EPA/310-R-95-003

EPA Office of Compliance
Sector Notebook Project

Profile of the Wood Furniture and Fixtures Industry

September 1995

Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
401 M St., SW (MC 2221-A)
Washington, DC 20460

This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be **purchased** from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included at the end of this document.

All telephone orders should be directed to:

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 512-1800
FAX (202) 512-2250
8:00 a.m. to 4:30 p.m., EST, M-F

Using the form provided at the end of this document, all mail orders should be directed to:

U.S. Government Printing Office
P.O. Box 371954
Pittsburgh, PA 15250-7954

Complimentary volumes are available to certain groups or subscribers, such as public and academic libraries, Federal, State, local, and foreign governments, and the media. For further information, and for answers to questions pertaining to these documents, please refer to the contact names and numbers provided within this volume.

Electronic versions of all Sector Notebooks are available on the EPA Enviroene Bulletin Board and via Internet on the Enviroene World Wide Web. Downloading procedures are described in Appendix A of this document.

Contacts for Available Sector Notebooks

The Sector Notebooks were developed by the EPA Office of Compliance. Particular questions regarding the Sector Notebook Project in general can be directed to the EPA Work Assignment Managers:

Michael Barrette
U.S. EPA Office of Compliance
401 M St., SW (2223-A)
Washington, DC 20460
(202) 564-7019

Gregory Waldrip
U.S. EPA Office of Compliance
401 M St., SW (2223-A)
Washington, DC 20460
(202) 564-7024

Questions and comments regarding the individual documents can be directed to the appropriate specialists listed below.

Document Number	Industry	Contact	Phone (202)
EPA/310-R-95-001.	Dry Cleaning Industry	Joyce Chandler	564-7073
EPA/310-R-95-002.	Electronics and Computer Industry	Steve Hoover	564-7007
EPA/310-R-95-003.	Wood Furniture and Fixtures Industry	Bob Marshall	564-7021
EPA/310-R-95-004.	Inorganic Chemical Industry	Walter DeRieux	564-7067
EPA/310-R-95-005.	Iron and Steel Industry	Maria Malave	564-7027
EPA/310-R-95-006.	Lumber and Wood Products Industry	Seth Heminway	564-7017
EPA/310-R-95-007.	Fabricated Metal Products Industry	Greg Waldrip	564-7024
EPA/310-R-95-008.	Metal Mining Industry	Keith Brown	564-7123
EPA/310-R-95-009.	Motor Vehicle Assembly Industry	Suzanne Childress	564-7018
EPA/310-R-95-010.	Nonferrous Metals Industry	Jane Engert	564-5021
EPA/310-R-95-011.	Non-Fuel, Non-Metal Mining Industry	Keith Brown	564-7123
EPA/310-R-95-012.	Organic Chemical Industry	Walter DeRieux	564-7067
EPA/310-R-95-013.	Petroleum Refining Industry	Tom Ripp	564-7003
EPA/310-R-95-014.	Printing Industry	Ginger Gotliffe	564-7072
EPA/310-R-95-015.	Pulp and Paper Industry	Maria Eisemann	564-7016
EPA/310-R-95-016.	Rubber and Plastic Industry	Maria Malave	564-7027
EPA/310-R-95-017.	Stone, Clay, Glass and Concrete Industry	Scott Throwe	564-7013
EPA/310-R-95-018.	Transportation Equipment Cleaning Industry	Virginia Lathrop	564-7057

WOOD FURNITURE AND FIXTURES
(SIC 25)
TABLE OF CONTENTS

Page

WOOD FURNITURE AND FIXTURES

(SIC 25)

TABLE OF CONTENTS (CONT'D)

WOOD FURNITURE AND FIXTURES
(SIC 25)
TABLE OF CONTENTS (CONT'D)

Page

WOOD FURNITURE AND FIXTURES
(SIC 25)
EXHIBITS INDEX

WOOD FURNITURE AND FIXTURES
(SIC 25)
EXHIBITS INDEX (CONT'D)

WOOD FURNITURE AND FIXTURES
(SIC 25)
LIST OF ACRONYMS

AFS -	AIRS Facility Subsystem (CAA database)
AIRS -	Aerometric Information Retrieval System (CAA database)
BIFs -	Boilers and Industrial Furnaces (RCRA)
BOD -	Biochemical Oxygen Demand
CAA -	Clean Air Act
CAAA -	Clean Air Act Amendments of 1990
CERCLA -	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS -	CERCLA Information System
CFCs -	Chlorofluorocarbons
CO -	Carbon Monoxide
COD -	Chemical Oxygen Demand
CSI -	Common Sense Initiative
CWA -	Clean Water Act
D&B -	Dun and Bradstreet Marketing Index
ELP -	Environmental Leadership Program
EPA -	United States Environmental Protection Agency
EPCRA -	Emergency Planning and Community Right-to-Know Act
FIFRA -	Federal Insecticide, Fungicide, and Rodenticide Act
FINDS -	Facility Indexing System
HAPs -	Hazardous Air Pollutants (CAA)
HSDB -	Hazardous Substances Data Bank
IDEA -	Integrated Data for Enforcement Analysis
LDR -	Land Disposal Restrictions (RCRA)
LEPCs -	Local Emergency Planning Committees
MACT -	Maximum Achievable Control Technology (CAA)
MCLGs -	Maximum Contaminant Level Goals
MCLs -	Maximum Contaminant Levels
MEK -	Methyl Ethyl Ketone
MSDSs -	Material Safety Data Sheets
NAAQS -	National Ambient Air Quality Standards (CAA)
NAFTA -	North American Free Trade Agreement
NCDB -	National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan	
NEIC -	National Enforcement Investigation Center
NESHAP -	National Emission Standards for Hazardous Air Pollutants
NO_2 -	Nitrogen Dioxide
NOV -	Notice of Violation

WOOD FURNITURE AND FIXTURES
(SIC 25)
LIST OF ACRONYMS (CONT'D)

NO_X - Nitrogen Oxide
NPDES - **National Pollution Discharge Elimination System (CWA)**
NPL - **National Priorities List**
NRC - **National Response Center**
NSPS - **New Source Performance Standards (CAA)**
OAR - **Office of Air and Radiation**
OECA - **Office of Enforcement and Compliance Assurance**
OPA - **Oil Pollution Act**
OPPTS - **Office of Prevention, Pesticides, and Toxic Substances**
OSHA - **Occupational Safety and Health Administration**
OSW - **Office of Solid Waste**
OSWER - **Office of Solid Waste and Emergency Response**
OW - **Office of Water**
P2 - **Pollution Prevention**
PCS - **Permit Compliance System (CWA Database)**
POTW - **Publicly Owned Treatments Works**
RCRA - **Resource Conservation and Recovery Act**
RCRIS - **RCRA Information System**
SARA - **Superfund Amendments and Reauthorization Act**
SDWA - **Safe Drinking Water Act**
SEPs - **Supplementary Environmental Projects**
SERCs - **State Emergency Response Commissions**
SIC - **Standard Industrial Classification**
SO_2 - **Sulfur Dioxide**
TOC - **Total Organic Carbon**
TRI - **Toxic Release Inventory**
TRIS - **Toxic Release Inventory System**
TCRIS - **Toxic Chemical Release Inventory System**
TSCA - **Toxic Substances Control Act**
TSS - **Total Suspended Solids**
UIC - **Underground Injection Control (SDWA)**
UST - **Underground Storage Tanks (RCRA)**
VOCs - **Volatile Organic Compounds**

WOOD FURNITURE AND FIXTURES (SIC 25)

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 WOOD FURNITURE AND FIXTURES INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the Wood Furniture and Fixtures 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.

