowline, the fibers are sprayed with a resin which is injected from a line located either immediately after the blowvalve or anywhere along the blowline. Material is dried to an acceptable moisture content in a flash tube dryer at low temperatures after the blowline. If the blending is done mechanically, as in PB, it is done after the flash tube dryer.

MDF is formed using a dry process which uses air to distribute the furnish in a random orientation onto a moving caul (tray), belt, or screen. The mats are then pressed using a multi-opening platen press or a continuous press is currently used in three MDF plants in the United States. The boards are then cooled and finished like other reconstituted wood panels.

Hardboard

Hardboard is a higher-density version of MDF. It is typically used for siding, furniture drawer bottoms, dust stops, sliding doors, and cabinet doors and tops. There are three types of hardboard: wet, wet/dry, and dry process hardboard, each classified by their manufacturing processes. The furnish used to manufacture hardboard consists of the same green or dry process wood residues used to manufacture PB and MDF. The cooked semi-plastic furnish is "rubbed" apart into fiber bundles as in the MDF process. The fibers are all the same size, therefore, they need no screening.

In the manufacture of wet, and wet/dry process hardboard, the furnish is not dried because the forming process uses water. Wet and wet/dry process hardboard mats are formed using a wet process in which fibers are mixed with water and Phenol

Formaldehyde adhesive and then metered onto a wire screen. Water is drained away with the aid of suction applied to the underside of the wire. The fiber mat, along with the supporting wire, is moved to a prepress where excess water is squeezed out. Wet/dry process hardboard is dried in an oven before being hot pressed.

In the manufacture of dry process hardboard, the furnish is dried using dryers typical of the reconstituted wood panel industry. As with MDF, the hardboard fibers are discharged through a blowvalve into a blowline after refining. Dry process hardboard mats are formed using a process similar to that of MDF and PB in which air is used to distribute the furnish in a random orientation onto a moving caul (tray), belt, or screen. All reconstituted wood panels are hot pressed to increase their density and to cure the resin.

Oriented Strandboard

The furnish used to manufacture OSB is specially flaked from roundwood. Logs entering OSB plants may be either tree length or cut to 100 inch lengths by a slasher saw. The logs are then debarked and sent to a strander which slices them into strands approximately 0.028 inch thick. The strands are then conveyed to a storage bin to await processing through the dryers. (Note: Some older mills cut the logs into 33 inch blocks before sending them to the strander.)

The strands are dried to a low moisture content to allow for moisture gained by adding resins and other additives. The strands are then blended with additives in long retention time blenders in which the furnish passes through in several minutes. The blenders are very large rotating drums (several feet in diameter and many feet in length) that are tilted on their axes. As the strands are fed into the drums, they are sprayed with either PF or MDI (Methylenediphenyl diisocyanate) resin and either liquid or emulsified paraffin wax. The tumbling action of the strands through the drums allows the strands to mix thoroughly with the resin and wax.

OSB is formed by a dry process, which uses air to distribute the furnish. OSB is produced by deliberate mechanical lining-up of the strands. In the mechanical orientation processes, mats are produced by dropping long slender flakes between parallel plates or disks onto a moving caul (tray), belt, or screen. The boards are then hot pressed and finished.

Engineered Lumber

Several composite wood products, intended as substitutes for lumber as well as other structural materials, are now on the market. Parallel strand lumber, made from long strands of veneer, is extruded with PF resin into various cross sections and widths. Parallel laminated veneer, or laminated veneer lumber (LVL), is constructed of veneers that are bonded together with phenol-formaldehyde (PF) adhesive resin to form a laminate. The veneers are layered with the wood grain along the long axis of the beam. Laminated veneer lumber is manufactured to typical lumber sizes (2 x 4, 2 x 6, etc.). The length of the beams that can be manufactured is varied using end joints or finger joints. Another application of LVL is in the construction of wood "I" joists (a small beam that resembles the letter "I"). LVL is used to construct the top and bottom (flanges) of the joist and OSB or plywood is used to construct the center (web).

