

# **Wood Furniture:**

## **The Clean Air Act Amendments of 1990 and Pollution Prevention Opportunities**

**The Northeast Waste Management Officials' Association**

**and**

**The Northeast States for Coordinated Air Use Management**

**August 1997**

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# The Hazardous Air Pollution Prevention Project

In December 1995, the Northeast Waste Management Officials' Association (NEWMOA) and the Northeast States for Coordinated Air Use Management (NESCAUM) initiated a joint project, "Promoting Innovative Technologies in Hazardous Air Pollutant Standards," which is commonly referred to as the Hazardous Air Pollution Prevention (HAP2) project. The project is funded under a U.S. Environmental Protection Agency (U.S. EPA) Environmental Technology Initiative grant and administered by the U.S. EPA Region I office. The project promotes pollution prevention (P2) approaches for compliance with the hazardous air pollutant (HAP) control requirements of the 1990 Clean Air Act Amendments (CAAA). The HAP2 Workgroup, which consists of representatives from the pollution prevention and air quality programs in the NESCAUM/NEWMOA member states, was formed to coordinate this interstate project and to develop P2 manuals for three National Emission Standard for Hazardous Air Pollutant (NESHAP) source categories. The first source category selected by the HAP2 Workgroup for this project is the wood furniture manufacturing industry.

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For more information about NEWMOA and NESCAUM, contact:

NEWMOA  
129 Portland Street, 6th Floor  
Boston, MA 02114  
(617) 367-8558  
(617) 367-0449 (FAX)

NESCAUM  
129 Portland Street, 5th Floor  
Boston, MA 02114  
(617) 367-8540  
(617) 742-9162 (FAX)

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Steven De Santis, New York State Department of Environmental Conservation  
William Etherington, New Jersey Department of Environmental Protection  
Gina Friedman, Rhode Island Department of Environmental Management  
Brian Fitzgerald, Vermont Agency of Natural Resources  
George Frantz, Massachusetts Office of Technical Assistance  
Rich Girasole, Rhode Island Department of Environmental Management  
Kim Hibbard, Maine Department of Environmental Protection  
Kim Hudak, Connecticut Department of Environmental Protection  
Douglas Kretkowski, New Jersey Technical Assistance Program  
Rita Lomasney, Connecticut Technical Assistance Program  
Sharon Rehder, New York State Department of Environmental Conservation  
Chris Rushton, Maine Department of Environmental Protection  
Yi Tian, Massachusetts Department of Environmental Protection  
Paul VanHollebeke, Vermont Agency of Natural Resources  
Paul Walsh, Massachusetts Department of Environmental Protection  
David Westcott, Connecticut Department of Environmental Protection

## Project Staff / Contributors

Jennifer Griffith, NEWMOA/NESCAUM Project Manager - Researcher/Author  
Terri Goldberg, NEWMOA P2 Program Manager - Managing Editor  
Margaret Round, NESCAUM Research Analyst - Managing Editor  
Janet Bowen, U.S. EPA Region I - U.S. EPA Project Manager

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# CHAPTER 1: INTRODUCTION

NESHAP, CTG, Title I, Title III, Title V, MACT, RACT - you may have heard these acronyms over the past several years as the United States Environmental Protection Agency (U.S. EPA) has begun implementing the various requirements of the Clean Air Act Amendments of 1990 (CAAA). But what do all these terms mean to wood furniture manufacturers and to those who regulate them? This Manual is written to answer these questions and to present vital information about methods for reducing air emissions and for complying with the various federal requirements.

The U.S. EPA has targeted wood furniture manufacturers because they are the largest industrial users of solvents in paints and coatings among original equipment manufacturers in the United States, using over twice as much solvents as automobile manufacturers.<sup>1</sup> Wood is coated to protect it from physical and chemical damage, and natural degradation, as well as to impart an aesthetically pleasing finish. The coating materials traditionally used by the furniture industry contain a substantial quantity of solvents that volatilize to the air within the plant and/or are directly vented to the outside, usually without treatment. This Manual presents federal and state regulations established to reduce air emissions to the outdoor environment only.

This Manual is divided into four chapters. Chapter 1 contains background information on the reasons for regulating emissions from wood furniture manufacturing including a brief regulatory perspective, an overview of the health effects of the five solvents used in the largest quantities, sources of emissions from a typical wood furniture manufacturing facility, and a summary of the new federal wood furniture regulations. Chapter 2 defines pollution prevention (P2) and discusses the elements of a successful P2 program. Chapter 2 is somewhat general and is included as a reference to provide companies with a framework to evaluate the pollution prevention opportunities presented in Chapter 3 and to develop a comprehensive pollution prevention program, if desired. Chapter 3 presents the various P2 opportunities available for wood furniture finishing, cleaning, gluing and housekeeping operations. For each of these activities, Chapter 3 also discusses regulatory requirements and pollution prevention technologies, and presents case studies. Chapter 4 concludes with recommended pollution prevention strategies.

Appendix A presents a history of the regulatory developments leading up to the CAAA and includes an outline of the various sections, known as Titles, of the CAAA. Appendix B contains extensive general information beyond that contained in Chapter 1 and is included as a reference for those not familiar with the wood furniture manufacturing process. Appendix C contains state-specific regulations that apply to wood furniture manufacturers in the Northeast.<sup>2</sup> Appendix D contains lists of chemicals regulated by the new wood furniture rule. Finally, Appendix E contains a list of technical assistance and regulatory agencies, and other resources where companies can obtain further information.

## 1.1 Brief Regulatory Perspective

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<sup>1</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>2</sup> In this Manual, Northeast includes the following states: CT, ME, MA, NH, NJ, NY, RI and VT.

In the Northeast, the solvents emitted in the greatest quantities from furniture finishing are toluene, xylenes, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK) and methanol.<sup>3</sup> All of these compounds are flammable liquids that quickly evaporate in air. In addition, the U.S. EPA considers them hazardous air pollutants (HAPs) that can cause adverse health effects and volatile organic compounds (VOCs) that can contribute to ambient air quality problems. In the CAAA, Congress established a list of 189 HAPs whose emissions are regulated because of their probable adverse health effects.<sup>4</sup> The U.S. EPA is required to regulate industrial source categories that emit large quantities of one or more HAPs. The U.S. EPA has recently promulgated regulations under the CAAA that significantly affect the use of volatile HAPs (VHAPs) and VOCs by the wood furniture industry.<sup>5</sup>

On December 7, 1995, the U.S. EPA promulgated a National Emission Standard for Hazardous Air Pollutants (NESHAP) for the wood furniture manufacturing industry. The NESHAP applies to all wood furniture manufacturers with the potential to emit 10 tons per year (tpy) or more of a single HAP or 25 tpy or more of a combination of HAPs. Potential to emit is defined and discussed in Section 1.4.1 of this Manual. Existing sources emitting 50 tpy or more of HAPs are required to comply with these new federal regulations by November 21, 1997; sources emitting below 50 tpy HAPs have an extended compliance date of December 7, 1998. The wood furniture NESHAP is among the first federal air toxic control regulations that requires pollution prevention work practice standards and includes the option of using innovative P2 approaches to comply with the VHAP emission limits on coatings and adhesives used by the industry. The U.S. EPA and others refer to reducing or eliminating hazardous chemical use and by-products as P2.

On May 20, 1996, U.S. EPA issued a control technology guideline (CTG) for reducing VOC emissions from wood furniture finishing. VOCs are a different grouping of chemicals from HAPs and are regulated because they contribute to the formation of smog and other outdoor air quality problems.<sup>6</sup> Virtually all VHAPs are also VOCs. Therefore, many wood furniture manufacturers have to understand and comply with the requirements of two different federal mandates. In addition, many of the Northeast states regulate the wood furniture industry under their state air toxics control programs. A wood furniture manufacturing facility should contact their state air quality agency to determine the state's specific regulatory requirements.

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<sup>3</sup> U.S. EPA, Toxic Release Inventory (TRI) database, 1993. The Emergency Planning and Community Right-to-Know Act (EPCRA) established a list of more than 300 chemicals that are subject to reporting to the TRI. All manufacturing facilities in Standard Industrial Classification (SIC) codes 20-39 that employ more than 10 persons, and manufacture or process more than 25,000 pounds, and/or use more than 10,000 pounds of any listed chemical must report all releases of listed chemicals to the TRI annually. Now more than 600 chemicals are subject to TRI reporting.

<sup>4</sup> Caprolactam was removed from the HAP list on June 18, 1996. There are 188 listed HAP chemicals.

<sup>5</sup> VHAPs are a subset of the list of HAPs. The use of VHAPs is restricted by the wood furniture NESHAP. The term VHAP is used in this Manual instead of the more general term HAP, unless using VHAP is incorrect.

<sup>6</sup> VOC is defined in 40 CFR (Code of Federal Regulation), Part 51.100 (s).



Wood furniture manufacturing is a significant part of the industrial base in the Northeast. Based on a survey conducted for this project in early 1996, approximately 35 facilities in the Northeast will have to comply with these new regulations and many more will have to keep the proper records to verify that they are exempt. Facilities are now examining their current practices and contemplating changes in anticipation of the new wood furniture regulations. This Manual examines P2 techniques to reduce the use of hazardous chemicals in the wood furniture manufacturing industry. Because many of these techniques are an integral component of the NESHAP, facilities are encouraged to evaluate their compliance options and to consider the benefits of implementing P2 beyond what is required in the NESHAP.

A P2 project or group of projects might enable a facility to lower its air emissions to below levels that are regulated by the federal NESHAP and/or state air toxics and VOC control programs.

Firms that have implemented P2 beyond the requirements of the NESHAP are more likely to meet future requirements. In the CAAA, U.S. EPA is required to review the impact of each NESHAP after 8 years and revise the standard if necessary to ensure that public health is protected with an ample margin of safety. Revisions could include adding to the list of regulated VHAPs. Facilities that have reduced the use of VHAPs and other volatile chemicals significantly through P2 are likely to meet future NESHAP revisions without altering their operations.

The U.S. EPA is required to review each NESHAP and revise the standard if necessary to ensure that public health is protected with an ample margin of safety.

In addition to improving conditions for employees and reducing environmental impacts, firms that implement P2 techniques often realize a financial benefit. Financial gains can be substantial and are typically realized from reductions in coating use, waste generation, labor requirements, fire insurance premiums, and record keeping and reporting burdens. In some cases, investing in P2 can improve a facility's productivity. A P2 project or group of projects might enable a facility to lower its air emissions to below levels that are regulated by the federal NESHAP and/or state air toxics and VOC control programs. If a regulation no longer applies, then record keeping and reporting requirements are significantly reduced, often requiring firms to prove only that the regulation does not apply.

Firms that implement P2 techniques often realize a financial benefit.

Chapter 3 of this Manual presents P2 opportunities available for compliance with the NESHAP requirements and contains several case studies illustrating the benefits of P2. Although the NESHAP regulates only large facilities, the P2 opportunities presented in Chapter 3 also can provide benefits to small facilities. This Manual is written to help both large and small firms make cost-effective P2 improvements.

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## 1.2 Adverse Health Effects of Selected VHAPs<sup>7</sup>

Most wood furniture manufacturing facilities exhaust their emissions directly to the outside of the facility without any treatment. Therefore, in addition to possible occupational exposure to VHAPs, persons living in close proximity to the plant might also be exposed to air toxic emissions from the facility. Chemicals enter the body via three primary routes: inhalation, ingestion or direct contact with the skin. In the work environment of a wood finishing line, the primary exposure route to VHAPs is inhalation. Accidental direct contact or ingestion is possible, particularly if employees are not adequately trained and/or appropriate housekeeping practices are not implemented. For persons living near the facility, the primary exposure route also would be inhalation. This section only addresses health effects associated with exposure by inhalation.

The VHAPs traditionally used in the largest quantities by the wood furniture industry in the Northeast (i.e. toluene, xylenes, MEK, MIBK and methanol) can result in adverse health effects at certain levels of exposure. The adverse health effects associated with these five compounds are well documented. The following presents a summary of the health effects associated with relatively high levels of inhalation exposure to toluene, xylenes, MEK, MIBK and methanol.<sup>8</sup>

Breathing toluene, xylene, MEK, MIBK or methanol vapors can cause:

    C headaches

    C fatigue

    C nausea

and other symptoms. Long-term exposure can cause more serious health effects.

Toluene: Both short and long-term inhalation of toluene affects the central nervous system and can cause symptoms such as headaches, fatigue and nausea. Long-term exposure to toluene can also cause irritation of the upper respiratory tract, eyes and throat; as well as impaired speech, hearing and vision. Developmental effects have been reported in children born to women exposed to toluene during pregnancy. An increased risk of miscarriage has been associated with paternal exposure to toluene. There is no evidence linking exposure to toluene and cancer.

Xylenes: Short-term inhalation of xylenes results in irritation of the eyes, nose and throat, nausea, vomiting, and neurological damage. Long-term exposure to xylenes can result in central nervous system effects such as headaches, dizziness, fatigue, tremors and impaired coordination. Long-term exposure can also impair lung function, and increase heart palpitation and chest pain; and possibly can affect the blood and kidney. Animal studies also show developmental damage in offspring born to mothers that inhaled xylenes. There is no evidence that xylenes are carcinogenic.

Methyl Ethyl Ketone (MEK): Short-term inhalation of MEK irritates the eyes, nose and throat, depresses the central nervous system; and causes headaches and nausea. Long-term exposure to

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<sup>7</sup> All information was obtained from: U.S. EPA, *Health Effects Notebook*, Draft March 1995.

<sup>8</sup> The human health effect of a substance is related to the quantity of the substance a person is exposed to and the length of time over which the exposure occurs. In addition, some compounds are more toxic than others so that smaller quantities are more harmful than larger quantities of a less toxic substance. Information regarding concentration, length of exposure and corresponding health effect can be obtained over the internet from U.S. EPA's Technology Transfer Network (<http://www.epa.gov/ttn>) or by contacting the state air toxics program.

MEK can affect the central nervous system, liver and respiratory system. There is no evidence linking exposure to MEK and cancer.

**Methyl Isobutyl Ketone (MIBK):** Short-term inhalation of MIBK affects the nervous system and can cause symptoms such as headaches, dizziness, confusion, weakness, memory loss, lack of coordination and nausea. Long-term exposure to MIBK can also affect the way the kidneys and liver function. There is no evidence that exposure to MIBK is carcinogenic.

**Methanol:** Short-term inhalation of methanol is linked to motor dysfunctions and visual disturbances such as blurred vision leading to blindness. Long-term exposure can result in headaches, insomnia and visual disturbances. There is no evidence linking exposure to methanol and cancer.

Toluene, xylenes, MEK, MIBK and methanol also are classified as VOCs. Once released to the atmosphere, VOCs react with nitrogen oxides and sunlight to form ground-level ozone. Ground-level ozone can affect respiratory function adversely, particularly among sensitive people with asthma or pre-existing respiratory disease. Broad areas of the Northeast region are in non-attainment of the existing 1 hour ozone standard intended to protect public health.<sup>9</sup> Furthermore, the proposed revision to the current ground-level ozone standard is likely to increase the areas of non-attainment in this region.