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

The furniture and fixtures industry encompasses companies that manufacture household, office, store, public building, and restaurant furniture and fixtures. These practices correspond to the Standard Industrial Classification (SIC) code 25 created by the Bureau of the Census to track the movement of goods and services within the economy. Although it is difficult to determine the exact number of facilities that fall within SIC code 25, 1987 Census data indicate that there were approximately 11,000 furniture manufacturing facilities in operation (complete 1992 Census data were not available).

SIC 25, Furniture and Fixtures, consists of the following five three-digit industry groups:

SIC 251 - Household Furniture
SIC 252 - Office Furniture
SIC 253 - Public Building and Related Furniture
SIC 254 - Partitions, Shelving, Lockers, and Office and Store Fixtures
SIC 259 - Miscellaneous Furniture and Fixtures.

The following discussion focuses on SIC 251 because a majority of the wood furniture manufacturing facilities fall into this SIC code and the facilities in this SIC code tend to be the most heavily regulated. The Bureau of the Census estimates that in 1992, 256,000 people were employed by the household furniture manufacturing sector (SIC 251) of the furniture industry, a decline of approximately 10 percent from 1987. The 1993 value of shipments for these firms exceeded $22 billion, representing an increase of approximately seven percent over the previous year. Sales from the household furniture manufacturing industry were expected to rise by four percent in 1994.

The household furniture manufacturing industry (SIC 251) consists of producers of wood furniture (SIC 2511), accounting for 42 percent of household furniture industry shipments in 1993; upholstered furniture (SIC 2512), accounting for 30 percent of shipments; metal furniture (SIC 2514), accounting for ten percent of shipments; and miscellaneous furniture (SIC 2517 and 2519), accounting for four percent of shipments.

This industry is comprised of the production of many different types of products including wood household furniture, metal household furniture, mattresses, machine cabinets, shelving, and lockers. Because the items produced vary greatly in design depending upon the type of material used, style, price, and final use, the different types of machinery used in the various phases of production can reach into the hundreds or even thousands. This diversity of products provides a challenge for most manufacturers.

Production lines for assembling furniture are costly, and because of this most manufacturers do not supply an exceptionally large range of items. To combat this problem, many firms specialize their production processes, allowing facilities to fill a specific niche in the market while still retaining flexibility in their manufacturing area. Manufacturers may specialize depending on the product manufactured, the product group, or the production process. Specialization has also allowed manufacturers to focus on quality by more carefully monitoring the entire production process, from raw material to finished product.

Because SIC 25 covers such a diverse group of products, much of this profile will concentrate on the wood furniture manufacturing industry as defined by the following SIC codes:

SIC 2511	- Wood Household Furniture, Except Upholstered
SIC 2512	- Wood Household Furniture, Upholstered
SIC 2517	- Wood Television, Radio, Phonograph, and Sewing Machine Cabinets
SIC 2521	- Wood Office Furniture
SIC 2531	- Public Building and Related Furniture
SIC 2541	- Wood Office and Store Fixtures, Partitions, Shelving, and Lockers.

All discussions on production processes and applicable regulations will be limited to activities covered by these four-digit SIC codes.

II.B. Characterization of the Wood Furniture and Fixtures Industry

The discussion of the characterization of the wood furniture and fixtures industry is divided into the following four topics: industry size and geographic distribution, profile of the top ten furniture manufacturers, characterization of products, and economic health and outlook.

II.B.1. Industry Size and Geographic Distribution

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

Size Distribution

According to 1987 Census data, approximately 63 percent of household furniture manufacturing facilities (SIC 251) have fewer than 20 employees. Approximately 53 percent of facilities within this SIC code produce wood household furniture, while approximately 20 percent produce upholstered household furniture. Exhibit 1 provides a distribution by facility size for household furniture manufacturing facilities.

Exhibit 1
Facility Size Distribution of Household Furniture Manufacturers

Type of Furniture Facility	Facilities with 1 to 19 employees	Facilities with 20 to 99 employees	Facilities with 100 or more employees	Total
Wood Household SIC: 2511	2,084	573	291	2,948
Upholstered Household SIC: 2512	574	358	218	1,150
Metal Household SIC: 2514	207	123	88	418
Mattresses and Bedsprings SIC: 2515	504	282	53	839
Wood Television and Radio Cabinets SIC: 2517	44	22	14	80
Household Furniture (misc.) SIC: 2519	126	38	13	177
Total	**3,539**	**1,396**	**677**	**5,612**

Source: 1987 Census of Manufacturers Industry Series.

According to information contained in EPA's October 1991 draft guidelines for the *Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations*, approximately 86 percent of the wood furniture industry (SIC codes 2434, 2511, 2512, 2517, 2519, 2521, 2531, and 2541) have fewer than 50 employees. Approximately 37 percent of facilities in this listing are wood household furniture manufacturers, while approximately 34 percent are wood kitchen cabinet manufacturers. Exhibit 2 provides a breakdown by facility size for the wood furniture manufacturers.

Exhibit 2
Facility Size Distribution of Wood Furniture Manufacturers

Type of Furniture Facility	Facilities with 1 to 49 employees	Facilities with 50 to 249 employees	Facilities with 250 or more employees	Total
Wood Kitchen Cabinets SIC: 2434	3,460	218	35	3,713
Wood Household Furniture, except upholstered SIC: 2511	2,466	344	138	2,948
Wood Household Furniture, upholstered SIC: 2512	782	292	76	1,150
Wood Television, Radios, Phonograph, and Sewing Machine Cabinets SIC: 2517	61	11	8	80
Household Furniture, not elsewhere classified SIC: 2519	150	22	5	177
Wood Office Furniture SIC: 2521	505	113	31	649
Public Building and Related Furniture SIC: 2531	381	95	15	491
Wood Office and Store Fixtures, Partitions, Shelving, and Lockers SIC: 2541	1,672	184	10	1,866
Total	**9,477**	**1,279**	**318**	**11,074**

Source: EPA Draft Guidelines for the Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations.

Geographic Distribution

According to 1987 Census data, of the estimated 11,000 furniture manufacturing facilities (SIC 251), approximately 17 percent are located in California. North Carolina is home to approximately seven percent of these facilities, even though four of the top ten facilities are located in this State. Exhibit 3 provides a geographic distribution of the number of furniture and fixtures manufacturers (State totals are based on the number of facilities per State with 150 or more employees in a given industry sector).

Exhibit 3
Geographic Distribution of the Furniture and Fixtures Industry
Source: 1987 Census of Manufacturers Industry Series.