Glulam beams are also emerging as a substitute for lumber. Glulam is short for glued-laminated structural timber – large beams fabricated by bonding layers of specially-selected lumber with Resorcinol or Resorcinol/PF adhesives and timber. End and edge jointing permit production of longer and wider structural wood members than are available naturally. Glulam timbers are used with structural wood panels for many types of heavy timber construction.

Most of the engineered lumber products are used as substitutes for structural softwood lumber of large sizes and in applications where uniform strength is essential. I-beams, however, are finding wide application, with extensive use as floor joists and beams for various structures. There are several advantages of composite lumber when compared with sawn softwood lumber. First, these products allow production of large sizes of lumber from small, low-grade logs. Normally, relatively large and high-grade sawlogs are needed for production of lumber of this size. Second, composite lumber compares advantageously to solid sawn lumber in terms of both uniformity of quality and straightness. While the quality of lumber is determined to a great extent by the raw material, the quality of the reconstituted product is dependent upon the manufacturing process. It is likely, however, that use of composite lumber will increase in the future.

Wood Preserving

Wood is treated with preservatives to protect it from mechanical, physical, and chemical influences. Preserved wood is used primarily in the construction, railroad, and utilities industries to prevent rotting when wood is exposed to damp soil, standing water, or rain, and as protection against termites and marine borers. The most common preservatives include water-borne inorganics like chromated copper arsenate (CCA) and ammoniacal copper zinc arsenate (ACZA), and oil-borne organics like pentachlorophenol (PCP) and creosote. Generally, water-borne inorganic solutions constitute approximately 78 percent of all preservatives used, while oil-borne creosote and PCP comprise 15 percent and 6 percent, respectively.

Creosote, PCP, and inorganic wood preservatives are all applied using similar processes. More than 90 percent of the wood preservation in the U.S. is performed using pressure treatment processes. Exhibit 10 illustrates a two-cylinder pressure treatment process for CCA. A limited quantity of wood is preserved using non-pressure treatment processes in which the preservative is allowed to diffuse into the wood. This process is used with some oil-borne preservatives, but not with waterborne inorganics.

The penetration required to adequately preserve wood can be achieved only if the wood has been conditioned properly; that is, if the moisture content of the freshly-cut wood is reduced to a point where the preservative can penetrate and be retained by the wood. Wood is usually conditioned in the open air or conditioned in the cylinder (retort) in which the pressure treatment is performed. The sawn lumber is sometimes incised to increase preservative penetration. Open air drying is typically used to prepare large stock for treatment with oil-borne preservatives. Other methods for conditioning wood prior to treatment with oil-borne preservatives include steaming, heating, and vapor drying. Kiln drying is used primarily for water-borne treatment. Conditioning is a major source of wastewater in the wood preserving industry.

After the moisture content of the wood has been reduced, the wood is preserved using either non-pressure or pressure methods. Non-pressure processes include brushing, spraying, dipping, soaking, and thermal processes. These processes involve the repeated use of preservative in a treatment tank with fresh preservative solution added to replace consumptive loss. The continual reuse of preservative leads to the accumulation of wood chips, sand, stones, and other debris contaminated with various hazardous constituents in the bottom of the treating tanks. This contaminated debris is a major source of process waste for non-pressure processes.

Exhibit 11
Example Flow Diagram For a Two-Cylinder CCA Pressure-Treating Facility

Source: Title III, Section 313 Release Reporting Guidance; Office of Pesticides and Toxic Substances; March 1983.

There are two basic types of pressure treatment processes, distinguished by the sequence in which vacuum and pressure are applied. These are "empty-cell" and "full-cell" or "modified full cell" processes. The terms "empty" and "full" are measures of the level of preservative retained by the wood cells.