### 1.3 Sources of VHAP Emissions and Waste Generation

What are the various sources of air emissions and other wastes at a wood furniture manufacturing facility? The vast majority of air emissions are generated from the coatings used in the wood finishing process. In the manufacture of partitions and fixtures and other types of wood furniture products that involve covering a composite material core with a wood veneer or plastic laminate, the adhesives used can generate significant air emissions.

VHAP/VOC emissions are affected by:

- ∩ coating/adhesive formulation
- ∩ application equipment
- ∩ housekeeping practices

The quantity of coatings or adhesives used, and therefore the emissions generated, also correlates with the application equipment used. Some air emissions also arise from the use of solvents to clean spray guns, spray booths and other equipment. A generalized process flow diagram showing air emission and solid and/or hazardous waste sources from traditional solvent-based coating application and cleaning techniques is presented in Figure 1.1. Because the emissions and wastes generated are similar for each coating application, they are shown for one application only. Therefore, the more coating

<sup>9</sup> Non-attainment and other general information related to the control of ground-level ozone can be obtained in Appendix A of this Manual.



layers applied, the more times a piece of furniture cycles through the diagram and the greater the air emissions and solid and/or hazardous wastes generated.

The various pollution problems associated with all of these components of the finishing process are described in the following sections. Because VOCs have been regulated at the federal level for a longer period of time than VHAPs, much of the available literature on the various finishing materials and adhesives refers to their VOC content, not their VHAP content. Virtually all VHAPs are VOCs; however, not all VOCs are VHAPs. Most of the information contained in this report presents VOC content and is included to provide an indication of the relative quantity of emissions generated. In addition, VOC emissions themselves are regulated under the CAAA as discussed in Section 1.5 of this Manual.

### 1.3.1 Wood Surface Finishing

This section presents a brief description of the emission sources from wood surface finishing and assumes a familiarity with the finishing process. For those not familiar with the wood finishing process or the terminology used, more information can be found in Appendix B of this Manual.

Generally, there are two types of wood surface finishing processes, a long sequence and a short sequence. High-end furniture manufacturers use a long sequence where seven or more different types of finishing materials are applied to the wood, with several types applied more than once. Medium- and low-end manufacturers often use a short sequence consisting of three application steps: stain, sealer and topcoat. The relative percentage of total VOC emissions from the finishing process contributed by each of the typical application steps in the long and short sequences is shown in Table 1.1. All percentages in this Manual refer to percent by weight.

**Table 1.1 Relative VOC Emissions<sup>10</sup>**

<b>Application Type</b>	<b>Short Sequence (in percent)</b>	<b>Long Sequence (in percent)</b>
<b>Stain</b>	32	26
<b>Washcoat</b>		4
<b>Filler</b>		3
<b>Wiping stain</b>		8
<b>Sealer</b>	32	18
<b>Highlight</b>		1
<b>Topcoat</b>	36	40
<b>Total</b>	100	100

In the short sequence, VOC emissions are divided almost evenly among the stain, sealer and topcoat. In the longer sequence, the stain, sealer and topcoat still contribute the largest VOC emissions, relative to the other steps, although the percentages are altered. As shown in Table 1.1,

<sup>10</sup> U.S. EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995.

washcoat, filler, wiping stain and highlight coats combine for 16 percent of VOC emissions, sealer 18 percent, stain 26 percent and topcoat 40 percent. Overall, emissions from long sequences are significantly higher than those from short sequences because the total number of finishing steps (i.e. the amount of coating used to finish a single item) is greater.

Traditionally, all wood finishing materials are solvent-based and their VHAP content is regulated by the wood furniture NESHAP. Generally, two types of sealer and topcoat materials are used by the wood furniture industry: nitrocellulose and catalyzed. Nitrocellulose sealers and topcoats are used in both long and short sequence finishing; catalyzed coatings are generally limited to short sequence finishing. The stains used under catalyzed sealers and topcoats are the same as those used under nitrocellulose coatings, and are typically methanol-based. Both nitrocellulose and catalyzed materials generate significant air emissions and their VHAP and VOC content are covered by the NESHAP and new CTG, respectively.

## Nitrocellulose Coatings

Substantial quantities of VOC and/or VHAP emissions are generated by the nitrocellulose finishing process. Nitrocellulose sealers and topcoats are used widely in the wood furniture industry because they are easy to apply and repair, dry quickly, are familiar to the industry, and provide the final product appearance that consumers are accustomed to. However, three main drawbacks offset the benefits of nitrocellulose coatings: nitrocellulose is highly flammable; the coating requires the use of solvents that are toxic and volatile, creating large quantities of potentially harmful emissions; and the dried finish is not highly durable - it is easy to damage, is ruined by water, and turns yellow when exposed to sunlight.<sup>11</sup>

Clear nitrocellulose topcoats are commonly known as lacquers. Traditional nitrocellulose coatings contain a low percentage of solids, typically ranging from 10 to 30 percent for sealers and lacquers.<sup>12</sup> Because only the solids remain as the dried coating on the finished piece of furniture, 70 to 90 percent of the liquid that is applied to the item ends up as air emissions, depending on the type of coating. For example, a typical nitrocellulose coating with 16 percent solids contains approximately 6 pounds of VOCs per gallon (less water).<sup>13</sup> In units of pounds VOC per pound solids (lbs. VOC/lb. solids), a typical 20 percent solids lacquer contains approximately 4 lbs. VOC/lb. solids.<sup>14</sup> Solvents dissolve

Nitrocellulose coatings have three primary drawbacks:

- Ⓒ high flammability
- Ⓒ solvents are toxic and volatile
- Ⓒ not durable - easy to damage, ruined by water, and turns yellow in sunlight

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<sup>11</sup> U.S. EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

<sup>12</sup> U.S. EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995.

<sup>13</sup> P.J. Dambek, et al, *A Guide to Pollution Prevention for Wood Furniture Finishing*, Capstone Project, Tufts University, August 1992.

<sup>14</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

nitrocellulose, so cleanup is accomplished by adding solvent to the dried coating. Therefore, the cleanup of nitrocellulose coatings generates more solvent emissions.

## Catalyzed Coatings

Catalyzed coatings are used for sealer and topcoat applications, typically in the manufacture of kitchen cabinets and high use furniture such as office desks and casual dining sets. Catalyzed coatings are more durable than traditional nitrocellulose coatings, exhibiting greater resistance to moisture, and physical and chemical damage. Acid-catalyzed topcoats are commonly known as conversion varnishes. Acid-catalyzed coatings typically have a lower VOC content and a higher solids content than nitrocellulose coatings, although air emissions are still significant. For example, a 40 percent solids conversion varnish contains 4.75 lbs. VOC/ gallon (less water).<sup>15</sup> A 35 percent solids conversion varnish contains 1.9 lbs. VOC/ lb. solids.<sup>16</sup>

Acid-catalyzed conversion coatings typically have a lower VOC content than nitrocellulose coatings, although air emissions are still significant.

Acid-catalyzed conversion coatings emit some VHAPs that are different than those emitted by nitrocellulose coatings such as formaldehyde.<sup>17</sup> Inhalation exposure to formaldehyde can result in eye, nose and throat irritation, and respiratory problems; studies have linked formaldehyde with increased cancer risk.<sup>18</sup> The NESHAP contains special provisions for formaldehyde emissions from acid-catalyzed conversion coatings. Formaldehyde is also a VOC. The CTG contains emission limits specifically for acid-catalyzed conversion coatings.

### 1.3.2 Application Equipment

The transfer efficiency (TE) of an application technology is the percentage of material that exits the application equipment and actually contacts the furniture item. The lower the TE of the application equipment, the more virgin material consumed to coat a given item, the greater the amount of overspray generated, and the larger the quantity of total air emissions. Therefore, the application technology used can have a significant impact on the amount of finishing materials used, and consequently VOC and VHAP emissions. Generally, there are two broad types of application technologies: manual spray guns and automated finishing systems.

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<sup>15</sup> Architectural Woodwork Institute, "Catalog and Evaluation of Compliant Wood Coatings For New York State Woodwork Manufacturers," Copyright 1994.

<sup>16</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>17</sup> J. Heltzer, "Wood Furniture Finishing," *Industrial Pollution Prevention Handbook*, edited by H.M. Freeman, McGraw Hill, 1995.

<sup>18</sup> U.S. EPA, *Draft EPA Health Effects Notebook*, March 1995.

## Manual Spray Gun Application

Most furniture made in the Northeast, particularly high-end furniture, is finished manually using a spray gun. Although conventional air spray guns have the lowest TE of all the spray application technologies, they are still widely used in the wood furniture industry because they allow high production rates and have been used for decades, making them a familiar technology.

Conventional air spray application equipment is defined as air spray technology "... in which the coating is atomized by mixing it with compressed air and applied at an air pressure greater than 10 pounds per square inch (gauge)

at the point of atomization."<sup>19</sup> Conventional air spray application has a TE in the range of 30 to 40 percent<sup>20</sup>; however, transfer efficiencies as low as 20 percent are not unusual.<sup>21</sup> Therefore, 60 to 80 percent of coating purchase costs are wasted. In addition, the wasted coating solids end up on spray booth filters, walls and floors requiring more frequent cleaning and disposal than if the TE were higher. Cleaning wasted coating generates solid and/or hazardous wastes that must be properly managed, as discussed in Section 1.2.4, Housekeeping.

Conventional air spray guns have a transfer efficiency of only 20 to 40 percent. Therefore, 60 to 80 percent of coating purchase costs are wasted.

Other types of spray guns used in the industry include high volume low pressure (HVLP), airless, air-assisted airless and electrostatic. These application technologies have higher TEs than conventional air spray guns and are discussed in more detail in Chapter 3, Pollution Prevention Opportunities.

The TE of spray application is affected by a number of variables, including:<sup>22</sup>

- Ⓒ size and geometry of the target (e.g. finishing a large tabletop generates less overspray than coating an intricately cut chair back)
- Ⓒ skill of the operator (both spray technique and equipment adjustment)
- Ⓒ type of application equipment
- Ⓒ type of coating
- Ⓒ atomizing air pressure
- Ⓒ fluid flow rate

The TE of spray application is affected by:

- Ⓒ size and geometry of the target
- Ⓒ skill of the operator
- Ⓒ type of application equipment
- Ⓒ type of coating
- Ⓒ atomizing air pressure
- Ⓒ fluid flow rate
- Ⓒ air velocity and flow direction in spray booth

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<sup>19</sup> U.S. EPA, "National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions from Wood Furniture Manufacturing Operations," *Federal Register*, December 7, 1995, p. 62937.

<sup>20</sup> DeVilbiss Industrial Coating Equipment Company informational brochure, "HVLP all you want to know about high volume low pressure finishing," copyright 1994.

<sup>21</sup> L. Snowden-Swan, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992.

<sup>22</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.



## C air velocity and flow direction in spray booth

The size and geometry of the item being finished is assumed to be fixed. However, a company can improve the TE of their spray application through optimizing the other variables. Optimizing each of the variables is discussed in Chapter 3, Pollution Prevention Opportunities.

## Automated Finishing

In automated flatline finishing, the flat wood pieces travel on a conveyor to each finishing station. The system applies the coating material using rollers or an automated spray technique, or by passing the item through a curtain (cascade) of coating. Production rates are typically faster with flatline finishing than with manual spray gun application. In all flatline application techniques, the excess coating can be collected below the conveyor and recirculated to the coating reservoir for reuse. TEs in flatline finishing are significantly higher than for manual spray gun application, with continuous coating systems essentially at 100 percent because all excess coating is reused. The coating application stations in flatline finishing systems are often enclosed and production rates are typically fast and constant. Therefore, air emissions from flatline systems might be at a high enough and a consistent enough concentration to make the use of an air emission control and treatment device feasible.

TEs in flatline finishing are significantly higher than for manual spray gun application, with continuous coating systems essentially at 100 percent.

Some facilities use automated spray guns to apply coatings to either flat or three-dimensional pieces in a spray booth. Automated spray gun application in a booth setting can be appropriate if the production line finishes uniformly sized items. Variations in item size and configuration can be handled if electronic sensors feed information about the item to a computer that controls the spray guns. Automated spray gun application minimizes the reduction in TE because of operator technique and equipment adjustment. Therefore, TEs are higher with an automated spray gun system than with manual spray gun application, but lower than with a flatline system. Production rates can be faster with an automated spray gun system than with manual application.

Dip coating is another coating method that can be automated. Although the TE can be high, the open reservoir generates significant air emissions if solvent-based coatings are used because the solvent can freely evaporate.

### 1.3.3 Gluing Operations

Furniture manufacturers use contact adhesives for securing a laminate to a underlying wood substrate.<sup>23</sup> The laminate is commonly a form of vinyl, polyvinyl chloride (PVC), coated paper, melamine or wood veneer. Substrates are typically particleboard or medium density fiberboard

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<sup>23</sup> The wood furniture NESHAP regulates the use of contact adhesives (adhesives that bond a laminate to a substrate without the use of clamping or other prolonged pressure). Therefore, the use of adhesives to aid in furniture assembly is not discussed in this Manual. Contact adhesives also are used in the manufacture of upholstered furniture to glue fabric to foam, and foam or fabric to the wooden frame. The production of upholstered furniture is not significant in the Northeast and, therefore, is not discussed in detail in this Manual.

(MDF). Contact adhesives can be applied with manual spray guns or brushes, or an automated system, particularly at large facilities. Contact adhesives are applied to both the laminate and the substrate, and are allowed to set for a short period of time before contact is made. Once contact is made, the bond requires additional time to reach its final strength.

The laminate and the substrate can be joined by placing one surface onto the other by hand, or they can be joined as part of an automated process. After the two materials are joined, pressure is applied to the surface to eliminate air bubbles and ensure total contact. For flat surface laminates, pressure can be applied by a hand-held roller or by machine called a pinch roller. If the laminate is used to cover the side edge of the substrate, a technique known as edgebanding, pressure is applied by a hand roller or an automated process that is customized to the part configuration.

Different types of contact adhesives are used for different applications. The seven general categories of contact adhesives used by the wood furniture industry are solvent-based, epoxy resin, urea-formaldehyde resin, hot melt, heat seal, aqueous-based and polyvinyl acetates (PVA). Solvent-based, urea-formaldehyde resin and some epoxy resin adhesives contain VHAPs and/or VOCs and can generate significant air emissions. Hot melt, heat seal, aqueous-based and PVA adhesives do not generate significant air emissions at wood furniture manufacturers and are considered alternatives to solvent-based adhesives. These adhesives are discussed in Chapter 3, Pollution Prevention Opportunities.

Solvent-based adhesives are used for a wide range of laminate applications. They contain polymeric resins dissolved in a VOC solvent and are typically 15 to 20 percent solids and 80 to 85 percent solvents.<sup>24</sup> Solvent-based adhesives can be applied manually with spray guns or rollers, or in an automated roll station. Solvent-based adhesives generally need to set for 15 to 20 minutes after application before the two surfaces are bonded together. The total cure time for solvent-based adhesives is on the order of several hours.