Information contained in EPA's draft guidelines for the *Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations* shows that of the estimated 10,757 wood furniture manufacturing facilities (SIC codes 2434, 2511, 2512, 2517, 2519, 2521, 2531, and 2541) approximately 17 percent are located in California. Although more facilities are located in California, the largest furniture manufacturing facilities and those responsible for producing the highest volume of furniture are located in North Carolina. Exhibit 4 provides a geographic distribution of the wood furniture manufacturing industry (information is not available for Alaska, Delaware, Hawaii, Montana, Washington D.C., and Wyoming).

Exhibit 4
Geographic Distribution of Wood Furniture Manufacturing Facilities

Source: EPA Draft Guidelines for the Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations.

According to a 1990 ranking by total annual sales of the top 300 wood furniture manufacturing facilities in Furniture Design and Manufacturing Magazine, Masco Corporation is the largest residential wood furniture manufacturer, with annual sales of $1.2 billion. Steelcase, Inc. is the largest manufacturer of wood office/institutional furniture, with annual sales of $1.8 billion. Exhibit 5 provides a breakdown of the top ten manufacturers of residential wood furniture and wood office/institutional furniture (sales figures are based on 1988 and 1989 data and are estimates in some instances).

Exhibit 5
Top Ten Wood Furniture Manufacturers - 1990

Rank	Name of Manufacturer	Annual Sales, $ million
Residential Furniture		
1	Masco Corporation	1,200
2	Interco	1,100
3	Ohio Mattress Company	700
4	La-Z-Boy Chair Company	553
5	Bassett Furniture Industries, Inc.	466
6	Ladd Furniture	450
7	Simmons USA	425
8	Thomasville Furniture Industries, Inc.	417
9	Mohasco Corporation	400
10	Klaussner Furniture Industries	250
Office/Institutional Furniture		
1	Steelcase, Inc.	1,800
2	Herman Miller, Inc.	793
3	Hanworth, Inc.	>500
4	HON Industries, Inc.	500
5	Kimball International, Inc.	475
6	Knoll International	275
7	Allsteel, Inc.	220
8	Virco Manufacturing Corporation	183
9	Westinghouse Furniture Systems	170
10	Shelby William Industries, Inc.	169

Source: Furniture Design and Manufacturing Magazine.

II.B.2. Product Characterization

The furniture and fixtures industry, as defined by SIC 25, manufactures a wide variety of products, including wood and metal furniture, mattresses, draperies, public seating (i.e. stadium seats and bleachers), lockers, and restaurant furniture. Because this profile focuses on the wood furniture portion of the industry (SIC codes 2511, 2512, 2517, 2521, 2531, and 2541), the product characterization of the profile is limited in scope. Products covered under the relevant four-digit SIC codes include wood household furniture, such as beds, tables, chairs, bookshelves; wood television and radio cabinets; wood office furniture such as cabinets, chairs, and desks; and wood office and store fixtures and partitions, such as bar fixtures, counters, lockers, and shelves.

II.B.3. Economic Trends

According to the American Furniture Manufacturers Association (AFMA), wood furniture comprises approximately 50 percent of all furniture shipments nationally. Following a steady decline beginning in 1989, the furniture industry experienced moderate increases in 1992 and 1993. This is in part attributed to the fact that private housing starts increased for the second consecutive year and the value of new residential construction rose an estimated seven percent. This rise in home sales and residential construction figures translated into a five percent increase in furniture shipments in 1993. Employment in the furniture and fixtures industry increased by two percent in 1993 following a five year decline.

Wood furniture manufacturers' profits did not rise by as much as the increased shipments would suggest. Major increases in lumber prices, over 30 percent for softwood in approximately one year, significantly gouged profits in 1993. A similar rise in hardwood prices occurred in early 1992. Although lumber prices may fluctuate mildly, they are not expected to fall to the reduced levels of 1991 or early 1992.

In 1993, wood furniture accounted for 48 percent of total furniture exports, followed by upholstered furniture (19 percent), metal furniture (10 percent), plastic furniture (four percent), and mattresses and bedsprings (three percent). Although overall U.S. household furniture exports increased five percent to $1.2 billion in 1993, imports rose more than 14 percent in the same time period. The resulting $2.3 billion furniture and fixtures industry trade deficit mimicked that of 1989. However, U.S. exports increased almost 150 percent from 1989 through 1993 while imports increased only 25 percent in the same time period. As foreign markets become increasingly important to U.S. manufacturers of household furniture, attention is being focused on international agreements to ease trade restrictions. For example, many furniture manufacturers favored the North American Free Trade Agreement (NAFTA). Under this agreement, Mexico, a major importer of American home furniture, will immediately eliminate taxes on 21 percent of all imports of U.S. household furniture, with additional reductions to follow.

The real value of U.S. shipments of household furniture is expected to increase by four percent to an estimated $23 billion in 1994 due to improvements in the economy and consumer confidence. Over the next five years, household furniture shipments are expected to increase three to five percent annually. This prediction relies primarily upon increases in product prices rather than overall furniture units produced.

III. Industrial Process Description

This section describes the major industrial processes within the Wood Furniture and Fixtures 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 byproducts 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 Wood Furniture and Fixtures Industry

The following description of production processes focuses on the manufacturing of wood furniture. The primary input for wood furniture manufacturing is raw lumber, and the production processes include steps such as drying, sawing, planing, sanding, gluing, and finishing. Each of these activities is described below.

III.A.1. Drying

Some furniture manufacturing facilities may purchase dried lumber, but others perform drying on-site. Drying of raw lumber is accomplished by using a drying kiln or oven, fired by a boiler. According to EPA document AP-42, furniture manufacturing facilities generally burn wood waste (from later stages of the production process) in boilers to heat the drying kilns and to alleviate possible solid waste disposal problems. The following boiler firing configurations are used for burning wood waste: Dutch oven; fuel cell oven; spreader stoker; suspension-fired; and fluidized bed combustion. The primary outputs of burning wood waste in boilers are point-source emissions to the atmosphere. A more detailed discussion of all material inputs and pollution outputs will be covered in the following section.

Types of Boilers

One common type of boiler used in smaller operations is the Dutch oven. This unit is widely used because it can burn fuels with very high moisture content. Wood waste is used as fuel and is fed into the oven through an opening in the top of a refractory-lined furnace. The fuel accumulates in a cone-shaped pile on a flat or sloping grate. Combustion is accomplished in two stages: 1) drying and gasification, and 2) combustion of gaseous products. The first stage takes place in the primary furnace, which is separated from the secondary furnace chamber by a bridge wall. Combustion is completed in the secondary chamber before gases enter the boiler section.

In the fuel cell oven, fuel is dropped onto suspended fixed grates and is fired in a pile. Unlike the Dutch oven, the refractory-line fuel cell also uses combustion air preheating and positioning of secondary and tertiary air injection ports to improve boiler efficiency. Because of their overall design and operating similarities, fuel cell and Dutch oven boilers have comparable emission characteristics.

The most common firing method employed for wood-fired boilers larger than 45,000 kg/hr steam generation rate is the spreader stoker. With this boiler, wood enters the furnace through a fuel chute and is spread either pneumatically or mechanically across the furnace, where small pieces of the fuel burn while in suspension. Simultaneously, larger pieces of fuel are spread in a thin, even bed on a stationary or moving grate. The burning is accomplished in three stages in a single chamber: 1) moisture evaporation; 2) distillation and burning of volatile matter; and 3) burning of fixed carbon. This type of operation has a fast response to load changes, has improved combustion control, and can be operated with multiple fuels. Natural gas or oil is often fired in spreader stoker boilers as auxiliary fuel. This is done to maintain constant steam when the wood waste supply fluctuates and to provide more steam than can be generated from the wood waste alone.