"Empty-cell" processes obtain relatively deep penetration with limited absorption of preservative. In the Reuping empty-cell process, air pressure is applied to the wood as preservative is pumped into the treating cylinder. Once the desired level of retention has been achieved, the unused preservative is drained off and the excess preservative is vacuum pumped away from the wood. The process is the same in the Lowry empty-cell process, except no initial pressure is applied. In both processes, air compressed in the wood drives out part of the preservative absorbed during the pressure period when pressure is released.

The second method, know as the "full-cell" (Bethel) process, results in higher retention of preservative but limited penetration compared to the empty-cell process. The full-cell or modified full cell procedures are used with both oil- and water-borne preservatives. A vacuum is created in the treating cylinder and preservative is pumped in without breaking the vacuum. Once full, hydrostatic or pneumatic pressure is applied until the wood will retain no more preservative. A final vacuum may then be applied to remove excess preservative, which is returned to the work tank for reuse. The treated wood is removed from the cylinder and placed on a drip pad where it remains until dripping has ceased (see Exhibit 12). Preservative solution, washdown water, and rainwater are collected on the drip pad and maintained in the process. At waterborne plants, these materials are transferred to a dilution water tank where they are blended with additional concentrate to make fresh treating solution. At oil-borne plants, these materials are processed to recover preservative and usable process water. Excess waste water is treated either on-site in a wastewater treatment unit or off-site at a publicly owned treatment works.

Exhibit 12
Drip Pad with Liner

Source: U.S. EPA.

III.B. Raw Material Inputs and Pollution Outputs

Exhibit 13 provides an overview of the material inputs and pollution outputs for different processes in the lumber and wood products industry.

Logging

With the exception of concerns for species and ecosystem preservation, harvesting practices have minimal environmental impacts. Harvesting practices often cause discharges of materials into surrounding waters, threatening water quality standards. The Federal Water Protection Control Act regulates these discharges. In addition, road construction for access to timber areas is of concern, due to impacts on surrounding ecosystems.

Exhibit 13
Process Materials Inputs and Pollution Outputs

Process	Material Input	Air Emissions	Process Waste	Other Waste
Logging	Trees, diesel, gasoline	PM-10, VOCs, CO, NOx	Not applicable	Waste wood particles
Sawing	Wood logs, diesel, gasoline	PM-10, VOCs, CO, NOx	Not applicable	Waste wood particles
Surface Protection	Wood, 3-Iodo-2-Propynyl Butyl Carbamate (IPBC), Didecyl Dimethyl Ammonium Chloride (DDAC)	IPBC, DDAC, ethyl alcohol, petroleum naphtha	Dripped formulation mixed with rainwater and facility washdown water	Sawdust, wood chips, sand, dirt, stones, tar, emulsified or polymerized oils
Plywood and Veneer	Veneer, phenol-formaldehyde resins, urea-formaldehyde resins, melamine-formaldehyde resins, sodium hydroxide, ammonium sulfate, acids, ammonia	PM-10, VOCs, CO, CO_2, NOx, formaldehyde, phenol, wood dust, condensable hydrocarbons, terpenes, methanol, acetic acid, ethanol, furfural	Not applicable	Waste wood particles, adhesive residues
Reconstituted Wood Products	Wood particles, strands, fiber, same resins as plywood and veneer, methylenediphenyl diisocyanate resins	PM-10, VOCs, CO, CO_2, NOx, formaldehyde, phenol, wood dust, condensable hydrocarbons, terpenes, methanol, acetic acid, ethanol, furfural	Not applicable	Waste wood particles, adhesive residues
Wood Preserving	Wood, pentachlorophenol, creosote, borates, ammonium compounds, inorganic formulations of chromium, copper, and arsenic, carrier oils	Pentachlorophenol, polycyclic organics, creosote, ammonia, boiler emissions, air-borne arsenics, VOCs	Dripped formulation mixed with rainwater and facility washdown water, kiln condensate, contact cooling water	Bottom sediment sludges, process residuals

Sawn Lumber

Most of the residual wood from sawn lumber production is reused as mulch, pulp, and furnish for some types of reconstituted wood panels; some is burned to produce steam or electricity. Studies cited by the Western Wood Products Association indicate that approximately 70 percent of a sawn log is utilized for lumber and other parts are used for co-products. Some of the small residuals are gathered with pneumatic systems for combination with larger amounts destined for use in other products. While there is virtually no waste from the manufacturing process because all parts of the log are used for one product or another, wood residuals are high in organic matter and can threaten aquifers if improperly handled.