Solvent-based contact adhesives contain VHAPs and/or VOCs that become air emissions.
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Urea-formaldehyde resin adhesives are used widely in the manufacture of particleboard and MDF, but they also are used to apply wood veneers and in upholstery operations. Not all of the formaldehyde in the adhesive volatilizes; however, emissions from the free formaldehyde, which does not bind into the adhesive during curing, can be significant. As discussed in the section on catalyzed coatings, formaldehyde is a VHAP and can have serious health consequences.

Epoxy resins are often used to laminate vinyl to MDF. Many epoxy resin adhesives are solvent-based; however, some are 100 percent solids. Epoxy resin adhesives typically are applied by manual or automated roll-coating. Solvent-based epoxies typically contain methylene chloride<sup>25</sup> and are used because they tend to have a higher initial bond strength than 100 percent solids epoxies. Epoxy resin adhesive lamination requires cure temperatures of more than 50 degrees Fahrenheit for a period of 1 to 3 days. Substituting 100 percent solids epoxy resin for solvent-

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<sup>24</sup> S. Rasor, Memorandum to Madeleine Strum of U.S. EPA, Research Triangle Park, NC, November 9, 1994.

<sup>25</sup> Daubert Chemical Company Inc., MSDS for Duabond DC 8795 A Modified Epoxy Resin, June 22, 1989.

based epoxy resin adhesives can be a feasible alternative in many circumstances and will virtually eliminate VHAP emissions.

### 1.3.4 Housekeeping

While the majority of air emissions are generated from coating and adhesive application and drying, there are numerous other potential sources of air emissions at a wood furniture finishing facility. Many of these other sources result from what are termed "housekeeping" practices.

Housekeeping includes material storage and distribution, and the maintenance of the facility and equipment, including routine cleaning.

The purchase of solvents that are used for cleaning represents approximately 10 percent of the total volume of finishing materials purchased at a wood furniture facility,

indicating that a significant percentage of total

emissions are from the various cleaning activities.<sup>26</sup> In addition to air emissions, housekeeping activities at facilities usually generate several solid and/or hazardous waste streams.

Approximately 10 percent of solvents purchased are used for cleaning, indicating that a significant percentage of air emissions are from cleaning.

## Air Emissions

Potential sources of air emissions from housekeeping activities include:

- ☐ leaks in the coating/adhesive supply system
- ☐ transfer of coatings/solvents/adhesives from large to small containers
- ☐ uncovered coating/solvent/adhesive containers
- ☐ uncovered washoff tanks
- ☐ spray booth cleaning
- ☐ coating/adhesive supply system cleaning, including spray guns
- ☐ spills
- ☐ used rags

Leaks in the coating/adhesive supply system can occur at the seal with the reservoir, in the transfer line or from seals in the application equipment itself. The farther the reservoir is located from the application point, the more transfer line and connections are required, increasing the likelihood of leakage. In addition, a leak in the line can remain undetected longer if it passes through unoccupied areas than if the line passes through well traveled areas.

Unless the transfer system is fully automated, material is manually transferred from storage containers to pressure pots for use. Manual transfer of materials by pouring one into the other increases aeration (and volatilization) and can result in spills that volatilize as they dry. Storage containers and washoff tanks that are not covered and tightly sealed when not in use also can be a significant source of air emissions.

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<sup>26</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, U.S. EPA/453/R-96/007, April 1996.

Spray booth cleaning generates three potential sources of air emissions: strippable spray booth coating, absorbent materials laden with coating, and solvents used to remove dried coatings from metal filters (if used) and other portions of the booth. The strippable spray booth lining reduces the need to use solvents to remove the dried coating. However, the strippable spray coating itself often contains a significant concentration of VOCs that are emitted as the coating dries on the spray booth components.

Absorbent materials are often placed on the floor of the spray booth to capture liquid runoff, particularly during staining. If metal spray booth filters are used, they require periodic cleaning. Cleaning is typically performed using solvents to dissolve and remove the coating material. Storing the absorbent and spent solvent wastes, particularly liquid cleaning solvents, in open or loosely sealed containers prior to their disposal can create notable emissions.

Gun and line cleaning is carried out frequently and can be a significant source of emissions. Typically, spray gun(s) are cleaned daily by dismantling the gun and soaking it in a small container of solvent at the work site. The parts are removed and dried with a rag, and then the gun is reassembled. Emissions occur when the container is not covered tightly, either when in use or not in use, and when the parts are removed and dried.

Housekeeping air emission sources include:

- C leaks in the coating/adhesive supply system
- C transfer of coatings/solvents/adhesives from large to small containers
- C uncovered coating/solvent/adhesive containers
- C uncovered washoff tanks
- C spray booth cleaning
- C coating/adhesive supply system cleaning
- C spills
- C used rags

At small facilities, the same spray gun might be used for the application of more than one type of coating, requiring gun and incoming line cleaning between each application of different types of coatings or different color coatings. This type of cleaning is typically performed by running pure solvent through the line and gun and discharging it into the air of the spray booth or into a container for collection. If the solvent is simply discharged from the gun into the spray booth for evaporation, emissions are significant. When the solvent is collected in a container that is then immediately covered and sealed, emissions are lowered, but not eliminated. If the container is not covered tightly, emissions will continue after collection.

At large facilities, each type of coating typically has its own dedicated gun and line. With dedicated guns, there are no coating or color changes. Daily cleaning is confined to the gun itself, as described above. However, prior to daily startup, the line is usually flushed with coating until the operator believes that the coating is “fresh” and the gun is working properly. The coating material, which is considered a waste product, can be collected to reduce emissions.

Finally, rags are used throughout the finishing process for controlling runs and to cleanup spills, as well as for specific finishing steps such as application of wiping stain. The storage of used rags can result in air emissions unless the containers are covered and tightly sealed.

## Solid and/or Hazardous Wastes

Sources of solid and/or hazardous wastes include spray booth cleaning, used cleaning solvents and rags, and empty coating/solvent/ adhesive containers. Much of the overspray dries as lacquer dust and is considered a hazardous waste because of its flammability.

Eventually, coating overspray also builds up on the spray booth and the strippable lining is peeled off. Spray booth cleaning generates waste containing the strippable lining covered with dried overspray, the absorbent materials used in the spray booth, and the paper, styrofoam, or polyester filters from spray booths (if used). These are disposed of as a solid or hazardous waste, depending on the composition of the particular waste material.

### Solid and/or hazardous waste sources:

- ☐ spray booth cleaning
  - < lacquer dust
  - < dried overspray
  - < disposable filters
- ☐ spent cleaning solvents
- ☐ used rags
- ☐ empty containers

If spent material is a listed or characteristic waste, as defined by the Resource Conservation and Recovery Act (RCRA), then it must be handled and disposed of as a hazardous waste. RCRA cites specific waste streams from specific processes as listed wastes. The wood furniture industry is not among these processes. However, spent solvents are a listed hazardous waste and must be handled accordingly. Other wastes are classified as characteristic wastes if they are corrosive, toxic, ignitable and/or reactive. Generally, wastes from the wood furniture finishing process are, or are not RCRA characteristic wastes because of ignitability and/or toxicity. The only way to verify that a waste is not ignitable or toxic, as defined by RCRA, is to have the waste material analyzed. If the material is not a listed or characteristic waste, it can be disposed of as a solid waste.

Used cleaning solvents are generated from the washoff, spray booth cleaning, and gun and line flushing and cleaning operations. Collected solvent can be reused at the facility for other cleaning applications such as spray booth cleaning. When reuse is no longer feasible, used solvents can be recycled on site by distillation or sent off site for recycling or disposal as a hazardous waste.<sup>27</sup> On-site distillation results in still bottoms that require disposal as a hazardous waste, although in much smaller quantities than the used solvent. State or local governments might have regulations governing the on-site distillation of solvents.

Used rags containing solvents can be sent off site for disposal as a hazardous waste or cleaned at an industrial laundry for reuse. Facilities generally prefer to avoid hazardous waste disposal costs by sending used rags to an industrial laundry for cleaning. The laundry must be permitted to handle solvent-containing fabrics, and the rags cannot contain any free liquid.

The U.S. EPA has developed stringent new regulations for the wood furniture industry in response to the large quantities of emissions from the traditional coating, adhesive and cleaning processes described above and their possible health and environmental effects.

<sup>27</sup> U.S. EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995.

## 1.4 Summary of The Wood Furniture NESHAP<sup>28</sup>

The NESHAP for Wood Furniture Manufacturing Operations was published in the *Federal Register* on December 7, 1995. This section presents an overview of the wood furniture NESHAP. Details of the NESHAP requirements are presented by subject in the appropriate sections of Chapter 3, Pollution Prevention Opportunities. Most of the Northeast states have air toxics and VOC control regulations that currently apply to the wood furniture industry. These regulations will be changing in light of the NESHAP and the new CTG, but will remain in force until the revisions take effect. The updated state regulations have to be at least as stringent as the federal requirements, and can be more stringent.

Most Northeast states are planning to continue their risk-based air toxic control programs in addition to implementing the NESHAP. In addition, states might regulate sources not covered by the federal version of the NESHAP such as smaller sources or manufacturers of other wood products. A wood furniture manufacturer should contact their state air quality program to determine the specific requirements that apply to their facility. Appendix C presents a description of the various state-specific air and P2 requirements in effect as of June 1997 for the wood furniture industry in each of the Northeast states. Table 1.2 summarizes the categories of existing state regulations that might affect a wood furniture facility.

State-specific regulations that might affect wood furniture manufacturers are contained in Appendix C.

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<sup>28</sup> Unless otherwise noted, all discussion of regulations from "National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions From Wood Furniture Manufacturing Operations," *Federal Register*, Vol. 60, No. 235, December 7, 1995.

**Table 1.2 Existing State Programs Regulating the Wood Furniture Industry**

State	Air Toxics Program	VOC Control Program*	Toxics Use Reduction Program or P2 Planning Requirements
Connecticut	Yes	No	No
Maine	Yes	No	Yes
Massachusetts	No	Yes	Yes
New Hampshire	Yes	Yes	No
New Jersey	Yes	Yes	Yes
New York	Yes	Yes	Haz. waste reduction only
Rhode Island	Yes	Yes	No
Vermont	Yes	Yes	Yes

\* Specific regulations for wood furniture finishing. All Northeast states regulate sources with the potential to emit 50 tpy of VOC or more under their general VOC control program, and some states also include smaller sources.

### 1.4.1 Facilities Covered by the NESHAP

The wood furniture NESHAP applies to manufacturing facilities that are major emission sources of hazardous air pollutants. A major source has been defined by Title III of the CAAA to be a facility that has the potential to emit 10 tpy or more of a single HAP, or 25 tpy or more of a combination of HAPs. The concept of potential to emit is discussed later in this section.

The first step in determining whether the NESHAP applies to a particular facility is to see if the facility meets the definition of a wood furniture manufacturer contained in the NESHAP. The next step is to determine whether the facility is a major source by calculating the facility's potential to emit HAPs. The last step is to determine whether any of the exemptions contained in the NESHAP apply to the facility. If the facility meets the definition of a wood furniture manufacturer, has the potential to emit above the major source threshold and does not qualify for any of the exemptions, the NESHAP applies to that facility. The definition of a wood furniture manufacturer, a discussion of major source and potential to emit and the exemptions contained in the NESHAP are presented in the following subsections.

### Definition of Wood Furniture Manufacture

Generally, the U.S. EPA defines wood furniture manufacturing facilities as those that make cabinets, residential and commercial furniture, and furniture components from wood. Facilities that refinish and restore furniture are not subject to the NESHAP. The wood furniture NESHAP covers the manufacture of "... any product made of wood, a wood product such as rattan or wicker,

or an engineered wood product such as particleboard that is manufactured...’’<sup>29</sup> under any of the SIC codes listed in Table 1.3.

**Table 1.3 SIC Codes for Wood Furniture Manufacturers<sup>30</sup>**

SIC Code	Product Description
2434	Wood kitchen cabinets
2511	Wood household furniture, except upholstered
2512	Wood household furniture, upholstered
2517	Wood television, radio, phonograph and sewing machine cabinets
2519	Household furniture, not otherwise classified
2521	Wood office furniture
2531	Public building and related furniture
2541	Wood office and store fixtures, partitions, shelving, and lockers
2599	Furniture and fixtures, not otherwise classified
5712	Furniture stores manufacturing custom cabinets

The U.S. EPA provides the SIC codes as a reference in their regulations. However, the NESHAP applies to all facilities engaged in the manufacture of the types of wood furniture products covered by the listed SIC codes whether the facility is actually classified under one of the listed SIC codes. Manufacturers of small wooden items, such as baskets, spice racks and gunstocks, as well as some large items such as burial caskets, are not regulated by the wood furniture NESHAP because those types of products are covered under SIC codes that are not listed in Table 1.3. However, an individual state can choose to expand the definition of wood furniture to include these products when implementing the NESHAP.

Of the SIC codes listed in Table 1.3, numbers 2519, 2531 and 2599 cover facilities that manufacture furniture from wood and/or materials other than wood. If a facility in one of those SIC codes manufactures furniture only from materials other than wood, such as metal or plastic, the facility is not required to comply with the wood furniture NESHAP.

## Determining if a Facility is a Major Source - Potential to Emit

When determining whether a facility is a major source, all HAP emissions from the facility must be included, even those from activities unrelated to the manufacture of wood furniture or components. Facilities that are not major sources are known as area sources. Area sources are

<sup>29</sup> "National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions From Wood Furniture Manufacturing Operations," *Federal Register*, Vol. 60, No. 235, Thursday, December 7, 1995, p. 62939.

<sup>30</sup> "Final MACT (NESHAP) for the Wood Furniture Finishing Industry," North Carolina Small Business Ombudsman's Office, Fact Sheet, p. 1.



not subject to the NESHAP, but can be subject to other air quality regulations within a particular state.

Potential to emit refers to the maximum level of emissions that would be possible under unrestricted operation of the facility. Unrestricted operation implies continuous 24 hour per day production at the maximum output possible given the facility's physical and operational design. The only restrictions to an operation that limit the potential to emit are those that are "federally enforceable."<sup>31</sup> Federally enforceable means that the emission restriction is part of a permit condition and that a permit is issued under the authority of the U.S. EPA,<sup>32</sup> which then has the ability to enforce the permit conditions. Unrestricted operation also assumes that air pollution control (treatment) devices are not in place, unless they are required under a federally enforceable permit. Therefore, the potential to emit at most wood furniture manufacturers is likely to be substantially greater than the actual emissions.

Facilities can use several mechanisms to limit their potential to emit. For example, a facility that is a major source can implement P2 methods such as those discussed in Chapter 3, Pollution Prevention Opportunities, to reduce their potential HAP emission level to below that of major source classification. Facilities can also obtain a federally enforceable permit condition from their state permitting authority that restricts their potential to emit. If potential emissions are reduced to below major source levels prior to the first compliance date of the standard, then the facility is no longer subject to the federal NESHAP requirements. However, if the emission reduction occurs after the first compliance date, the facility must comply with the NESHAP requirements for the life of the operation regardless of how low potential emissions are.<sup>33</sup> This U.S. EPA "once in, always in" policy provides an incentive to make changes to lower potential to emit before the NESHAP compliance date.