The suspension-firing boiler can be used for wood combustion, and differs from a spreader stoker in that small-sized fuel (normally less than 2 mm) is blown into the boiler and combusted by supporting it in air rather than on fixed grates. Rapid changes in combustion rate, and therefore steam generation rate, are possible because the finely divided fuel particles burn very quickly.

A recent development in wood firing is the fluidized bed combustion boiler. A fluidized bed consists of inert particles through which air is blown so that the bed behaves as a fluid. Wood waste enters in the space above the bed and burns both in suspension and in the bed. Because of the large thermal mass represented by hot inert bed particles, fluidized beds can handle dirty fuels (up to 30 percent inert material). Wood fuel is burned faster in a fluidized bed than on a grate due to its immediate contact with hot bed material. As a result, combustion is rapid and results in nearly complete combustion of the organic matter, minimizing unburned organic compound emissions.

III.A.2. Machining

Once the lumber is dried, it is sawed into a shape of the approximate dimensions of the final furniture part, such as a table leg or a chair rung. Sawing across the grain in called crosscutting, and sawing parallel with the grain is referred to as ripping. Types of power saws used in furniture manufacturing include circular saws, band saws, scroll saws, radial saws, and portable handsaws.

After sawing, the surfaces of the wood which will be flat in the final product are planed. Planing involves shaving one surface of wood by using a wide edged blade or blades called a planer. The type of power planer usually used in this manufacturing process is the jointer or jointer planer, which consists of blades fastened to a rotating cutterhead. The primary outputs from the sawing and planing processes are wood chips.

The design of some furniture pieces requires that certain wooden parts be bent. This production step follows the planing process and usually involves the application of pressure in conjunction with a softening agent and increased atmospheric pressure. While soaking wood in water alone does increase its plasticity, the combination of heat and steam does increase further the plasticity of wood. The actual bending is accomplished by compressing the wood into the desired shape and then drying it to remove excess moisture. Drying after bending is accomplished in much the same way as the drying of raw lumber, in drying kilns using boilers to generate heat.

III.A.3. Assembly

Wood furniture can either be finished (coated) and then assembled, or assembled and then finished. Residential and office/institutional furniture manufactured in the U.S. is generally made up of irregularly shaped, curved components, and for ease of production is assembled and then finished. Cabinets manufactured in the U.S., however, are frequently finished before assembly.

After the wood parts have been planed and, if necessary, bent, they are assembled to form one furniture part, such as a tabletop. The assembly process usually involves the use of adhesives (either synthetic or natural) in conjunction with other joining methods, such as nailing. The wood furniture manufacturing industry uses adhesive formulations containing solvents (typically used for upholstered wood furniture) and hot melts or polyvinyl acetate (typically used for non-upholstered wood furniture). According to a representative of Masco Corporation, the vast majority of adhesives used to assemble non-upholstered wood furniture are hot melts or polyvinyl acetate. The amount of adhesives used depends on the type of product.

The next step in the production process is the application of veneer. Veneer is a thin piece of wood of uniform thickness which is usually rotary-cut from a bolt of wood using a lathe. Not all furniture manufacturing involves the application of veneer. The production of veneer falls under SIC code 24 (lumber and wood products). The veneer is applied to the furniture part using adhesives, some of which require the use of heat and/or pressure. While not a significant source of releases, gluing operations and the use of adhesives for assembly and veneer are a source of atmospheric solvent releases.

After veneer application or furniture assembly, the furniture part is sanded to ensure that its surface is as smooth as possible for the finishing stages of the production process. Sanding is usually accomplished by a disk, belt, or roller sanding machine using either open- or closed-coated sand paper. For open-coated sand paper, approximately 50 to 70 percent of the paper surface is coated with abrasive. For closed-coated sand paper, the paper surface is completely covered with abrasive. Closed-coated sand paper is generally used in operations requiring higher removal rates. The sanding process can also be employed at other stages of the production process, such as prior to the application of veneer or between the application of several coats of varnish during the finishing process. The primary outputs from sanding are wood particulates.

III.A.4. Pre-finishing

After initial sanding, an even smoother surface is attained by spraying, sponging, or dipping the furniture part with water, which causes the fibers of the wood to swell and "raise." After the surface is dried, a solution of glue or resin is applied and allowed to dry, causing the raised fibers to become more brittle. The raised fibers are then sanded down to form a particularly smooth surface. The primary outputs from second sanding are wood and glue or resin particulates.

Because certain types of wood contain rosin (a naturally occurring resin) which can interfere with the effectiveness of certain finishes, a process known as derosination may be employed. Derosination is accomplished by applying a mixture of acetone and ammonia to the surface of the wood. Spent acetone and ammonia are the primary outputs from derosination.

Once the unwanted rosin is removed from the wood, a process known as bleaching is used to lighten the color of the wood when the natural color is darker than that of the stain or finish to be applied. The process entails spraying, sponging, or dipping the wood into a bleaching agent, such as hydrogen peroxide. Spent bleaching agents are the primary outputs of this step of the production process.

III.A.5. Coating Application

There are various coating application techniques used by the wood furniture manufacturing industry for applying finishing coatings. The two principal methods are flatline finishing and spray application. Flatline finishing is used only to coat truly flat furniture parts and cannot be used for curved pieces, preassembled pieces, or pieces with many recesses. Although, spray application is the most commonly-used method to finish these furniture parts, brushing and dipping can also be used.

The two principal ways of performing flatline finishing are roll coating and curtain coating. Roll coating involves the transfer of coating material by a roller or series of rollers, while curtain coating involves passing the furniture part through a cascade, or curtain, of coating material.

The methods used to spray apply coatings include air, airless, air-assisted airless, high-volume low-pressure (HVLP), electrostatic, and the UNICARB® spray system. The conventional air spray technique uses compressed air to atomize the coating materials as they are being sprayed, by forcing them through a small opening at high pressure. The liquid coating is not mixed with air before exiting the nozzle. Air-assisted airless spray uses an airless spray unit with a compressed air jet to finalize the breakup of the coating material.

HVLP spraying involves the use of a high volume of air delivered at low pressure to atomize the coating material into a pattern of low-speed particles. The use of low pressure can result in decreased overspray, which translates into less coating usage and less volatile organic compound (VOC) emissions.

Electrostatic spraying has long been used in the metalworking and automobile industries to coat metal products. In the wood furniture industry, electrostatic spraying has somewhat limited use, mostly by cabinet and chair manufacturers. This finishing process is performed by spraying negatively-charged coating particles onto positively-charged wood products. If the wood piece has a sufficient moisture content, it can be electrostatically sprayed without pretreatment. However, some wood must be pretreated to allow the piece to hold a positive charge. The material used for pretreatment often contains VOCs.