A major emission of concern from wood boilers is particulate matter (PM), although other pollutants, particularly CO and organic compounds, may be emitted in significant quantities under poor operating conditions. Boilers that burn wood waste produce: fly ash, carbon monoxide, and volatile organic compounds (VOCs). New boilers must meet new source performance standards (NSPS) for air pollutants. In addition, mills are potential sources of toxic manganese air emissions.

Two types of primary waste streams are typically generated during the surface protection phase of sawn lumber production operations: process residuals and drippage. Secondary waste streams include spent formulations and wastewaters.

Typical process residuals from surface protection are tank sludges that accumulate in the dip tank and/or mix tank as a result of continuous reuse of the protectant. Some plants use spray systems that generate a sludge when recovered formulation is filtered. Periodically, the accumulated sludge must be removed, and is typically placed on sawdust or wood chip piles on-site. The ultimate destination of the sludge is dependent upon the management of the sawdust piles. Plants have reported burning sawdust on-site or shipping it off-site for use as boiler feed for energy recovery. Depending upon the particle size, some wood chips may be shipped to a pulp or paper mill.

Some plants generate little or no tank sludge as a result of certain process variations. Dip tank operations sometimes utilize an internal circulation system to enhance mixing and promote penetration into the packed bundles. The agitation does not allow any particulates to settle, and when the bundles are removed, some of the suspended solids are also removed. Green-chain operations sometimes use a system of rollers that are partially submerged into the dip tank. These rollers force the pieces of lumber under the surface of the formulation to ensure thorough coverage of the exposed surfaces. Forcing the lumber deeper into the tank physically drags the lumber through any sludge that has settled in the tank and this sludge leaves the tank with the treated lumber.

Another wastestream results from the excess formulation drippage from freshly surface protected lumber. In the absence of a drip pad, excess drippage can fall on the ground when the wood is transported from the dip tank or green chain to stacking and packaging areas. Spray operations tend to result in less excess formulation on the wood than either the dipping or green-chain operations. Some plants utilize simple recovery systems to minimize the loss of formulation. For example, pack dip operations hold the wood over the dip tank at an angle to collect excess formulation prior to transfer to storage. Green chain and spray operations may utilize a collection pan under the conveyor to collect formulation as the freshly treated lumber runs along the green chain.

Panel Products

In mills where chips or other furnish is generated on-site, operations such as debarking, sanding, chipping, grinding, and fiber separation generate PM emissions in the form of sawdust and wood particulate matter. The following discussion of pollution outputs from panel production is not divided along product lines. Instead, due to similarities in manufacturing process, this section describes pollution outputs during the drying and pressing stages, where most emissions occur.

Dryers

Organic aerosols and gaseous organic compounds, along with a small amount of wood fiber are found in the emissions from veneer impingement dryers. A mixture of organic compounds is driven from the green wood veneer as its water content is converted to steam in the drying process. Aerosols begin to form as the gaseous emissions are cooled below 302_F. These aerosols form visible emissions called blue haze.

Emissions from the rotating drum wood chip dryers used in reconstituted wood panel plants are composed of wood dust, condensable hydrocarbons, fly ash, organic compounds evaporated from the extractable portion of the wood, and may include products of combustion such as CO, CO_2, and NO_x if direct-fired units are used. The organic portion of industry emissions includes terpenes, resin and fatty acids, and combustion and pyrolysis products such as methanol, acetic acid, ethanol, formaldehyde, and furfural. The condensable hydrocarbons and a portion of the VOCs leave the dryer stack as vapor but condense at normal atmospheric temperatures to form liquid particles that create the blue haze. Both the VOCs and the liquid organic mist are combustion products and compounds evaporated from the wood. Quantities emitted are dependent on wood species, dryer temperature, and fuel used.