If potential emissions are reduced to below major source status prior to the first compliance date of the standard, the facility is no longer subject to the federal NESHAP requirements. However, if the emission reduction occurs after the first compliance date, the facility must comply with the NESHAP requirements for the life of the operation. Therefore, facilities should lower their potential to emit before their compliance date.

A flow chart to assist a facility in calculating their potential to emit is shown in Figure 1.2. Figure 1.2 assumes that all of the facility's emissions are from coating operations on a single production line. If other sources of VHAP emissions exist, the facility should account for them in their

<sup>31</sup> The federally enforceable provision is currently being litigated, so this requirement might change in the future. Contact the state permitting authority for the current potential to emit definition and requirements.

<sup>32</sup> Many state permitting programs get their authority from the U.S. EPA through various delegation programs so a state-issued permit can be federally enforceable. Check with the state permitting authority to determine whether particular permit conditions are federally enforceable.

<sup>33</sup> The U.S. EPA issued this policy known as "once in, always in" in a May 16, 1995 memo "Potential to Emit for MACT Standards - Guidance on Timing Issues." Contact the state permitting authority for the current policy.

potential to emit. Prior to calculating potential to emit using Figure 1.2, several facility-specific variables must be determined. These variables are:

- Ⓒ CLS = Current Production Line Speed (units per hour)
- Ⓒ G1, G2, G3, ... = Gallons of Each Coating Used (gallons per year)
- Ⓒ VHAP1, VHAP2, VHAP3, ... = Total VHAP Content of Each Coating (pounds of VHAP per gallon)



## Exemptions

There are four exemptions to the wood furniture NESHAP, even if a facility's potential to emit is that of a major source. Therefore, if a facility is a major source based on the calculations in Figure 1.2, the next step is to determine if the NESHAP applies. A flow chart to determine applicability of the wood furniture manufacturing (WFM) NESHAP is included in Figure 1.3.

The four NESHAP exemptions are:

1. Incidental wood furniture manufacturers are exempt from the NESHAP provided that they maintain records demonstrating that the facility is "... a major source that is primarily engaged in the manufacture of products other than wood furniture or wood furniture components and that uses no more than 100 gallons per month of finishing material or adhesives in the manufacture of wood furniture or wood furniture components."<sup>34</sup>

The three other exemptions can apply to a facility as long as 90 percent or more of their total HAP emissions originate from the use of finishing materials, adhesives, cleaning solvents and washoff solvents for wood furniture manufacturing. A facility that meets the exemption criteria must maintain records to demonstrate that this 90 percent criteria is met. Exemptions 2, 3 and 4 are:

2. A facility uses no more than 250 gallons per month, every month, of coating, gluing, cleaning and washoff materials, regardless of whether they contain VHAPs, in all of its operations (including those other than wood furniture).
3. A facility uses no more than 3,000 gallons for each and every 12-month rolling period (e.g. January 1 to December 31, and February 1 to January 31, and March 1 to February 28, etc.) of coating, gluing, cleaning and washoff materials, regardless of whether they contain VHAPs, in all of its operations (including those other than wood furniture).
4. A facility's actual use of all materials from all of its operations (including those other than wood furniture) contains no more than a total of 5 tpy of any one HAP, or 12.5 tpy of any combination of HAPs, during each and every 12-month rolling period. At least 90 percent of

### NESHAP Exemptions:

- C incidental wood furniture manufacturer (uses no more than 100 gallons of coatings or adhesives per month in the manufacture of wood furniture)
- C uses no more than 250 gallons of coating, gluing, cleaning and washoff materials per month
- C uses no more than 3,000 gallons of coating, gluing, cleaning and washoff materials per rolling 12-month period
- C actual use of materials from all operations contain no more than a total of 5 tpy of any one HAP or 12.5 tpy of any combination of HAPs

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<sup>34</sup> "National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions From Wood Furniture Manufacturing Operations," *Federal Register*, December 7, 1995, p. 62938.



the facility wide emissions must result from the manufacture of wood furniture or wood furniture components.

If a facility qualifies for one or more of the four exemptions discussed above, the facility must maintain the appropriate records to demonstrate compliance with the exemption. Appropriate records are discussed in Section 1.4.3, Record Keeping and Reporting.

## Compliance Dates

The wood furniture NESHAP became effective with its publication in the *Federal Register* on December 7, 1995. Compliance dates vary depending upon the type of the facility, and are presented in Table 1.4.

**Table 1.4 NESHAP Compliance Dates**

Type of Facility	Compliance Date
Existing with actual emissions of 50 tpy or more	November 21, 1997
Existing with actual emissions of less than 50 tpy	December 7, 1998
New sources	December 7, 1995 or upon startup (whichever is later)

Actual emissions for the calendar year 1996 are to be used to determine the applicable compliance date for existing sources. New sources are defined as those whose construction began after the NESHAP was proposed on December 6, 1994. Finally, an existing non-major (area) source that increases their potential to emit to a level above the major source threshold has one calendar year from the date on which the emission increase to come into compliance with the NESHAP.

Existing facilities that undergo major reconstruction are subject to the requirements for new facilities. Major reconstruction occurs when a facility replaces components and the fixed cost of the new components exceeds 50 percent of the cost to construct a comparable new affected source. The costs of purchasing and installing air pollution control equipment is not included in the calculation of reconstruction costs. The costs associated with retrofitting or replacing equipment specifically to comply with the NESHAP also are not included in calculating reconstruction costs.

### 1.4.2 General Requirements

The U.S. EPA has developed two categories of requirements in the wood furniture NESHAP: emission limits and work practice standards. Emission limits have been established to limit the VHAP content of materials used in various operations, including finishing, gluing and cleaning. Work practice standards apply to finishing and cleaning techniques and contain requirements for employee training, record-keeping and reporting, and material storage.

## Emission Limits

The NESHAP contains VHAP emission limits for materials used in finishing, gluing and cleaning operations. The list of VHAPs regulated by the wood furniture NESHAP is contained in Appendix D, Table D-1. Emission limits for the finishing operation are summarized here to provide the proper context for Section 1.4.3, Record Keeping and Reporting. Emission limits and compliance options for gluing and cleaning operations can be found in Sections 3.3 and 3.4 of this Manual, respectively. Additional details of the finishing emission limits are presented in Section 3.1.1 of this Manual.

The emission limits for finishing operations are different for existing and new major sources. The NESHAP emission limits for finishing operations can be met by one or a combination of three techniques:

1. Achieve a weighted average across all coating materials, as applied, of 1.0 pound VHAP per 1.0 pound solids (1.0 lb. VHAP/1.0 lb. solids) for existing sources and 0.8 lb. VHAP/ 1.0 lb. solids for new sources.
2. Use all compliant finishing materials. The coatings covered by this method are limited to stains, washcoats, sealers, topcoats, basecoats, enamels and thinners. The VHAP content limits for each of these materials, as applied, are presented in Table 1.5.

Emission limits for finishing operations can be met by one or a combination of:

- ☐ achieve a weighted average across all coatings of 1.0 and 0.8 lb. VHAP/1.0 lb. solids for existing and new sources, respectively
- ☐ use all compliant finishing materials
- ☐ use a control device such that emissions are no greater than 1.0 and 0.8 lb. VHAP/ lb. solids for existing and new sources, respectively

**Table 1.5 Compliant Finishing Material VHAP Content Limits**

Finishing Material	Existing Source Limit (lb. VHAP/ lb. solids)	New Source Limit (lb. VHAP/ lb. solids)
Stains	1.0	1.0
Washcoats*	1.0	0.8
Sealers	1.0	0.8
Topcoats	1.0	0.8
Basecoats*	1.0	0.8
Enamels*	1.0	0.8
Thinners (maximum percent by weight)	10.0	10.0

\* If washcoats, basecoats and enamels are formulated on site, as done at some facilities, they must be formulated using compliant finishing materials and a thinner containing no more than 3 percent HAPs by weight prior to mixing in order for the washcoat, basecoat or enamel to be considered compliant.

3. Use a control device that operates at an efficiency equivalent to emissions of no greater than 1.0 lb. VHAP/ 1.0 lb. solids for existing sources, and 0.8 lb. VHAP/ 1.0 lb. solids for new sources.

## Work Practice Standards

Work practice standards are designed to minimize emissions of HAPs that result from the storage, handling and application of materials, and are the same for both new and existing sources. The work practice standards are summarized in Table 1.6 and detailed in the appropriate sections of Chapter 3, Pollution Prevention Opportunities.

**Table 1.6 Summary of NESHAP Work Practice Standards**

Subject	Requirements
<b>Workplans:</b>	
Work practice implementation	Describes how the facility will implement all of the other workplace standards
Operator training	Includes a list of current personnel to be trained, an outline of subjects covered, lesson plans, and methods to document completion of training
Inspection and maintenance	Describes leak inspection and maintenance program specifying schedule, documentation, and timeframe for leak repair
Formulation assessment	Identifies VHAPs of potential concern (listed in Appendix D, Table D-2); establishes baseline use, tracks annual use, explains use over baseline, and develops a mitigation plan, if needed
<b>Cleaning:</b>	
Solvent accounting system	Records quantity and type of organic solvents used for cleaning and washoff, number or pieces washed off, reasons for washoff, quantity of spent solvent generated and whether it was recycled or disposed of
Chemical composition restrictions	Cannot use cleaning or washoff solvents containing any of the HAPs listed in Appendix D, Table D-3 in concentrations where material safety data sheet (MSDS) reporting is required by the Occupational Safety and Health Administration (OSHA)
Spray booth cleaning methods	Use compounds containing less than 8.0 percent (by weight) of VOC unless cleaning conveyors, continuous coaters or metal filters. If refurbishing, use no more than 1.0 gallon of organic solvent per booth
Line cleaning	Pump or drain all cleaning solvent into a container that is normally closed
Gun cleaning	Collect all cleaning solvent and store in a container that is normally closed
<b>Finishing:</b>	
Application equipment	Discontinue using conventional air spray guns, except under certain conditions
Washoff operations	Use normally closed containers for washoff solvents and minimize dripping
<b>Storage:</b>	
	Store finishing, gluing, cleaning and washoff solvents in closed containers





### 1.4.3 Record Keeping and Reporting

In order to ensure compliance with the NESHAP, facilities are required to maintain records of emissions and work practices and to periodically submit reports to their state permitting authority and/or the U.S. EPA. Facilities that are major sources, but are exempt from the NESHAP because of one of the exemptions discussed in Section 1.4.1, must also maintain records to demonstrate compliance with the exemption.

#### Record Keeping - Emission Limits

The NESHAP requires record keeping to demonstrate compliance with the emission standards. The exact type of records depends on the compliance approach selected by the facility. The record keeping requirements for each of the three compliance options are summarized below.

##### Averaging:

- Ⓒ certified product data sheets (CPDS)<sup>35</sup> for each finishing material, strippable spray booth coating, adhesive and thinner subject to the emission limits
- Ⓒ the VHAP content (in lbs. VHAP/ lb. solids) of each finishing material and adhesive, as applied
- Ⓒ the VOC content (in lbs. VOC/ lb. solids) of the strippable spray booth coating, as applied.
- Ⓒ records showing the quantity of the various finishing materials, adhesives and thinners used each month
- Ⓒ copies of the averaging calculations for each month

##### Compliant Coatings:

- Ⓒ CPDSs are required for each finishing material, strippable spray booth coating, adhesive and thinner subject to the emission limits<sup>36</sup>
- Ⓒ for continuous coating operations (flatline), records must be maintained on solvent and coating additions to the reservoir; and viscosity measurements; and to demonstrate the relationship between viscosity and VHAP content (to show that viscosity is an appropriate parameter for demonstrating compliance)

##### Control Device:

- Ⓒ CPDSs for each finishing material, strippable spray booth coating, adhesive and thinner subject to the emission limits
- Ⓒ VHAP content (lbs. VHAP/ lb. solids) of each finishing material and adhesive, as applied
- Ⓒ VOC content (in lbs. VOC/ lb. solids) of the strippable spray booth coating, as applied

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<sup>35</sup> CPDS are to be furnished by the supplier and provide: HAP content (measured by EPA Method 311), solids content (by EPA Method 24) and the density (by EPA Method 24).

<sup>36</sup> NOTE: The VHAP and VOC limits must be satisfied so if thinners are added, facilities should keep records and calculate the as applied VHAP content (in lbs. VHAP/ lb. solids) of each finishing material and adhesive and the VOC content (in lbs. VOC/ lb. solids) of the strippable spray booth coating. If finishing materials and adhesives are used as purchased (thinner is not added at the facility), the only records required are the CPDSs.

- Ⓒ calculations demonstrating that the overall efficiency of the control system is sufficient to limit emissions from finishing and gluing operations to the required level
- Ⓒ records of daily average operating parameter measurements

## Record Keeping - Work Practice Standards

The work practice standards require the preparation of a Work Practice Implementation plan within 60 days of the applicable compliance date. The Work Practice Implementation plan should describe how the company will ensure that all of the other work practice standards are implemented. This written plan must be available at the facility for inspection upon request. The work practice implementation plan includes the following written components: an operator training program, a leak detection and repair plan, a formulation assessment plan and a solvent accounting form. In addition, all records that show compliance with the work practice implementation plan, must be kept with the plan. These records include:

### Operator Training:

- Ⓒ list of personnel that require training
- Ⓒ outline of subjects to be covered
- Ⓒ lesson plans
- Ⓒ documentation of completion of course by all listed personnel with completion dates

### Inspection and Maintenance:

- Ⓒ copies of completed inspection checklists
- Ⓒ records demonstrating repairs made, including timeframes

### Cleaning and Washoff Solvent Accounting System:

- Ⓒ records of the type and quantity of washoff and cleaning solvents used
- Ⓒ number of items requiring washoff and reason why
- Ⓒ record of quantity of spent solvent generated per month and documentation of how it is handled
- Ⓒ MSDSs for all cleaning and washoff solvents used to ensure that chemical composition limitations are met

### Formulation Assessment Plan:

- Ⓒ records of quantity of coatings used that contain VHAPs of potential concern (Appendix D, Table D-2) and comparisons with the established baseline. If the facility exceeds the baseline use of a VHAP of potential concern, the facility must explain the reasons for the increase

### Spray Booth Cleaning:

- Ⓒ VOC content of materials used for spray booth cleaning and quantity used

### Application Equipment:

- C if conventional spray guns are used, documentation that they are only being used as allowed in the NESHAP

## Record Keeping - Exemptions

Section 1.4.1 detailed the four exemptions provided in the NESHAP rule. Appropriate records to demonstrate compliance with Exemptions 1, 2 and 3 can be invoices for all coating, gluing, cleaning and washoff materials purchased indicating that less than the exemption threshold quantity was purchased by the facility. For Exemption 4, a facility needs the material purchase invoices as well as information on the HAP content of the materials purchased to demonstrate that their actual HAP emissions are below the exemption threshold. HAP content information is provided by what U.S. EPA has termed “certified product data sheets” (CPDS).<sup>37</sup> A typical MSDS does not have the proper HAP content information and is not adequate to demonstrate compliance.