The UNICARB® system is a relatively new system for spray coating developed by Union Carbide. A coating normally contains both coalescing (slow-evaporating) and diluent (fast-evaporating) solvents. The UNICARB® technology replaces the diluent solvents with liquid carbon dioxide. The carbon dioxide/coalescing solvent coating mixture is used to coat the wood with an airless spray gun. When the coating leaves the spray nozzle, the carbon dioxide in the mixture immediately flashes, and the coating material, which still contains coalescing solvents, continues enroute to the piece and cures in the conventional way. As of June 1991, the UNICARB® system was being tested in several coatings applications, but was not yet being used commercially in any production coating operation.

III.A.6. Finishing

The finishing of wood furniture can be subdivided into two different categories, interior finishing (furniture for indoor use) and exterior finishing (furniture for outdoor use), although the actual production processes involved are fairly similar. The main difference between interior and exterior finishing is the type of coating material applied, not the application processes. The following discussion outlines the production processes involved in interior finishing; exterior finishing will be mentioned only when the process differs from that of interior finishing.

Wood finishing processes include coating, drying, and sanding the furniture in a series of steps which are repeated until the desired final appearance is achieved. While in small facilities the assembled furniture is sometimes moved between finishing stations manually, in most facilities the furniture is moved along the finishing line mechanically by tow-lines, overhead chain conveyors, and other conveyors including belt, roller, and slat conveyors. Tow-lines, chains or cables mounted in or on the floor, move a pallet, on which the assembled piece of furniture rides along the finishing line. The pallets can rotate and can be automatically disengaged from and reengaged to the tow-line to allow for pauses, as needed. Some facilities move the furniture on pallets that are hung from overhead chain conveyors. Many facilities use a combination of these methods to transport the furniture along the finishing line.

Many of the finishing application methods use relatively high concentrations of VOCs which volatilize when the coating is applied. For example, solvents are used in the stains, paints, and finishes as well as in the inks used to print simulated wood grain onto plywood and particleboard. In addition, solvents are used in cleanup operations (i.e., to remove overspray from spray booths and to rinse solvent-based finishes from spray lines and equipment between color changes). The primary outputs from the following finishing applications are point-source and fugitive air emissions, as well as wood and coating material particulates.

Staining involves the application of a clear colorant which adds_initial color, evens out color, and accents without hiding the natural wood grain. Stains usually consist of transparent or semitransparent color solids (typically less than five percent by volume) suspended in a volatile liquid solution with a certain amount of a nonvolatile binder, which facilitates spreading, penetration, and fixation of color. Commonly-used stains, all of which are used in conjunction with organic solvents, include: nongrain-raising, dye-type, no-wipe, and toners.

Nongrain raising stains are dye-type stains which are intended to give clarity and depth to the wood finish. Dye-type stains consist of dyes that are completely dissolved in methanol. No-wipe stains are pigmented stains, containing a small amount of oil, pigment, and solvent, that are sprayed on and not wiped off. No-wipe stains are used to accent the wood grain, provide color uniformity and color retention. Toners are stains that contain nitrocellulose or vinyl binders, dissolved in solvent.

Toners are not wiped, and are often pigmented.

After staining, a washcoat, consisting of 2 to 13 percent solids by volume, is applied to the furniture piece. Washcoating is used to aid in adhesion, assist in filling or color uniformity, and partially seal the wood from subsequent staining operations. Washcoat also prepares the wood surface for another sanding after stain application. Some facilities buy sealer in bulk, and dilute their sealer to make washcoat. There are three main types of washcoat materials: standard nitrocellulose; vinyl or modified vinyl; and vinyl-modified/"conversion" types. Advantages of nitrocellulose washcoats include quick drying, easy sanding, and clarity. Vinyl and vinyl-modified washcoats consist of nitrocellulose and vinyl and provide better toughness and adhesion than pure nitrocellulose washcoats; however, some clarity is sacrificed. The "conversion" or precatalyzed-type washcoats also provide good adhesion and toughness, and are good for open pore woods. Because they react in place, they are impervious to solvents contained in subsequently applied sealers and topcoats.

Fillers are applied to the wood surface to produce a smooth, uniform surface for later stages in the finishing process. Fillers, which consist of colorless or covering pigments, can be combined with stains or other pigments and are usually dispersed in a vehicle of drying oils, synthetic resins, and thinners based on organic solvents. Fillers are usually supplied as heavily pigmented, high-solids, low-VOC materials, which are reduced on the job. As supplied, solids contents of fillers are in the 75 percent solids by volume range. Once reduced, the solids contents usually range from 10 percent to 45 percent by volume. Fillers are usually spray applied, then wiped into the wood.

Sealing, which is completed after staining and either before or after filling, consists of applying one or many coats of sealer. Sealers are usually a nitrocellulose-based lacquer, although vinyl or vinyl-modified sealers and catalyzed sealers are also available and provide advantages similar to those of the washcoat counterparts. The primary purposes of sealers are to provide adhesion, make sanding more effective, and to seal the wood and establish a foundation for further coating applications. Solids contents of sealers typically range from ten to 30 percent by volume.

For outdoor furniture, instead of, or in addition to, the filling and sealing processes, the wood surface is treated through a process known as priming. Priming treatments commonly used for outdoor wooden furniture include the application of fungicide and water-repellent.

One alternative to staining is painting. The process for applying paints is similar to that of applying stains or other finishes, although the chemical composition of paints differs from the other finishes. Paint is a viscous fluid, usually consisting of a binder or vehicle, a pigment, a solvent or a thinner, and a drier. Pigments are insoluble in the coating material and are deposited onto the wood surface as the vehicle dries. The chemical composition of a pigment varies according to its color as illustrated in

Exhibit 6.

Exhibit 6
Chemical Components of Pigments Found in Paint

Pigment Color	Chemical Components
White	Titanium dioxide, white lead, zinc oxide
Red	Iron oxides, calcium sulfate, cadmium selenide
Orange	Lead chromate-molybdate
Brown	Iron oxides
Yellow	Iron oxides, lead chromate, calcium sulfide
Green	Chromium oxide, copper, phosphotungstic acid, phosphomolybdic acid
Blue	Ferric ferrocyanide, copper
Purple	Manganese phosphate
Black	Black iron oxide

Source: McGraw-Hill Encyclopedia of Science and Technology, 1987.

After the furniture part has been stained or painted, a topcoat, such as varnish or shellac, is applied in one of the final stages of the finishing process. Topcoats provide a clear coat whose function is to protect the color coats, enhance the beauty of the furniture, and provide a durable final finish. Typical solids contents range from 13 to 30 percent solids by volume. There are four categories of topcoats: standard nitrocellulose topcoats; acrylic topcoats; catalyzed topcoats; and conversion varnishes.

Nitrocellulose lacquers provide the best clarity, pick up little dirt, dry quickly, and are easy to wipe off and repair. Acrylic lacquers are used over white or pastel finishes as protection from common household cleaning products. They can also be applied over nitrocellulose topcoats for color retention. The clarity of acrylic lacquers is not as good as the nitrocellulose lacquers. Catalyzed topcoats are available in one- and two-pack form. The one-pack coatings are precatalyzed, and contain nitrocellulose resins and a small amount of urea resin. Because only a small amount of catalyst is added, it can take up to three to four weeks after application until the coating is completely cured, although it dries to the touch much sooner. The shelf life of precatalyzed coatings is more than six months. Conversion varnishes do not dry as quickly as nitrocellulose topcoats, and are difficult to spot repair, with washoff also being difficult or impossible. Conversion varnishes, like two-pack coatings, have a limited pot life.