One significant cause of blue haze is overloading a dryer by attempting to remove too much moisture within a given time. Overloading results in the introduction of green material to a high-temperature flame or gas stream causing a thermal shock that results in a rapid and excessive volatilizing of hydrocarbons that condense upon release to ambient air, causing the characteristic blue haze.

Another factor affecting the composition of the effluent from rotary drum dryers is inlet dryer temperatures. A study conducted in 1986 by The National Council of the Paper Industry for Air and Stream Improvement (NCASI) with data from five different mills using rotary drum dryers concluded that at inlet gas temperatures greater than 600_F, the emission rate of the total condensable portion of total gaseous nonmethane organics (TGNMO) increased as a function of temperature. The report concluded that the concentration of formaldehyde in the dryer exhaust was also directly related to dryer inlet temperature.

The type of wood species burned also affects the composition of the effluent from rotary drum dryers. A second NCASI study concluded that high TGNMO emission rates from the dryers occurred when the wood species processed had high turpentine contents, such as Southern Pine. In a separate study on formaldehyde emissions, NCASI showed that dryers processing hardwood or a mixture of hardwood and softwood species had a moderate to dramatic increase in formaldehyde emissions at dryer inlet gas temperatures greater than 800_F, but dryers processing only softwood species had only a slight increase in formaldehyde emissions with increasing temperatures.

Presses

Emissions from board presses are dependent upon the type of resin used to bind the wood furnish together. Emissions from hot presses consist primarily of condensable organics. When the press opens, vapors that may include resin ingredients such as formaldehyde, phenol, MDI, and other organic compounds are released to the atmosphere through vents in the roof above the press. Formaldehyde emitted through press vents during pressing and board cooling operations is dependent upon the amount of excess formaldehyde in the resin as well as press temperature and cycle time.

Mole ratios are used to measure the number of moles of one compound to another in an adhesive. For example, the F:U (formaldehyde to urea) mole ratio measures the number of moles of formaldehyde to the number of moles of urea in the principal adhesive used for PB and MDF. The nature of the product and the process dictates the mole ratio of resin used. The ratio directly impacts the ultimate strength the resin will produce in the board, i.e., certain products require higher mole ratio resins to attain an adequate level of bond strength. The higher the mole ratio, the higher the board emissions of formaldehyde. Thus lowering the F:U mole ratio is one way of lowering press and board emissions of formaldehyde. However, mole ratio is only one of several variables that can effect formaldehyde emissions. Other variables include application rates, process rates, and the nature of the specific resin formations.

Higher press temperatures generally result in higher formaldehyde emissions. In an NCASI study, emissions of formaldehyde and phenol from PF resins (used mainly for OSB) and structural plywood were not found to be related to any operating procedures, but were affected by different resin compositions. The types of resins used can effect the amount of emissions. There was little information on emissions from the curing of MDI resins (used for OSB along with PF resins).

Wood Preserving

The chemicals used in the wood preserving process and the drip pads used to collect preservative drippage after treatment of wood have been the subject of considerable regulatory action. EPA has issued final regulations regarding wood preserving wastewater, process residuals, preservative drippage, and spent preservatives from wood preserving processes at facilities that use chlorophenolic formulations, creosote formulations, and inorganic preservatives containing arsenic or chromium.

There are six EPA-classified hazardous wastes from wood preserving operations. These are: U051, discarded unused creosote, F027, discarded unused pentachlorophenol-formulation; K001, bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote or PCP; F032, wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations; F034, wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use creosote formulations; and F035, wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use inorganic preservatives containing arsenic or chromium.