To demonstrate compliance with Exemptions 3 or 4, records are needed on the compliance date for the previous 12 months. Therefore, the facility needs to begin keeping the appropriate records no less than 1 year before the compliance date. The compliance date for a company eligible for these exemptions is December 7, 1998, so the facility should begin keeping the appropriate records on or before December 1, 1997.

## Reporting

Facilities that are subject to the NESHAP emission limit and work practice standard requirements must submit semi-annual compliance reports to the state permitting authority and U.S. EPA within 30 days following the end of each 6-month period. The compliance reports must include certification of compliance with the work practice implementation plan. Each certification of compliance must be signed by a responsible official of the company. For the averaging approach, calculations for each month of the reporting period must be submitted. For the compliant coatings, adhesives and spray booth coatings approaches, there must be a certification that compliant materials were used each day of the reporting period. For the control device approach, certification must be submitted stating that the device has not operated, on a daily average basis, at greater than, or less than, the chosen operating parameter value. All supporting records must be maintained for a minimum of 5 years.

Semi-annual compliance reports are due to state permitting authorities and the U.S. EPA within 30 days following the end of the 6-month period. An initial compliance report is due within 60 days of the applicable compliance date.

Additional reporting requirements could apply to a facility depending upon its particular operation. These additional reports could include excess emission reports; notification pursuant to the formulation assessment plan, if increased use occurs; and notification of a performance test, if a control device is used.

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<sup>37</sup> CPDS are to be furnished by the supplier and provide HAP content (measured by EPA Method 311), solids content (by EPA Method 24) and the density (by EPA Method 24).

The NESHAP requires an initial compliance report within 60 days of the applicable compliance date, corresponding to January 20, 1998, for major sources with actual emissions of 50 tpy or greater (in 1996), and February 5, 1999, for other major sources. The initial compliance report contains the same information as the semi-annual report, except that it only covers the 30-day period immediately following the initial compliance date. Facilities using the control device approach must include the results of the initial performance test, calculation of overall capture efficiency and a plan for monitoring operating parameters in the initial compliance report.

## 1.5 Other Clean Air Act Amendment Requirements - Title I

Title I - the ozone, carbon monoxide, and PM-10 non-attainment provisions of the CAAA - can also affect a wood furniture manufacturing facility. The CAAA Title I program controls the seven ambient air quality criteria pollutants, including ground-level ozone. A major component of Title I is the control of VOCs emitted in areas that do not meet the ground-level ozone standard.

Under Title I, the U.S. EPA has issued VOC CTGs for several industry source categories, including the wood furniture industry. These guidelines recommend reasonably available control technology (RACT) to reduce VOC

Wood furniture manufacturers can also be affected by Title I VOC control efforts.

emissions from the source category. States then must use the CTG and RACT to develop regulations that are at least as strict as the federal recommendations. The U.S. EPA issued the final CTG for the wood furniture industry on May 20, 1996. In the Northeast, the wood furniture industry CTG applies to all facilities that have the potential to emit 25 tpy or more of VOCs.<sup>38</sup> The CTG facility compliance date is May 20, 1998, or the compliance date specified in the state's RACT rule.

Like the NESHAPs, the U.S. EPA has a “once in, always in” policy for the VOC control program. If a facility lowers its potential to emit VOCs to below 25 tpy before May 20, 1998, the facility will not be required to implement RACT. However, if the reduction occurs after May 20, 1998, the facility will need to comply with RACT for the life of the operation. RACT includes emission limits and work practice standards, and all the associated record keeping and reporting requirements. Therefore, facilities that can reduce their potential to emit to below 25 tpy VOCs should do so before May 20, 1998, or the compliance date specified in the state's RACT rule.

Like the NESHAP, the wood furniture CTG contains both emission limits and work practice standards in the RACT. The RACT emission limits are presented in the following section. The work practice standards are identical to those contained in the NESHAP, except that the formulation assessment and the chemical composition restrictions are not included. The work practice standards are summarized in Section 1.4.2 and are detailed in the appropriate sections of Chapter 3.

<sup>38</sup> All of the Northeast states are in the Ozone Transport Region. Therefore, all wood furniture manufacturers located in the Northeast that have the potential to emit more than the CTG threshold of 25 tpy of VOCs are subject to Title I requirements, regardless of the attainment status of their particular geographic location. See Appendix A for more information on attainment and the Ozone Transport Region.

### 1.5.1 Control Technique Guidelines (CTG) - Emission Limits

The CTG recommends RACT to reduce VOC emissions from finishing and cleaning operations. The VOC limits specified in the RACT determination are summarized in Table 1.7. The RACT emission limits are based upon aqueous-based topcoats, or high-solids sealer and topcoat. Facilities may use techniques other than the specified RACT to comply with the requirements of the CTG, as long as the facility meets the VOC limits.

**Table 1.7: Wood Furniture RACT**

<b>Operation</b>	<b>RACT</b>	<b>VOC Limit</b> (lb. VOC/ lb. solids)*
<b>Finishing</b>	Topcoats	0.8
	Higher solids sealers and topcoats:	
	Sealers	1.9
	Topcoats	1.8
	Acid-cured alkyd amino vinyl sealers	2.3
	Acid-cured alkyd amino conversion varnishes	2.0
<b>Cleaning</b>	Waterborne strippable spray booth coating	0.8

\* As applied (after the addition of thinners, if used)

As with the NESHAP, compliance with the CTG can be achieved by one or a combination of three methods:

1. Use all compliant coatings. Compliance is demonstrated by maintaining records of the CPDSs for the coatings used and, if coatings are thinned on site, copies of the calculations used to determine the as-applied VOC content.
2. Achieve a weighted average across all coatings specified in Table 1.7 that is no greater than 90 percent of the VOC limit from Table 1.7. Compliance is demonstrated by submitting records of daily coating use and VOC content, and results of the averaging calculation. Contact the state permitting authority for the proper calculation.
3. Use a control device that operates at an efficiency equivalent to emissions of no greater than the VOC limit specified in Table 1.7 for the coatings listed in Table 1.7. Contact the state permitting authority for the proper record keeping requirements.

Reporting requirements are similar to those of the NESHAP. Initial and semi-annual compliance reports are specified to demonstrate compliance with both the emission limit and work practice standard portions of the rule. Compliance must be certified by a responsible official at the facility. The facility's permitting authority will have information regarding state-specific record keeping and reporting requirements.

### 1.5.2 Differences Between the NESHAP and the CTG

There are several differences between the NESHAP and the CTG:

- C The RACT emission limits in the CTG are the same for both new and existing facilities; whereas the NESHAP emission limits for new and existing facilities are different.
- C The CTG emission limits only affect topcoat materials (and sealers, if aqueous-based topcoats are not used). The NESHAP emission limits affect seven types of finishing materials: stains, washcoats, sealers, topcoats, basecoats, enamels and thinners.
- C The CTG requires that compliance with the emission limits using an averaging approach is confirmed on a daily basis; whereas the averaging approach in the NESHAP requires only monthly calculations.
- C The strippable spray booth material emission limits are the same in the RACT and the NESHAP, but the RACT mentions using “waterborne” coatings specifically, whereas the NESHAP does not.
- C Two of the work practice standards required by the NESHAP are not contained in the CTG: the formulation assessment plan and the chemical composition restrictions. The work practice standards are summarized in Section 1.4.2 and detailed in the various sections of Chapter 3 of this Manual.

## 1.6 Implementation of the NESHAP and CTG - Title V

The HAP and VOC control requirements discussed above will be implemented by each state through their Title V permitting program. Title V permits are intended to bring all of a facility's air emissions and compliance requirements into a single comprehensive permit that is renewable at 5-year intervals. All major sources of HAPs or VOCs must obtain a Title V permit, even if they are not covered by a specific NESHAP or CTG. A Title V permit is required for all wood furniture manufacturers that are major sources of HAPs and are subject to the Title III NESHAP.

All facilities that are classified as major sources of VOCs also must obtain a Title V permit. Therefore, many wood furniture manufacturers will have both the NESHAP and CTG requirements in their Title V permit. In the Northeast, major sources of VOCs are facilities that have the potential to emit 50 tpy VOC or more.<sup>39</sup> The wood furniture CTG applies to all facilities with the potential to emit 25 tons VOC per year or more. Therefore, a facility can have to comply with the CTG requirements, but does not have to obtain a Title V permit if the facility has the potential to emit between 25 and 50 tpy VOCs and if the facility also is not subject to the NESHAP.

The Title V permit programs are designed and implemented by each individual state. In general, a Title V permit includes the following types of information, although the exact requirements and format can vary from state to state:

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<sup>39</sup> Except in the metropolitan New York City area of Connecticut, New Jersey and New York, where the major source threshold is 25 tons VOC per year. This area is classified as “severe” non-attainment of the ground-level ozone standard. Contact the state permitting authority to determine if the facility location is classified as “severe.”

- C basic facility information such as SIC code(s), location and ownership
- C descriptions of products and production processes
- C emission sources, emission control measures, and emission types and quantities from each source
- C applicable state and federal requirements (such as the NESHAP or CTG requirements)
- C compliance assurance plan and compliance certification

Facilities should contact their permitting authority to determine their particular Title V permit requirements.

## 1.7 Summary

The wood furniture industry is one of the major emitters of VHAPs in the Northeast. Most of the Northeast states have regulated both VOCs and the individual air toxic pollutants from this source category. In 1995 and 1996, the U.S. EPA promulgated new VHAP and VOC control regulations for the wood furniture manufacturing industry. The overall approach of these new federal regulations recognizes that most of the sources of VHAPs during the furniture finishing process cannot be controlled by traditional add-on air pollution control equipment. As a result, emission limits are placed on the VHAP content of the coatings and adhesives used by the industry. In addition, work practice standards are included to further reduce emissions.

The purpose of this Manual is to promote P2 approaches to comply with the emission limits contained in the NESHAP and to encourage companies to reduce emissions further by implementing cost-effective P2 technologies beyond those required by the NESHAP. Chapter 2 introduces the concept of P2 and the benefits of a P2 approach, and provides an overview of how to establish a comprehensive P2 program at a facility. Chapter 2 provides a framework for companies to evaluate the P2 options presented in Chapter 3.



## CHAPTER 2: POLLUTION PREVENTION

The quantity of waste generated from a manufacturing process provides an indication of the efficiency of that process; more waste is generated from a less efficient process. Reducing inefficiencies typically results in long-term cost savings for a company. Significant VHAP emissions are considered part of the normal operation of a wood furniture manufacturing operation. Should these emissions be considered normal or is there room for improvement? The wood furniture NESHAP work practice standard requirements will help manufacturers reduce air emissions because of inefficient application equipment and housekeeping practices. The emission limits will encourage use of low-VHAP containing coatings, which often increase coating use efficiency because less coating material is needed to produce the same mil thickness on the furniture item.

The quantity of air emissions and other wastes generated is an indicator of a facility's efficiency.

Increasing process efficiency is a major component of pollution prevention activities. In many situations, P2 is analogous to the business concept of continuous improvement. Many P2 projects improve process efficiency and product quality, and save money. Therefore, P2 should be integral to continuous improvement efforts. There are numerous benefits to implementing P2 projects. Pollution prevention not only improves a company's bottom line through reduced operating costs and other savings, but also improves working conditions and environmental quality. The benefits of embracing a P2 strategy and a step-by-step approach to implementing facilitywide P2 activities are presented in this chapter.

Many P2 projects improve process efficiency and product quality, and save money. Therefore, P2 should be integral to continuous improvement efforts.

To reap the maximum benefit, companies should establish a P2 program to provide a formal framework for evaluating current practices, receiving employee suggestions and making process changes, where appropriate. This chapter presents a somewhat ideal P2 program and P2 project evaluation methodology. Realities at a particular company can make some of the procedures impractical. However, many of the concepts can help companies comply with air quality requirements and save money. Many perceived obstacles to P2 might have to be overcome at the facility or corporate level before P2 projects can be implemented. These issues are discussed in the following sections.

## 2.1 Defining Pollution Prevention

What is pollution prevention? The U.S. EPA defines pollution prevention as “...the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use.”<sup>40</sup>

What is Pollution Prevention?

“...the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use.”

The U.S. EPA believes that out-of-process recycling is worthwhile, but does not consider it a pollution prevention strategy because recycling does not encourage a reduction in the manufacture or use of hazardous substances, and the waste materials are still generated. The term waste minimization is analogous to P2 when it refers to efforts to minimize waste generation. This Manual uses the U.S. EPA’s definition to present pollution prevention practices and techniques in this chapter and Chapter 3.

The Pollution Prevention Act of 1990 includes an environmental management hierarchy that has gained widespread acceptance. The hierarchy places pollution prevention, also known as source reduction, at the top as the most desirable method of environmental protection. Next is recycling, followed by treatment and lastly disposal. The 1990 Act directed the U.S. EPA to establish programs to encourage pollution prevention. Virtually all state governments have pollution prevention programs dedicated to reducing institutional barriers to P2, assisting companies with developing P2 programs, integrating P2 into other regulatory activities and promoting P2. Many states now have pollution prevention or toxics use reduction planning requirements in which P2 planning by industry is mandatory, but implementation is not.

Pollution Prevention Act of 1990 Waste Management Hierarchy

Most Desirable	Source Reduction
	Recycling
	Treatment
Least Desirable	Disposal

Essentially five different types of activities are considered pollution prevention:<sup>41</sup>

Input Substitution: a hazardous substance is replaced by a less (or non-) hazardous substance as an input to a manufacturing process to make essentially the

<sup>40</sup> U.S. EPA, “Environmental Protection Agency Pollution Prevention Directive,” May 13, 1990.

<sup>41</sup> New Jersey DEP, *Industrial Pollution Prevention Planning*, September 1995.

same product. In wood furniture finishing, this could include switching to a low/no HAP and VOC coating.

Product Reformulation: alter the formulation of a product so a hazardous substance is replaced by a less (or non-) hazardous substance; the function and/or appearance of the product might change. In wood furniture manufacturing, this could include changing some components of the furniture to a material that requires less/no coating.

Efficiency Improvement: change the production process to use hazardous substances more efficiently, so smaller quantities are needed to produce the same output. An example in the wood furniture industry is switching to higher transfer efficiency application equipment.

In-Process Recycling: collection, separation and refinement of waste streams at the process location with recycled material input directly into the same process from which it was generated. Other than switching to flatline continuous coating application equipment, this is not applicable to the wood furniture industry.

Housekeeping: items such as improvements in leak detection, spill prevention, inventory control and employee training can all prevent pollution at the process level. For example, studies of wood furniture finishing operations have shown that an ongoing operator training program can reduce coating use by up to 10 percent.<sup>42</sup>

Several waste management methods are NOT pollution prevention:<sup>43</sup>

- ⊘ out-of-process recycling, whether performed on or off site
- ⊘ waste treatment (e.g. incineration)
- ⊘ concentration of hazardous or toxic constituents to reduce volume (e.g. dewatering)
- ⊘ diluting constituents to reduce their hazard or toxicity
- ⊘ transfer of hazardous or toxic constituents from one environmental medium to another (e.g. collection of air contaminants on filters).