The two-pack coatings consist of two packs, one containing urea or melamine-based resins, and the other containing the catalyst. The two components are mixed before use. More catalyst is added to two-pack catalyzed coatings, so cure time is short (on the order of minutes or hours). Two-pack catalyzed coatings have a limited pot life after mixing (from one day to more than a week).

In the U.S., lacquers (mostly nitrocellulose-based) are used by approximately 75 percent of the wood furniture industry; mostly by residential furniture manufacturers. Nitrocellulose lacquers have been used in the residential wood furniture industry for many years; they are easy to use, quick drying, and easy to repair.

Approximately 15 percent of the wood furniture industry, primarily the cabinet and office/institutional furniture manufacturers, use conversion coatings (mostly acid-catalyzed coatings). Cabinets and office/institutional furniture require the chemical and mechanical resistance offered by catalyzed finishes. As of October 1991, polyurethane and unsaturated polyester and unsaturated polyacrylate coatings have had limited use in the United States.

Rubbing, polishing, and cleaning are the final steps of the production process. Rubbing consists of the application of an abrasive in conjunction with a lubricant to level or dull the luster. Polishing consists of the application of soft abrasives or possibly only waxy ingredients to increase the gloss. The furniture parts are then ready for shipment and sale after a final assembly stage, if appropriate (i.e., attaching table legs to a table top). Exhibit 7 illustrates the steps of the wood furniture manufacturing process.

Exhibit 7
Flow Diagram for Wood Furniture Manufacturing

Source: Process Flow Diagram for Franklin Furniture of Greeneville, Tennessee found in Pollution Prevention Options in Wood Furniture Manufacturing, 1992.

III.B. Raw Material Inputs and Pollution Outputs

The following discussion of raw material inputs and pollution outputs is organized along the same lines as the production process description. While there are solid waste and process wastewater implications for the wood furniture manufacturing industry, the vast majority of outputs from this industry are air emissions resulting from the solvent-intensive finishing operations.

III.B.1. Drying

The major emissions of concern from drying the raw lumber using wood boilers is particulate matter (PM), although other pollutants, particularly carbon monoxide (CO) and organic compounds, may be emitted in significant quantities if the boiler is in poor operating condition. The type and amount of the emissions depend on a number of variables, including the composition of the waste fuel burned, the degree of fly ash reinjection employed, and furnace design and operating condition.

The composition of wood waste depends largely on the industry from which it originates. Furniture manufacturing generates a clean, dry wood waste (e.g., 2 to 20 weight percent moisture) which produces relatively low particulate emission levels when properly burned. However, other operations, such as pulp manufacturing, produce great quantities of bark which may contain a much higher weight percent moisture, possibly causing bark boilers to emit considerable particulate matter to the atmosphere unless they are well controlled.

Furnace design and operating conditions are particularly important when firing wood waste. Because of the high moisture content that may be present in wood waste, a larger than usual area of refractory surface is often necessary to dry the fuel before combustion. In addition, sufficient secondary air must be supplied over the fuel bed to burn the volatiles that account for most of the combustible material in the waste. When proper drying conditions do not exist, or when secondary combustion is incomplete, the combustion temperature is lowered, and increased PM, CO, and organic compound emissions may result. Short-term emissions can fluctuate with significant variations in fuel moisture content.

Fly ash reinjection, which is commonly used with larger boilers to improve fuel efficiency, has a considerable effect on PM emissions. Because a fraction of the collected fly ash is reinjected into the boiler, the dust loading from the furnace and, consequently, from the collection device increase significantly per unit of wood waste burned. More recent boiler installations typically separate the collected particulate into large and small fractions in sand classifiers. The smaller particles, mostly inorganic ash and sand, are sent to ash disposal.

The four most common control devices used to reduce PM emissions from wood-fired boilers are mechanical collectors, wet scrubbers, electrostatic precipitators (ESPs), and fabric filters.

Fabric filters (i.e., baghouses) and ESPs are employed when collection efficiencies above 95 percent are required. However, fabric filters have had limited applications to wood-fired boilers. The principle drawback to fabric filtration, as perceived by potential users, is a fire danger arising from the collection of combustible carbonaceous fly ash. Steps can be taken to reduce this hazard, including the installation of a mechanical collector upstream of the fabric filter to remove large burning particles of fly ash.

Emissions of nitrogen oxides (NO_x) from wood-fired boilers are lower than those from coal-fired boilers due to the lower nitrogen content of wood and the lower combustion temperatures which characterize wood-fired boilers.

According to the AFMA document *Integrated Waste Management Program Applicable to the On-site Management of Certain Non-hazardous Wood Product Finishing Wastes,* dated May 1993, the operating temperatures of boilers used by this industry are sufficient to adequately combust the chemical constituents of wood product finishing waste (i.e., sawdust mixed with dust from the various coating materials used in furniture finishing operations such as dried lacquer chips). Based on its interpretation of hazardous waste as defined in 40 CFR 261.21(a)(2), the AFMA determined that wood product finishing waste was acceptable for combustion in a boiler. The State of North Carolina Department of Environment, Health, and Natural Resources initially disagreed with this interpretation. However, according to the AFMA, the Director of the Division of Solid Waste Management, in a March 9, 1994 meeting, approved the AFMA's interpretation.

III.B.2. Machining

The primary outputs from the sawing and planing processes are wood chips and sawdust, which are used as fuel in boilers for other furniture production processes. Wood chips may also be sold to manufacturers of other wood-based products, such as pulp and paper mills. Because no coating materials have been applied to the furniture prior to machining, the particles are almost completely composed of wood, unlike outputs from later sandings which contain particles of finishing material as well as wood particles.

III.B.3. Assembly

Adhesives can be either natural or synthetic in origin and typically contain solvents. Commonly used adhesive formulations contain solvents such as methyl isobutyl ketone, methyl ethyl ketone, xylene, toluene, and 1,1,1-trichloroethane. Solvents are also used to clean adhesive application equipment such as spray guns. Adhesives used to apply veneer can differ from adhesives used for assembly and usually include phenolics, ureas, melamines, polyvinyl resin emulsions, hot melts, contacts, and mastics. Application of some of the above-mentioned adhesives requires the use of heat and/or pressure. Solvent release from the use of adhesives during assembly and veneer application (either as a product carrier or cleaning agent) can be significant.

According to a representative of Masco Corporation, the wood furniture industry primarily uses hot melts or polyvinyl acetate which do not contain volatile organic compounds and therefore have little or no emissions implications. Wood chips and sawdust are outputs of the sanding performed after the assembly and application of veneer.

III.B.4. Pre-finishing

Typical outputs of the pre-finishing steps of the manufacturing process are spent solvents from the derosination process and spent bleaching agents from the bleaching process. Derosination entails the application of ammonia and acetone to remove the natural resin in the wood. The outputs from this step are, therefore, spent ammonia and acetone, as well as any of the naturally-occurring resin removed by this process. Bleaching agents typically used by the wood furniture industry include hydrogen peroxide, sodium bisulfite, sodium hyposulfite, sodium perborate, oxalic acid, potassium permanganate, and sodium or calcium hypochlorite.