Drips and spills during the oilborne preservative process may occur during chemical delivery, chemical storage and mixing, freshly-treated wood storage on bare ground (if RCRA guidelines are not followed), and dry-treated wood storage on ground. Aerosols and vapors may be released to ambient air during chemical storage and mixing, solution storage, and during pressure treatment (once the cylinder is opened). Sludges result if filters are used prior to solution reuse from wastewater treatment, and from the collection sumps at the facility.

During the inorganic treatment process, additional vapors such as arsenic, may be released to ambient air during the pressure treating process, such as from the process tank or work vent during the initial vacuum stage, the flooding via vacuum, pressure relief and blow back, and the final vacuum. Aerosols and vapor may also be released from the cylinder door area during pressure treating and door opening.

Wood preserving facilities generate wastewater during the conditioning of the wood prior to its treatment and as a result of the condensation removed from the treatment cylinder. Rainwater, spills collected from the area around the treatment cylinder, and drip pad wash down water also contribute to wastewater volume. Typical air emissions sources are volatilization of organic chemicals during wastewater evaporation, vapors released from the treating cylinder during unloading and charging operations, and emissions from the vacuum vent during the treating cycle.

After both pressure and non-pressure treatment, some unabsorbed preservative formulation adheres to the treated wood surface. Eventually, this liquid drips from the wood or is washed off by precipitation. If the wood has been pressure treated, excess preservative will also exude slowly from the wood as it gradually returns to atmospheric pressure. This is known as "kickback." Current regulations specify that all wood must be drip-free prior to transfer from a drip pad to a storage yard. Also, storage-yard drippage resulting from "kickback" must be cleaned up within 72 hours of the occurrence. Preservative formulation may continue to exude from pressure and non-pressure treated wood for long periods, even after the wood is shipped off-site and installed for its intended end use. (See Exhibit 11 for schematic of wood preserving process and waste generation)

III.C. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (EPA) requires facilities to report information about the management of TRI chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R. beginning with the 1991 reporting year. The data summarized below cover the years 1992-1995 and is meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention and compliance assistance activities.

While the quantities reported for 1992 and 1993 are estimates of quantities already managed, the quantities reported for 1994 and 1995 are projections only. The EPA requires these projections to encourage facilities to consider future waste generation and source reduction of those quantities as well as movement up the waste management hierarchy. Future-year estimates are not commitments that facilities reporting under TRI are required to meet.

Exhibit 14 shows that the lumber and wood products industry managed about 69 million pounds of production-related waste (total quantity of TRI chemicals in the waste from routine production operations) in 1993 (column B). Column C reveals that of this production-related waste, 17 percent was either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases by the total quantity of production-related waste. In other words, about 84 percent of the industry's TRI wastes were managed on-site through recycling, energy recovery, or treatment as shown in columns D, E and F, respectively. The majority of waste that is released or transferred off-site can be divided into portions that are recycled off-site, recovered for energy off-site, or treated off-site as shown in columns G, H, and I, respectively. The remaining portion of the production-related wastes (13.2 percent), shown in column J, is either released to the environment through direct discharges to air, land, water, and underground injection, or it is disposed off-site.

From the yearly data presented below it is apparent that the portion of TRI wastes reported as recycled on-site has increased and the portions treated or managed through energy recovery on-site have decreased between 1992 and 1995 (projected).

Exhibit 14
Source Reduction and Recycling Activity for SIC 24

A	B	C	D	E	F	G	H	I	J

Year	Production Related Waste Volume (10^6lbs.)*	% Reported as Released and Transferred	On-Site			Off-Site			Remaining Releases and Disposal
			% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	
1992	33	45%	55.17%	0.10%	11.02%	0.06%	1.84%	2.12%	29.69%
1993	69	17%	78.30%	0.05%	5.90%	0.07%	1.36%	1.09%	13.23%
1994	66	—	79.59%	0.07%	5.32%	0.08%	0.86%	0.59%	13.50%
1995	63	—	79.15%	0.03%	5.63%	0.09%	0.74%	0.62%	13.72%