## 2.2 Benefits of Pollution Prevention<sup>44</sup>

The thousands of facilities that have implemented pollution prevention projects have benefited in one or more of the following ways:

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<sup>42</sup> L. Snowden-Swan, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992.

<sup>43</sup> U.S. EPA, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, May 1992.

<sup>44</sup> Ibid.

- Ⓒ reduced operating costs
- Ⓒ reduced regulatory compliance issues
- Ⓒ reduced risk of criminal and civil liability
- Ⓒ improved employee morale and participation
- Ⓒ enhanced company image in the community
- Ⓒ increased public health and environmental benefits

Benefits of pollution prevention include:

- Ⓒ reduced operating costs
- Ⓒ reduced regulatory compliance issues
- Ⓒ reduced liability
- Ⓒ improved employee morale
- Ⓒ enhanced company image
- Ⓒ increased public health and environmental benefits

Each of these possible benefits is discussed in the following sections.

### 2.2.1 Reduced Operating Costs

Cost is perhaps the most important factor that business considers when evaluating P2 opportunities. Some P2 efforts involve some up-front expenditure, but this is typically more than offset by a reduction in operating costs. The two most common areas of savings come from a reduction in the quantity of virgin materials that need to be purchased and a reduction in the quantity of pollutants and other wastes that require control, treatment, storage or disposal (TSD). The main savings from P2 in wood furniture manufacturing are the reduction in virgin material use and/or labor requirements. These savings and others are illustrated in the numerous case studies contained in Chapter 3, Pollution Prevention Opportunities.

Main savings from P2 in wood furniture manufacturing are from reductions in:

- Ⓒ virgin material use
- Ⓒ labor requirements

Accompanying the elimination or reduction in the quantity of hazardous pollutants that require management is a savings in the labor needed to follow regulatory developments, obtain necessary permits, complete the required monitoring and record keeping, and operate pollution control equipment and/or an on-site TSD facility (if present). In wood furniture manufacturing, there is comparatively little solid or hazardous waste generation and the air emissions are vented to the atmosphere without treatment. However, an employee still has to follow regulatory developments, obtain permits and keep records.

Additional savings can result from reductions in:

- Ⓒ solid and/or hazardous waste disposal
- Ⓒ record keeping and reporting

P2 efforts can result in the elimination of one or more production steps, creating savings in both raw material inputs and the labor required to operate the eliminated step(s). For example, in wood furniture manufacturing, switching to a high-solids topcoat can eliminate the need for a second topcoat application to obtain a comparable finish. Improving the efficiency of production scheduling, material handling, inventory control and equipment maintenance can all reduce both emissions and cost. For example, finishing all items of the same color at the same time or scheduling the finishing of lighter shades before darker shades can reduce the frequency of

application equipment cleaning. Finally, a facility might realize a savings in energy and other utility costs because of improvements in equipment and/or operation and maintenance procedures.

P2 also can reduce insurance premiums. The wood furniture industry typically uses many highly flammable substances that also have potentially adverse health effects. Eliminating, or at least cutting back on the quantity of flammable substances used, can have significant effects on fire insurance rates. Workman's compensation insurance also takes into account the potential of employee exposure to hazardous substances in determining the rates that are assessed.

### 2.2.2 Reduced Regulatory Compliance Issues

By implementing P2 projects, a facility can comply with environmental regulations, such as the CAAA's wood furniture NESHAP emission standards, without having to install costly control technologies. A P2 project also might reduce emissions and/or waste generation so that the operation of an existing control technology is no longer needed. Finally, P2 efforts might reduce waste generation to such low levels that a given regulation no longer applies to the facility. This is an ideal situation, because of the accompanying reduction in record keeping and reporting requirements.

As discussed in Section 1.1, the CAAA contains a requirement for U.S. EPA to evaluate the wood furniture NESHAP after it has been in effect for 8 years to determine if public health is adequately protected. If this residual risk review determines that additional protection is needed, the NESHAP requirements could be strengthened, such as adding more chemicals to the regulated list. A facility that does the minimum to meet the current NESHAP requirements might find that they will have to make a second round of changes if the regulations are revised after U.S. EPA's residual risk review. A facility that implements P2 now might not need to alter operations in the future if regulations are developed that are more strict than the current requirements.

### 2.2.3 Reduced Liability

Environmental regulations contain penalty provisions and civil and criminal liability for non-compliance. The greater the quantity of hazardous substances used or generated, the greater the risk that one or more of the numerous and ever-tightening requirements is inadvertently missed, that an accidental spill happens or that other non-compliance situations occur. There is "cradle to grave" responsibility for hazardous wastes that are produced. This means that a hazardous waste shipped off site for treatment or disposal creates an ever-present liability for that by-product should the treatment or disposal facility have environmental problems at any point in the future. If the wastes are eliminated and there is no need for treatment or disposal, this potentially large future liability also is eliminated.

The presence of hazardous substances at a facility also creates a potential environmental liability for cleanup if a spill or another type of accidental release should occur. Releases to the environment, even permitted air emissions, could potentially endanger human health in the area surrounding the facility, or at least create the perception of human health impacts, thereby exposing a company to the potential for civil litigation.

### 2.2.4 Improved Employee Morale and Participation

Employees who have the opportunity to provide input to company initiatives, particularly those that will improve working conditions, and who believe that their ideas were heard usually feel more positively toward their employer. This can translate into increased productivity and greater commitment and loyalty from employees. Participating in pollution prevention efforts can increase communication among departments that might result in additional product quality enhancement and cost saving ideas unrelated to P2.

### 2.2.5 Enhanced Company Image

When companies implement P2 projects and publicize their efforts, the surrounding community, environmental advocacy groups and government regulators might feel more positively about them. The potential for hostile relations with, and legal suits initiated by local community members, environmental groups or government regulators might be diminished. In addition, the company can include a positive environmental message in its marketing efforts, thereby improving the feeling of customers about their products. This could result in increased market share.

### 2.2.6 Increased Public Health and Environmental Benefits

Reducing the use of hazardous substances has potential benefits over the entire life cycle of those substances. Upstream, ecological damage and human exposure because of raw material extraction, refining operations and transportation are reduced. Downstream, the risk of exposure during transportation, recycling, treatment, storage or disposal of wastes are all diminished. As mentioned previously, the risk of an accidental release to the environment is reduced if the facility minimizes the quantity of virgin hazardous substances or hazardous wastes handled at the site. Finally, improvements in the work environment increase employee morale and can lower employee health and safety risks.

Establishing an ongoing P2 program is the best way to realize the benefits outlined above. The next section describes the elements of both a P2 program and a P2 project evaluation.

## 2.3 Establishing a Pollution Prevention Program

Ideally, facilities should establish a comprehensive P2 program. However, a comprehensive P2 program might not be feasible at all wood furniture facilities. For smaller companies lacking sufficient resources, it is possible to short-circuit some of the comprehensive program steps if there is a commitment to reach a common goal and the right partnership is formed. To successfully alter a finishing material, the facility's operators and the equipment and coating suppliers should form a partnership. Multiple vendors should be enlisted in the development and evaluation of options to help ensure that the best solution is found. State and local technical assistance programs are another source of information and help. A listing of vendors and technical assistance providers is contained in Appendix E.

A comprehensive P2 program is a natural outgrowth of continuous improvement programs that are now prevalent at many companies. Most facilities with successful P2 programs report that corporate management must establish P2 as a priority and provide visible leadership. Evaluating and implementing P2 opportunities requires employee time and typically involves some up-front cost. In order to expend the time and money on P2, upper management support is critical to getting approval for the necessary financial and personnel resources.

Setting specific goals for the P2 program can help ensure its success. Goals can be either numerical (e.g. a target percent reduction in coating use) or technical (e.g. switching solvent-based coatings to aqueous-based coatings). After goals are set, the next step of a comprehensive program is to establish an internal team of employees with an interest in P2 to evaluate the facility and identify P2 options that are technically and economically feasible.

#### P2 Program Steps:

- Ⓒ management establishes P2 as a priority
- Ⓒ firm establishes a P2 team
- Ⓒ P2 team conducts a preliminary evaluation
- Ⓒ P2 team performs an in-depth feasibility study
  - < understand current process
  - < screen P2 options
  - < evaluate technical feasibility
  - < evaluate return on investment
  - < evaluate environmental benefits
- Ⓒ facility implements option(s)
- Ⓒ firm implements continuous improvements

Setting specific goals for the P2 program can help ensure its success.

### 2.3.1 Establishing a P2 Team

Ideally, representatives from all levels of employees at a facility are involved in P2 efforts, including the plant manager, environmental compliance staff, the finishing room supervisor and the operator of the actual process and/or equipment targeted for P2. Operators of the existing system often know where deficiencies are and what measures are feasible to implement at the process level. P2 efforts often succeed or fail based upon the degree of operator acceptance; therefore, their participation is vital. The finishing room supervisor has a knowledge of the whole process and can evaluate the effect of a change in one area on the overall system. The environmental manager knows the various regulations that affect the current process and can evaluate the regulatory impact of any changes. Few changes can be made without the support of the plant manager. Finally, the members of the team must be given the time that they need to effectively participate in the group's efforts.

Ideally, the P2 team has representatives from all levels of employees at a facility, including the plant manager, environmental compliance staff, the finishing room supervisor and equipment operators.

### 2.3.2 Preliminary Evaluation<sup>45</sup>

Once the P2 team is established and given the necessary support and resources by top management, members should perform an assessment of current operations. In manufacturing, pollution prevention takes place at the process level. Each specific process at a wood furniture manufacturer should be examined for source reduction opportunities, ways to reduce the amount of hazardous substances used in or generated by the process. This typically begins with a walk through of the entire finishing operation by the whole committee where employees in each area are interviewed. Then the committee should meet to discuss their impressions of each process and where improvements are possible. From this, the team can develop a list of processes, operations and/or waste streams that should be pursued further. At a wood furniture facility, this list would most likely include the coating material and application equipment used at each application step and would concentrate on air emissions and solid and/or hazardous waste generation. Another helpful exercise is to examine raw material purchase and waste disposal records and attempt to determine why and where hazardous substances are used, and why and where pollutants and other wastes are generated. This exercise can direct the committee toward production areas that can be beneficial to examine in greater depth.

At a wood furniture facility, the coating material and application equipment used at each application step should be evaluated and concentrate on air emissions and solid and/or hazardous waste generation.

Once a list of general ideas is established, the team should set some priorities. Criteria for prioritizing waste streams for further evaluation can include:

- C cost of raw materials
- C compliance with current and anticipated regulations
- C current costs of pollution control and other waste management activities (e.g. operating control equipment and treatment systems, and off site treatment and/or disposal costs)
- C quantities and costs of materials not incorporated into finished products
- C quantity of releases to the environment
- C hazardous properties of the pollutants and wastes generated
- C safety hazards to employees associated with the current system
- C available budget for the pollution prevention assessment program and projects
- C potential for environmental and safety liability
- C potential for removing inefficiencies in production or waste treatment
- C potential for recovery of valuable by-products
- C potential for minimizing wastewater discharges and/or air emissions
- C potential for reducing energy use

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<sup>45</sup> U.S. EPA, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, May 1992.



### 2.3.3 In-Depth Study<sup>46</sup>

After the team prioritizes the ideas, the high priority items should be studied in-depth. At this point, the P2 committee can split into sub-groups based on individual interest and bring in additional expertise to properly analyze each idea. Such expertise can be found both within the facility and in outside agencies or firms. These outside sources can be professional consultants, state or local P2 technical assistance providers, vendors, trade associations and/or literature such as trade journals and government reports. A listing of appropriate informational resources for the wood furniture industry is contained in Appendix E.

The goal of the in-depth evaluation is to gather and analyze information to quantify, to the extent possible, the costs and benefits of the P2 possibilities. To do this, the current process must be well understood to provide a set of data to compare with the P2 project.

#### Understanding the Current Process

To analyze the current process, a simple process diagram and mass balance of the existing operation can be helpful. A mass balance can be performed for each input material and should account for the entire input quantity. A simple mass balance equation is presented below.

$$\text{Mass in} = \text{Mass out (in product)} + \text{Mass out (in solid and hazardous waste and in wastewater)} \\ + \text{Mass out (released directly to environment such as air emissions)}$$

The costs associated with each term of the mass balance can be determined, including virgin material and waste management costs. Waste management costs include all on-site labor involved with collection, transport, record keeping, treatment, storage and/or disposal.

To ensure that all inputs and outputs are accounted for, the process should be visited again. Operations can be observed from start to finish so that all functions are directly observed as they happen, including housekeeping and waste management practices. If there is more than one shift, observations should be made during each shift to detect any differences. The existing personnel costs associated with each aspect of the process also are determined. If all of the steps of the operation are not clear, the P2 team members should ask the employees to clarify any questions. In addition, the team should ask the employees if they have any suggestions for improvements.

#### Screening Pollution Prevention Options

Once the current situation is well understood, the next step is to evaluate pollution prevention options. The team should brainstorm possible improvements to the process. P2 options can range from repairing any leaks to improving employee training and housekeeping practices, to purchasing new equipment and to input substitution as described at the beginning of this chapter. The U.S. EPA encourages P2 evaluations to "...look first at true source reduction options, such as improved operation procedures and changes in technology, materials, and products. Then [at] options that involve reuse, or closed-loop recycling... [and finally,] off-line and off-site recycling and

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<sup>46</sup> U.S. EPA, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, May 1992.

alternative treatment and disposal methods.”<sup>47</sup> The list of P2 options can be screened to eliminate options that are not worth further analysis. Suggested screening questions can include:

- Ⓒ what are the main benefits to be gained by implementing this option?
- Ⓒ does the necessary technology exist to implement the option?
- Ⓒ will the goal of reducing the generation of pollutants and other wastes be achieved?
- Ⓒ can the option be implemented within a reasonable amount of time without disrupting production?
- Ⓒ does the option have a good previous track record? If not, is there reason to believe it will work here?
- Ⓒ what other areas will be affected if the P2 option is implemented?

Options that survive the screening can then be subjected to detailed technical, economic and environmental feasibility evaluations.

## Technical Evaluation

Everyone at the facility that will be directly affected if the P2 option is adopted should be consulted during the technical evaluation. Typical questions asked during a technical evaluation include:

- Ⓒ will product quality be improved or maintained?
- Ⓒ is the required space available?
- Ⓒ are the new equipment, materials or procedures compatible with existing production operation procedures, work flow and production rates?
- Ⓒ will additional labor be needed to implement the option?
- Ⓒ will additional labor or retraining of existing personnel be required to maintain and operate the new system?
- Ⓒ are new utility services needed, and what are the associated costs?
- Ⓒ how long will production be stopped during installation?
- Ⓒ will the vendor provide acceptable assistance and service?