III.B.5. Coating Application

In the wood furniture industry, coatings are usually applied in spray booths, using various types of spray application equipment. The booths generally do not have any temperature or humidity control, and are maintained at ambient conditions. Often, both manual and automatic spray booths are equipped with dry filters, typically a paper material, to control particulates. In the past, water curtains had been used to control particulates. However, since the spent water had to be disposed of as a hazardous waste, and as hazardous waste disposal costs increased, the cost effectiveness of water curtain filtration decreased. Therefore, most of the new and modified spray booths in the wood furniture industry that use filters are equipped with dry filters. Some water-wash spray booths are still in use.

Recirculating a portion of the exhaust from the spray booth increases the concentration of VOCs in the exhaust air leaving the spray booth and discharged to an end-of-pipe control system. According to a document entitled *Demonstration of Paint Spray Booth Air Recirculation and Flow Partitioning: Design Validation*, the concept of recirculation was patented by John Deere Corporation in 1979, but a large segment of the coating industry mistakenly believed that this practice was prohibited by OSHA regulations. During approved recirculation practices, equal portions of fresh air and recirculated air are pumped back into the booth. One advantage of using recirculation is the decreased exhaust flow volume emitted to the atmosphere and decreased capitol and operating costs of the VOC control system. A joint EPA and U.S. Air Force research and development program developed these emissions control concepts for hazardous air pollutants (HAPs).

There are two types of add-on control devices, technologies used to capture pollutants from point-source air emissions: combustion control devices and recovery devices. Combustion control devices are used to destroy contaminants, converting them primarily to carbon dioxide and water. Combustion control devices used by the furniture industry include thermal incineration, with recuperative and regenerative heat recovery, and catalytic incineration.

Recovery devices are used to collect VOCs prior to their final disposition. One recovery device is carbon adsorption used in conjunction with regeneration of the carbon bed by steam or hot air. By using either steam or hot air, the VOCs may be recovered or disposed of following regeneration.

Thermal incineration is a process by which waste gas is brought to adequate temperature, and held at that temperature for a sufficient time for the organic compounds in the waste gas to oxidize.

Catalytic incineration is comparable to thermal incineration in that VOCs are heated to a temperature sufficient for oxidation to occur. However, with catalytic incineration, the temperature required for oxidation is considerably lower than that required for thermal incineration because a catalyst is used to promote oxidation of contaminants. Platinum is the most widely used catalyst; palladium is also commonly used. Because the metals used as catalysts are expensive, only a thin film is applied to the supporting substrate. A commonly used substrate is ceramic.

III.B.6. Finishing

The primary outputs of the finishing steps of the manufacturing process include solvent emissions to the atmosphere, as well as spent solvents, and particles of wood and coating materials applied to the furniture. Solvents or thinners typically used in paints include toluene or xylene. Rubbing and polishing, performed after finishing, require the use of materials containing lubricants, such as detergents and petroleum-based thin oils, and abrasives, such as pumice, tripoli, and diatomaceous earth. Because wood furniture finishing is a solvent-intensive process, the primary outputs are spent solvents and solvent emissions.

Flashoff areas are areas that are either between spray booths, or between a spray booth and an oven, in which solvent is allowed to volatilize from the coated piece. While some flashoff areas have forced air circulation and are referred to as forced-flashoff areas, most flashoff areas do not have a separate exhaust. The length of flashoff areas varies significantly by facility, and even within a facility, depending on whether the coating will be cured in an oven. A flashoff area that is not followed by an oven is often longer than one that is located in between a booth and an oven.

Ovens are used between some coating steps to cure the coating prior to the next step in the finishing sequence. Many types of ovens are used in the wood furniture industry. Most are steam-heated using either a wood- or coal-fired boiler; others are gas-fired. Infrared or ultraviolet ovens are also used, but their use in the wood furniture industry is limited at this time. Oven temperatures can range from less than 38 to 121 degrees Celsius depending on the type of coating used, the piece being coated, and the oven residence time. The exhaust rate from ovens also varies, and can range between 21.2 and 425 cubic meters per minute.

Exhibit 8 contains the relative VOC emissions for three different model plants: a residential furniture manufacturing facility using a long finishing sequence (consisting of a total of three or more stain applications; a single application of wash coat, filler, sealer, and highlight; and two or three topcoat applications); a residential furniture manufacturing facility using a short finishing sequence (consisting of two stain applications, one application of washcoat and sealer, and two topcoat applications); and an office/cabinet manufacturing facility using a short finishing sequence (consisting of one application of stain, sealer, and topcoat). The relative VOC emissions are presented as a percent of each coating applied for each model plant.

Exhibit 8
Relative VOC Emissions

Type of plant	**Furniture long**	**Furniture short**	**Office/cabinet**
Stain	26 percent	28 percent	32 percent
Washcoat	4 percent	4 percent	---
Filler	3 percent	---	---
Wiping stain/glaze	8 percent	---	---
Sealer	18 percent	32 percent	32 percent
Highlight	1 percent	---	---
Topcoat	40 percent	36 percent	36 percent
Total	**100 percent**	**100 percent**	**100 percent**

Source: EPA Draft Guidelines for the Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations.

III.B.7. Cleanup Operations

Solvent-borne nitrocellulose lacquers are the predominant type of coatings used by the wood furniture industry today. The resins in such coatings are relatively “difficult” to dissolve, so a high-solvency-rated solvent must be used in their formulation. Similarly, thinning of these coatings requires the use of the same solvent or one with equivalent solvency. This solvent is generically referred to as “lacquer thinner.” The current practice is to use lacquer thinner for both incidental thinning of premixed coatings and for cleanup of the coatings. Advantages of the lacquer thinner include its compatibility with the finishing materials and the ease with which it removes cured nitrocellulose lacquers.

In wood-coating operations, industrial solvents are used predominantly for cleaning application equipment. In addition, cleanup solvent can also be used to clean out piping, clean booths and rails, strip cured coatings from wood parts or machinery, and periodically clean centralized coating storage and distribution (pump room) equipment.

Application equipment must be cleaned every time there is a color change, and usually before the equipment is to be idle for a period of time (e.g., at the end of the day). For spray coating application, equipment cleaned with solvents includes spray guns, feed lines, and coating reservoirs (where applicable). In the case of roll coating operations, the rollers and spray bar nozzles must be cleaned periodically to maintain application quality as well as prior to color changes.

Spray guns have traditionally been cleaned by sending pure solvent from the coating reservoir through the gun, and atomizing the solvent into the booth ventilation system. Recognizing that this results in significant emissions of solvent, some operators cut off the atomizing air to the spray gun and pump the cleanup solvent through the gun into a container. This procedure can work if the gun is the type that does not depend on the flow of the atomizing air to pump the coating (or cleanup solvent) through the mechanism. Alternately, cleanup may involve soaking the entire gun in solvent. This guards against the possibility that small amounts of coating inadvertently missed during the cleaning will cure and clog the small orifices of the gun. Cleanup solvent is often reused within a facility, and eventually recycled in-house or sent out for recycling/disposal. Exhibit 9 provides an overview of the material inputs and pollution outputs for each step of the wood furniture manufacturing process.