In order to answer these questions, the facility can conduct a pilot-scale study. Vendors can assist in these efforts. Depending on the type of testing required, a vendor might be willing to perform pilot studies at the vendors’ facility, avoiding any possible disruption of production. The options that still appear feasible after undergoing the technical evaluation should be evaluated for their economic effects.

## Economic Evaluation

Many P2 projects have financial benefits that are easy to quantify. These include reductions in:<sup>48</sup>

- Ⓒ raw materials
- Ⓒ production labor

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<sup>47</sup> U.S. EPA, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, May 1992, p. 35.

<sup>48</sup> NEWMOA, *Pollution Prevention and Profitability - A Primer for Lenders*, 1996.

- Ⓒ compliance costs (e.g. permit fees, and monitoring and laboratory analysis)
- Ⓒ waste transportation and treatment and/or disposal

Another financial benefit that might apply to a particular situation and is easy to quantify is the avoided cost of having to install and operate a pollution control device. This situation typically arises when the facility is affected by a new regulation, or an existing regulation becomes more stringent. This is the situation facing the wood furniture industry. If changes are not made to the coatings used, many facilities will have to install and operate costly control devices to comply with the NESHAP.

Therefore, by implementing P2 to reduce emissions from coatings, a facility can avoid the costs associated with these control devices.

Direct P2 savings include:

- Ⓒ raw materials
- Ⓒ production labor
- Ⓒ compliance costs (e.g. fees, testing)
- Ⓒ waste treatment and/or disposal

Indirect P2 savings include:

- Ⓒ special handling and storage requirements
- Ⓒ safety training
- Ⓒ paperwork
- Ⓒ fire insurance costs

There are often indirect cost savings as well, resulting from reductions in:<sup>49</sup>

- Ⓒ special handling and storage requirements
- Ⓒ hazardous materials training
- Ⓒ paperwork involved in monitoring, record keeping, permitting and disposing of hazardous materials
- Ⓒ insurance expenses related to storage of flammable or hazardous materials

Quantifying costs to implement a P2 project begins with the cost to purchase and install the required new equipment, including (facility-provided) personnel costs. The total of these up-front expenditures are the capital cost of the project. Next, the effects on operation and maintenance (O&M) should be evaluated. The person analyzing the cost impact should ask:

- Ⓒ what quantity of input material will be required?
- Ⓒ what is the per unit cost of the required inputs?
- Ⓒ how much labor will be required to operate the new system, and what are the associated costs?
- Ⓒ what wastes will be generated, and what are the associated waste management costs?
- Ⓒ will fire insurance rates change?

The O&M cost information should be compared to the existing situation to see if there is an incremental change. Because O&M is an ongoing expenditure, it should be calculated on an annual basis. If there is a change in O&M costs, these will continue over time. Many businesses evaluate capital expenditures in terms of the length of the payback period, that is, the amount of time required for the annual savings to add up to the capital costs. Simply, the payback period is calculated as:

<sup>49</sup> NEWMOA, *Pollution Prevention and Profitability - A Primer for Lenders*, 1996.

$$\text{Payback period (years)} = \text{Total capital costs} \div \text{Annual net operating cost savings}$$

Many companies consider a payback period of less than 2 years to be acceptable and justification for implementing the project. Some firms are willing to tolerate a longer payback period because they believe that the qualitative benefits, such as a reduction in liability, are important enough to outweigh the longer payback period. Payback period is a simple financial analysis. A more sophisticated analysis would take into account such things as the time value of money (i.e. the discount rate).<sup>50</sup>

<u>Payback Period</u>	
Total capital costs (net)	÷ Annual operating cost savings

Many of the benefits of pollution prevention are not easy to quantify. This can present a problem when attempting to justify some P2 projects in purely monetary terms. Some of the qualitative benefits are:<sup>51</sup>

- Ⓒ reduced long-term liability risk associated with cradle-to-grave responsibility for toxic material use and disposal
- Ⓒ improved public image as an environmentally responsible business
- Ⓒ new potential to take advantage of “green market” trends
- Ⓒ improved employee health and safety
- Ⓒ enhanced relationships with local communities
- Ⓒ reduced regulatory headaches

The two main qualitative benefits for wood furniture manufacturers are improved working conditions for employees and reduced liability for future problems such as environmental contamination. Improving working conditions for employees might result in lower employee absences due to illness and improvements in productivity. Reducing the risk of future employee health problems can also result in potential savings in insurance premiums.

- |  |
|--|
| <p>Qualitative benefits include:</p> <ul style="list-style-type: none"> <li>Ⓒ Reduced Long-term Liability</li> <li>Ⓒ Improved Public Image</li> <li>Ⓒ “Green Market” Potential</li> <li>Ⓒ Improved Employee Health &amp; Safety</li> <li>Ⓒ Reduced Regulatory Headaches</li> </ul> |
|--|

Liability for on-site or off-site environmental contamination is not easy to quantify, and can range from never having a problem to a multi-million dollar responsibility. Eliminating the use of hazardous substances and/or the generation of hazardous waste products at the site could remove this potential liability. Reducing use or waste generation would reduce the risk of future liability.

<sup>50</sup> Information about more in-depth financial analysis of P2 projects is contained in the training manual *Improving Your Competitive Position: Strategic and Financial Assessment of Pollution Prevention Projects*, NEWMOA and the Massachusetts Office of Technical Assistance, 1994. U.S. EPA has also developed *P2/Finance*, a software package available by contacting U.S. EPA’s Pollution Prevention Information Clearinghouse at (202) 260-1023.

<sup>51</sup> NEWMOA, *Pollution Prevention and Profitability - A Primer for Lenders*, 1996.

Options that still appear feasible after the technical and economic evaluations should undergo an environmental evaluation.

## Environmental Evaluation

In conjunction with the technical evaluation, the P2 team should evaluate the advantages and disadvantages of each option with respect to the potential environmental impact. Three primary questions to answer are:

- Ⓒ will the option reduce the production of pollutants or other wastes?
- Ⓒ will the system create other environmental problems?
- Ⓒ is the system safe for employees?

If the use of hazardous substances is reduced without generating additional waste, there is a clear environmental advantage. This typically occurs when the P2 effort involves improved housekeeping and process efficiency. However, some options can decrease the use of one hazardous material and increase the use of another, and/or increase production waste. In these cases, the relative toxicity of the new input material and/or new pollutants or waste must be evaluated. The impact on employee health and safety also should be examined.

In addition, the impact on the regulatory status of the facility should be analyzed. In many cases, a P2 project can reduce the regulatory burden by reducing or eliminating the use and/or generation of a regulated substance. However, in some cases, one regulatory requirement could be replaced by another. The relative impact of the new requirement should be evaluated against the existing situation.

If the technical, economic and environmental evaluations are all favorable, most facilities would implement the P2 option. If this involves investing in a new system, most facilities would first undertake a rigorous pilot test<sup>52</sup> at the facility to ensure that the system works as well as promised by the vendor(s). The potential vendor(s) of the new system can be a valuable resource that facilities should rely on for cost and operating information. Facilities should take advantage of these resources to the greatest extent possible. The provider of any new system, including design and sales staff, is a new partner at the facility both during installation and operation.<sup>53</sup>

### 2.3.4 Continuous Improvement

Facilities should apply the principles of continuous improvement to their pollution prevention program and subject the effort to periodic evaluation to maximize its effectiveness and efficiency. The impacts of P2 efforts on the quantity of hazardous substances used and/or wastes generated should be evaluated, as well as the financial costs and benefits. Technology and markets constantly change and efforts should be made to keep ahead of new developments and to re-evaluate P2 ideas that were not implemented previously in light of new information. Employees

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<sup>52</sup> NEWMOA, *Pollution Prevention for the Metal Finishing Industry - A Manual for Pollution Prevention Technical Assistance Providers*, February 1997.

<sup>53</sup> Ibid.

should have an ongoing mechanism to present P2 and other ideas for evaluation. Pollution prevention awareness also should be part of regular employee training programs.

The pollution prevention team members should serve voluntarily and change periodically to ensure that fresh viewpoints are always welcome. Numerous firms have established recognition and cash award programs to stimulate employee interest and participation. Some firms also have included pollution prevention progress and willingness to implement change as criteria in employee performance reviews, particularly for managers.<sup>54</sup>

## 2.4 Overcoming Possible Barriers to Pollution Prevention

P2 often means altering the status quo and there can be a resistance to change at a wood furniture manufacturing facility. Concerns typically center around five main items:

- Ⓒ possible negative impacts on production rates
- Ⓒ perceived problems with product quality and customer acceptance
- Ⓒ availability of time and resources
- Ⓒ reluctance to alter regulatory status
- Ⓒ lack of information

Some of these concerns might be valid and should be evaluated during the in-depth study described above.

### 2.4.1 Effect on Production Rates

Some pollution prevention options can increase productivity while others can increase cycle time, sometimes substantially. Productivity and output in wood furniture finishing is primarily influenced by three factors: complexity of the item to be finished, the number of finishing steps required to achieve the desired appearance, and the amount of drying time required between steps. The geometry of the item is typically fixed; however, the number of finishing steps and/or the amount of drying time can be affected by a P2 option, sometimes increasing and sometimes decreasing productivity. A P2 option also can affect the amount of time required to perform a given finishing step. Finally, a P2 option can increase or decrease the labor required to support a given process through changing O&M, housekeeping and/or waste management requirements. All of these factors should be assessed when evaluating a P2 project.

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<sup>54</sup> U.S. EPA, *Facility Pollution Prevention Guide*, EPA/600/R-92/088, May 1992.

## 2.4.2 Product Quality and Customer Acceptance

After pilot testing, some furniture manufacturers have not implemented certain P2 options because of perceived problems with final product quality and customer acceptance. However, some of these firms might have mistakenly made assumptions about customer requirements. For example, when a stadium seating manufacturer switched to aqueous-based coating of chair arms, they found their customers actually preferred the slightly duller finish and appreciated the new coating's resistance to deterioration when exposed to water and sunlight. Many P2 options increase product quality and enhance customer acceptance, or leave the quality unchanged. For example, in many cases switching to a high-solids topcoat improves product quality and eliminates the need for a second application. Including a customer product evaluation in the pilot test can provide the information necessary to evaluate customer acceptance concerns.

## 2.4.3 Time and Resources

All P2 efforts will require an investment in terms of the time of one or more of a facility's employees. Time is required to assess the current situation, and to gather information about alternatives and evaluate them. Not all P2 projects are large and complex. Many require only simple, inexpensive changes that generate substantial benefits. When a P2 project is implemented, the affected employees might have to spend time training with the new system. A P2 option also might require an investment of capital by the company, sometimes a substantial outlay. The required human and capital costs can be real constraints for a given company, particularly smaller firms.

The burden on in-house personnel can be lessened by taking advantage of vendor services and/or state or local technical assistance programs. A listing of appropriate resources for the wood furniture industry is contained in Appendix E. There can be outside sources of financial assistance for P2 projects such as commercial bank loans, various U.S. Small Business Administration (SBA) loan programs, and state-affiliated P2 and community development loan programs.<sup>55</sup> A manufacturing company is considered a small businesses by the SBA if it has fewer than 500 employees. Therefore, most wood furniture manufacturing companies are small businesses and might be eligible for SBA loan guarantee programs.

## 2.4.4 Regulatory Status

Many companies can be overwhelmed by all of the requirements of government regulations. It can be difficult to keep track of all the different regulations that apply to a particular business. The federal government and the states recognize these problems and some have instituted programs to help companies negotiate the maze of regulations, and determine which apply and what that means to a particular facility. When management believes they understand all of these requirements and are in compliance, there can be tremendous reluctance to make any changes that can alter their regulatory status. For example, P2 improvements can create a need to change existing permits to reflect the new conditions. However, in most cases, implementing a P2 option will lessen the regulatory burden and is worth the up-front effort.

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<sup>55</sup> U.S. EPA New England, *Financing Pollution Prevention Investments - A Guide for Small and Medium-Sized Businesses*, 1995.

### 2.4.5 Lack of Information

The assumptions that there are no feasible alternatives to the current practice or that change will be too costly and time consuming to be worth it are often made by a firm's management or employees. These assumptions can be overcome by actively investigating useful and relevant information. Information about P2 can be obtained from a variety of sources such as professional consultants, state or local P2 technical assistance providers, vendors, trade associations and/or literature, including trade journals and government reports. A list of potential resources for the wood furniture industry can be found in Appendix E. In some rare cases, the initial assumption that there is no way to improve on existing conditions can prove true after further investigation. However, this is not typically the case. With information about P2 specific to the wood furniture industry, it might be possible to overcome resistance to change whether from management or operators.

## 2.5 Conclusions

This chapter presented the concept of pollution prevention, its definition and the benefits of P2, and outlined how to establish a P2 program and conduct a P2 evaluation at a facility. Even if a facility does not have the capacity to implement a comprehensive P2 program, many of the concepts presented can be valuable on their own. The next chapter provides specific information about P2 options for the wood furniture industry. The P2 information is presented in the context of the various requirements of the NESHAP that were outlined in Chapter 1. Numerous real world, facility-specific examples of P2 successes at wood furniture facilities also are included in Chapter 3, Pollution Prevention Opportunities.



## CHAPTER 3: POLLUTION PREVENTION OPPORTUNITIES

The wood furniture NESHAP incorporates several pollution prevention approaches. The coating emission limits encourage input substitution because installing and operating air emission control technology is a costly and economically inefficient compliance method for most wood furniture manufacturers. The work practice standards encourage material use efficiency and housekeeping improvements. The implementation of these innovative requirements through Title V permits provides a framework to incorporate P2 into the daily compliance strategies of wood furniture manufacturers. However, there are opportunities to achieve emission reductions beyond those required by the NESHAP through P2 approaches that often will save a wood furniture manufacturer money as well. The information presented in this chapter enhances the P2 components in the NESHAP by providing specific examples of technologies that can be used to meet or exceed the regulatory requirements. A P2 assessment modeled on the general information presented in Chapter 2 can be a valuable tool to determine the best method(s) for a particular company to achieve the emission reductions required by the NESHAP. In addition, a P2 assessment can identify additional cost-effective emission reduction and process efficiency opportunities.

There are many opportunities for pollution prevention at wood furniture manufacturing facilities, especially for those still using traditional low-solids solvent-based coatings and conventional air spray guns. This chapter will provide numerous examples of the benefits of pollution prevention specific to the wood furniture industry, particularly in terms of reducing operating costs, and VOC and VHAP emissions. Wood furniture manufacturers that are not large enough to be regulated by the NESHAP or CTG still can realize the benefits of P2 to their bottom line and to the work environment for their employees, and should investigate the P2 opportunities presented in this chapter as well.

Wood furniture manufacturers that are not large enough to be regulated by the NESHAP or CTG still can realize the benefits of P2.