Exhibit 9
Inputs and Outputs of Wood Furniture Manufacturing Facilities

Process	Material Input	Air Emissions	Process Wastes	Other Wastes
Drying				
Ovens/Drying Kilns (boilers covered below)	Raw lumber	Emissions, including water and possible chemicals used in pretreatment of raw lumber		
Machining				
Sawing/Planing/ Sanding	Dried lumber	Wood chips, sawdust	Wood chips, sawdust	Wood chips, sawdust
Bending/Drying (boilers covered below)	Lumber	Emissions, including water and possible chemicals used in pretreatment of raw lumber		
Assembly				
Gluing/Veneer Application	Hot melts, polyvinyl acetate, solvent-based adhesives (e.g., methyl isobutyl ketone, methyl ethyl ketone, xylene, toluene, 1,1,1-trichloroethane)	Solvent emissions (e.g., methyl isobutyl ketone, methyl ethyl ketone, xylene, toluene, 1,1,1-trichloroethane)		Spent solvent-based adhesives (e.g., methyl isobutyl ketone, methyl ethyl ketone, xylene, toluene, 1,1,1-trichloroethane)
Sanding	Assembled furniture	Wood chips, sawdust	Wood chips, sawdust	Wood chips, sawdust
Pre-finishing				
Watering/Sanding	Assembled furniture, water, adhesives, resins		Wood chips, sawdust, adhesive, and resin particles	Wood chips, sawdust, adhesive, and resin particles
Derosination	Ammonia, acetone	Solvent emissions (e.g., acetone)	Spent acetone, ammonia, natural resin from wood	Spent acetone, ammonia, natural resin from wood

Exhibit 9 (cont'd)
Inputs and Outputs of Wood Furniture Manufacturing Facilities

Process	Material Input	Air Emissions	Process Wastes	Other Wastes
Pre-finishing (continued)				
Bleaching	Bleaching agents (e.g., hydrogen peroxide, sodium bisulfite, sodium hyposulfite, sodium perborate, oxalic acid, potassium permanganate, sodium or calcium hypochlorite)		Spent bleaching agents (e.g., hydrogen peroxide, sodium bisulfite, sodium hyposulfite, sodium perborate, oxalic acid, potassium permanganate, sodium or calcium hypochlorite)	Spent bleaching agents (e.g., hydrogen peroxide, sodium bisulfite, sodium hyposulfite, sodium perborate, oxalic acid, potassium permanganate, sodium or calcium hypochlorite)
Finishing				
Staining	Mineral spirits, alcohol, solvents, pigments (e.g., iron oxides, lead chromate, calcium sulfate, cadmium selenide)	Solvent emissions		Pigment wastes (e.g., iron oxides, lead chromate, calcium sulfate, cadmium selenide), solvent wastes
Washcoating	Nitrocellulose-based lacquers, acrylic lacquers, varnish, shellac, polyurethane, solvents	Solvent emissions		Spent solvents, nitrocellulose-based lacquers, acrylic lacquers, varnish, poly-urethane, and shellac
Filling	Pigments (e.g., iron oxides, lead chromate, calcium sulfate, cadmium selenide), stains, drying oils, synthetic resins, solvent-based thinners	Solvent emissions		Spent solvents, stains, drying oils, synthetic resins, thinners, and pigments (e.g., iron oxides, lead chromate, calcium sulfate, cadmium selenide)

Exhibit 9 (cont'd)
Inputs and Outputs of Wood Furniture Manufacturing Facilities

Process	Material Input	Air Emissions	Process Wastes	Solid Wastes
Finishing (continued)				
Sealing	Nitrocellulose-based lacquers, acrylic lacquers, varnish, shellac, solvents, polyurethane	Solvent emissions		Spent solvents, nitrocellulose-based lacquers, acrylic lacquers, varnish, shellac, polyurethane
Priming	Fungicide, water-repellent			
Painting	Toluene, pigments (e.g., titanium dioxide, iron oxides, lead chromate), epoxy-ester resins, aromatic hydrocarbons, glycol ether, halogenated hydrocarbons, vinyl acetate, acrylic	Solvent emissions (e.g., toluene)		Spent solvents (e.g., toluene), pigments (e.g., titanium dioxide, iron oxides, lead chromate), epoxy-ester resins, aromatic hydrocarbons, glycol ether, halogenated hydrocarbons, vinyl acetate, acrylic
Topcoat Application	Denatured alcohols, resins, shellac, petroleum distillates, toluene, disocyanate	Solvent emissions (e.g., toluene)		Spent denatured alcohols, resins, shellac, petroleum distillates, toluene, disocyanate
Sanding (occurs intermittently between each of the above finishing applications)	Finished piece of furniture	Particles that include wood, adhesive, resin, nitrocellulose lacquer, paint, stain, filler, and sealer	Particles that include wood, adhesive, resin, nitrocellulose lacquer, paint, stain, filler, and sealer	Particles that include wood, adhesive, resin, nitrocellulose lacquer, paint, stain, filler, and sealer
Rubbing/Polishing	Lubricants, detergents, petroleum-based thin oils, pumice, tripoli, diamaceous earth			Spent lubricants, detergents, oils

Exhibit 9 (cont'd)
Inputs and Outputs of Wood Furniture Manufacturing Facilities

Process	Material Input	Air Emissions	Process Wastes	Solid Wastes
Cleanup Operations				
Brush Cleaning/ Spray Gun Cleaning	Acetone, toluene, petroleum distillates, methanol, methylene chloride, isopropanol, mineral spirits, alcohols	Solvent emissions (e.g., acetone, toluene, methanol, methylene chloride)	Spent solvents (e.g., acetone, toluene, methanol, methylene chloride), mineral spirits, alcohols, petroleum distillates	Spent solvents (e.g., acetone, toluene, methanol, methylene chloride), mineral spirits, alcohols, petroleum distillates
Boilers				
Boilers	Wood and coating material particulates from the finishing process	Boiler ash particulates		Boiler ash

Source: Pollution Prevention Options in Wood Furniture Manufacturing, 1992.

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 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 10 shows that the furniture and fixtures industry managed about 47 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, 98 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 one 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 (90.6 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 remained steady and the portions treated or managed through energy recovery on-site have decreased slightly between 1992 and 1995 (projected).

Exhibit 10
Source Reduction and Recycling Activity for SIC 25

A	B	C	D	E	F	G	H	I	J
			On-Site			**Off-Site**			
Year	**Production Related Waste Volume (10^6lbs.)**	% Reported as Released and Transferred	% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	**Remaining Releases and Disposal**
1992	44	100%	0.66%	0.00%	0.57%	2.32%	6.55%	0.90%	89.35%
1993	47	98%	0.70%	0.02%	0.42%	2.38%	5.10%	0.80%	90.58%
1994	44	—	0.76%	0.00%	0.46%	2.47%	4.60%	0.78%	90.93%
1995	44	—	0.73%	0.00%	0.46%	2.60%	5.19%	0.72%	90.31%