P2 efforts can be the most cost effective method to meet the requirements of the NESHAP. A P2 option or combination of efforts might even reduce VHAP emissions below levels regulated by the NESHAP. As discussed in Chapter 1, if the VHAP emission reduction occurs before the facility's compliance date (November 21, 1997, or December 6, 1998, for existing sources with actual VHAP emissions over or under 50 tpy, respectively) then the facility will not have to comply with the NESHAP, other than maintaining records documenting that emissions are below applicable

P2 efforts can be the most cost-effective method to meet the requirements of the NESHAP and CTG. Air emissions might even be reduced to below regulated levels.

thresholds. However, according to current U.S. EPA policy,<sup>56</sup> if the emission reduction occurs after the facility's respective compliance date, the facility must always comply with all the provisions of the NESHAP. Therefore, there are benefits to investigating P2 options and implementing suitable projects as soon as possible.

Successful P2 efforts in the wood furniture industry require the involvement of coating and equipment suppliers. Vendors are the primary source of facility-specific technical information in the wood furniture industry. If existing suppliers are not supportive of P2 efforts, alternative vendors should be contacted for information. Even if existing suppliers do support changes, solicit information from other vendors to make sure that the best system is chosen in terms of product quality, reduced VHAP and VOC emissions, and capital and operating costs. Pilot testing coatings from several manufacturers is particularly important when evaluating aqueous-based finishes and adhesives because their suitability to a particular application can vary widely among vendors.

Successful P2 efforts require the involvement of coating and equipment suppliers. Solicit information from multiple vendors to make sure the best system is chosen in terms of product quality, reduced VHAP and VOC emissions, and capital and operating costs.

This chapter contains a section on each of the different wood furniture manufacturing activities regulated by the NESHAP: coatings, application equipment, cleaning, gluing, operator training and housekeeping. After the NESHAP requirements are detailed, each section contains pollution prevention options, including specific examples if available.

## 3.1 Coatings

As discussed in Chapter 1, the coatings traditionally used in wood furniture finishing operations are the source of most emissions from wood furniture manufacturing. In recognition of this, the U.S. EPA has developed regulations limiting the VHAP content of coatings. The list of VHAPs regulated by the wood furniture NESHAP is presented in Appendix D, Table D-1. The NESHAP requirements for coatings are detailed in Section 3.1.1. Technically, because the NESHAP only regulates listed VHAPs, a facility could reformulate their coatings so that they still contain solvents, but do not contain listed VHAPs, or do not contain VHAPs that could result in emissions above the regulated thresholds. Reformulation with non-VHAP solvents is not a recommended compliance strategy because the health and environmental benefits might not be significant and because the regulatory standard can change in the future. As discussed previously, the U.S. EPA must review the effectiveness of the wood furniture standard within 8 years of implementation. If this residual risk review indicates that the public health is not adequately protected, then the U.S. EPA is required to tighten the NESHAP requirements. Stricter standards could include regulation of volatile chemicals not on the current VHAP list. Therefore, what was a non-VHAP coating can

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<sup>56</sup> U.S. EPA issued this policy, known as "once in, always in," in a May 16, 1995, memo "Potential to Emit for MACT Standards - Guidance on Timing Issues." However, this is only policy and, therefore, subject to change. Contact the facility's permitting authority for the current policy.

become a regulated coating in the future. By switching to an alternative coating now, a facility might avoid having to make process alterations in the future.

There are other reasons to avoid reformulation with non-VHAP solvents. For example, some facilities are reformulating their coatings using acetone as the solvent. Acetone is not a listed HAP and was recently removed from the VOC list as well. However, some states in the Northeast regulate the use of acetone and will continue to do so because acetone exposure does have potentially harmful health effects.<sup>57</sup> There are additional reasons not to increase acetone use at wood furniture manufacturing facilities. Acetone is more flammable than HAP-containing solvents, increasing fire and explosion hazards and most likely, fire insurance rates as well. Acetone is more volatile than most other solvents, creating potential quality problems because the coating dries too quickly. Furthermore, the smell of acetone is not pleasant for employees.

Acetone substitution is not recommended. Acetone has several potential negative consequences:

- C highly flammable, increasing fire hazards (and insurance rates)
- C can dry too quickly, negatively affecting product quality
- C smell is offensive to employees
- C is irritating to eyes, nose and throat and can cause headaches, confusion, drowsiness and vomiting at high doses.

Therefore, acetone reformulation is a less desirable alternative than other options and is not promoted in this Manual.

Fortunately for wood furniture manufacturers, numerous alternative coatings are available that can meet and/or exceed the NESHAP emission standards: higher-solids nitrocellulose, aqueous-based, ultraviolet (UV)-cured, polyester/polyurethane, and/or some traditional coatings in combination with one or more of the alternatives. All of these compliance methods can be considered pollution prevention opportunities and are discussed in Section 3.1.2, following the description of the NESHAP requirements.

The choice of an appropriate alternative coating strategy depends on product-specific attributes, such as desired gloss level and coating build, and whether the product can be produced by an automated system. Other factors that can influence the choice are the desire to reduce fire insurance costs or increase finish durability, impacts on productivity and employee health and safety, and the relationship between capital cost requirements and expected savings.

### 3.1.1 NESHAP Requirements

As described in Chapter 1, the NESHAP contains emission limit requirements for the coatings used in wood furniture finishing. Emissions from coatings can be estimated based on the volatile compound content of the liquid coating. Therefore, the NESHAP specifies the maximum VHAP content of the coating. The VHAP content is regulated in terms of pounds of VHAP per pound of solids (lbs. VHAP/ lb. solids) in the coating. These units differ from those that most regulators

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<sup>57</sup> Inhalation of a relatively high concentration of acetone is irritating to the eyes, nose and throat. Short-term exposure can cause headaches, confusion, drowsiness, vomiting and respiratory impairment. Source: U.S. EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995.

and manufacturers use. The NESHAP requirements can be met by one or a combination of three techniques:

1. Achieve a weighted average across all coating materials, as applied, of less than or equal to 1.0 lbs. VHAP/ 1.0 lb. solids for existing sources and less than or equal to 0.8 lb. VHAP/ 1.0 lb. solids for new sources, using the following equation:

$$E = (Mc_1Cc_1 + Mc_2Cc_2 + \dots + Mc_nCc_n + S_1W_1 + S_2W_2 + \dots + S_nW_n) / (Mc_1 + Mc_2 + \dots + Mc_n)$$

where:

E = weighted average (lbs. VHAP / lb. solids)

Mc = mass of solids in finishing material used monthly (lbs. solids / month)

Cc = VHAP content of finishing material, as supplied (lbs. VHAP / lb. solids)

S = VHAP content of solvent added to finishing material (expressed as a weight fraction)

W = mass of solvent added to finishing material each month (lbs. solvent / month)

2. Use all compliant finishing materials. The coatings covered by this method are stains, washcoats, sealers, topcoats, basecoats, enamels and thinners. The definitions contained in the NESHAP are:

- C stain: any color coat having a solids content by weight of no more than 8 percent that is applied in single or multiple coats directly to the substrate
- C washcoat: a transparent special purpose finishing material having a solids content by weight of 12 percent or less
- C sealer: a finishing material used to seal the pores of a wood substrate before additional coats of finishing material are applied
- C topcoat: the last film-building finishing material that is applied in a finishing system
- C basecoat: a coat of colored material, usually opaque, that is applied before graining inks, glazing coats, or other opaque finishing materials, and is usually topcoated for protection
- C enamel: a coat of colored material, usually opaque, that is applied as a protective topcoat over a basecoat, primer or previously applied enamel coats
- C thinner: a volatile liquid that is used to dilute coatings or contact adhesives

The VHAP content limits for each material, as applied, are shown in Table 3.1.

**Table 3.1 Compliant Finishing Material Content Limits**

Finishing Material	Existing Source Limit (lbs. VHAP/lb. solids)	New Source Limit (lbs. VHAP/lb. solids)
Stains	1.0	1.0
Washcoats	1.0	0.8
Sealers	1.0	0.8
Topcoats	1.0	0.8
Basecoats	1.0	0.8
Enamels	1.0	0.8
Thinners (max %)	10.0	10.0

If washcoats, basecoats, and enamels are formulated on-site, as done at some facilities, they must be formulated using compliant finishing materials and a thinner containing no more than 3 percent HAPs by weight prior to mixing in order for the washcoat, basecoat or enamel to be considered compliant.

3. Use a control device that operates at an efficiency equivalent to emissions of no greater than 1.0 lb. VHAP/ 1.0 lb. solids for existing sources and 0.8 lb. VHAP/ 1.0 lb. solids for new sources. The U.S. EPA assumes carbon absorbers or thermal oxidation control technologies are used by the wood furniture industry. With the exception of manufacturers that use automated flatline coating operations, such as large kitchen cabinet makers, the installation of control devices to capture emissions is not expected to be economically practical because finishing application in furniture production involves emissions to a relatively high volume of air.

All of the emission limits refer to the material as applied. Therefore, if the purchased product is thinned on site, the VHAP content limits apply to the composition of the newly formulated material. For finishing materials containing formaldehyde (e.g. acid-catalyzed conversion coatings) or styrene (e.g. polyester coatings), adjustments should be made as not all the material volatilizes and some formaldehyde or styrene remains in the finish. For formaldehyde, the VHAP content is the amount of free formaldehyde present in the material, as applied. For styrene, the VHAP content is calculated as the amount of styrene monomer present in the material, as applied, multiplied by a factor of 0.16.

In addition to the emission limits, the NESHAP has an additional requirement relating specifically to coating materials. The work practice standard portion of the NESHAP requires that a facility prepare a formulation assessment plan. The purpose of the formulation assessment is to monitor the use of VHAPs that the U.S. EPA considers of potential concern and ensure that their use is not increased. The formulation assessment plan is kept with the work practice implementation plan that was described in Section 1.4.2. The plan must include the following elements:

1. List of VHAPs of potential concern that are used in the finishing operations. VHAPs of potential concern are listed in Appendix D, Table D-2.
2. Baseline level of use for each VHAP of potential concern based upon the highest annual usage from 1994, 1995 or 1996 for each VHAP. If a control device is used, baseline can be adjusted to account for capture efficiency.
3. Method to track use of each VHAP of potential concern that is present in amounts subject to MSDS reporting under OSHA.
4. Description of any increased usage above the baseline occurring after November 1998, including reasons for the increased use and methods to reduce use, if practical and reasonable, as determined by the permitting authority. Reduction is not necessary if increase is less than 15 percent of baseline, use is below the *de minimis* level specified in Appendix D, Table D-2, the source is in compliance with its state's air toxic regulation or guideline, or the source material contains less than 1.0 lb. VOC/ lb. solids.

5. If a facility begins use of a VHAP of potential concern after November 1998, its baseline use must be the *de minimis* level or less. If use exceeds the *de minimis* level, then the conditions listed under Part 4 above are to be followed.

### 3.1.2 P2 Technologies

There are numerous alternatives to the low-solids solvent-based coatings that are traditionally used by the wood furniture industry. With few exceptions, the alternative coatings are considered compliant coatings as defined by the NESHAP. The coatings that are not compliant in themselves (e.g. some high-solids nitrocellulose and some polyurethane coatings) can be used in combination with other alternative coatings that have low HAP and VOC contents under the averaging compliance option. Each of the alternative coatings - high-solids nitrocellulose, aqueous-based, UV-cured and polyester/polyurethane - is discussed in the following sections. Estimated VOC reductions for the alternative coatings are presented in Table 3.2.

**Table 3.2 Estimated VOC Emission Reductions<sup>58</sup>**

Coating Type	VOC Reductions (in percent)
High-solids nitrocellulose	17 to 40*
Aqueous-based	90 to 95
UV cured	80 to 100
Polyester	85 to 100
Polyurethane	80 to 100

\* Estimated by increasing solids from 16 percent to 30 and 50 percent, respectively

In the following alternative coating descriptions, the benefits of switching from traditional low-solids solvent-based coatings to alternative coatings might be underestimated because the avoided cost of installing and operating a control device to meet the new standards has not been included in the discussion. Both manufacturers and vendors agree that for most situations a control device is not practical and most facilities will comply by switching to alternative coatings for at least some of their applications. However, if a facility does not switch to alternative coatings to meet the NESHAP averaging or compliant coatings approaches, they will be required to install a control device. Avoiding the cost of installing and operating a control device increases the attractiveness of alternative coatings.

### High-solids Nitrocellulose Coatings

High-solids nitrocellulose coatings generally are limited to sealer and topcoat materials. However, these are typically the largest emission sources in a plant, generating approximately 50 to 65 percent of all emissions. Traditional nitrocellulose topcoats and sealers typically contain less than 20 percent solids. High-solids nitrocellulose coatings contain approximately twice the solid content, ranging from 30 to 50 percent. Therefore, only half the amount of liquid material is

<sup>58</sup> U.S. EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

required to produce the same dried thickness of coating on an item, referred to as dry mil thickness.

If the VHAP and VOC content of the high-solids coating were the same as in the low-solids coating, using a high-solids coating would result in approximately 50 percent lower emissions from that coating step. If both high-solids sealer and topcoats are used, facilitywide emissions could drop by as much as 25 to 30 percent. Typically, the VHAP and VOC content of high-solids coatings is lower than in low-solids coatings so emission reductions could be even greater.

Several benefits are associated with the use of high-solids nitrocellulose coatings:

- C HAP and VOC emissions can be reduced by 50 percent or more from the applications where they are substituted.
- C High-solids nitrocellulose coatings are similar to traditional coatings, so there is little difference in application technique, repair or cleanup requirements, or the appearance of the final product. Therefore, other than the required equipment modifications, making the transition to high-solids nitrocellulose coatings is relatively easy.
- C One application layer can place twice the amount of solids on an item, so fewer finishing steps are needed to produce the same quality product.
- C Facilities that have switched to high-solids nitrocellulose coatings report that the final product is of a higher quality and appeal to consumers.

There are also several potential drawbacks to the use of high-solids nitrocellulose coatings:

- C Increasing the solids content makes the coating more viscous, so that when sprayed from a typical HVLP gun, the flow rate is too low for normal line speeds. Therefore,

**Ethan Allen  
Beecher Falls, Vermont**

The Beecher Falls plant makes several styles of high-quality bedroom and living room furniture. Beecher Falls switched to 35 percent solids sealer and topcoat. One topcoat application instead of two is needed, reducing topcoat use and associated HAP and VOC emissions by approximately 55 and 28 percent, respectively, and saving the labor of the two spray operators and two sanders associated with the second coat. The new coatings contain 42 percent fewer VOCs and 83 percent fewer HAPs, further reducing emissions.

Several obstacles had to be overcome in the transition. The high-solids material could not be applied at room temperature with the HVLP spray guns so the facility electrically heats the coating in-line. The HVLP gun cap, nozzle and tip were modified (but are still below 10 pounds per square inch (psi)). The high-solids sealer requires more time to dry so air flow in the flashoff area was increased and a flashoff tunnel was built to keep dirt off the items. Lastly, the sealer coat has a higher build, requiring two additional employees at the sealer sanding station.

	<b>Saving or (Cost)</b>
<b>Labor</b>	\$175,000 per year
<b>Materials</b>	(\$42,000 per year)
<b>Capital Costs</b>	(\$42,000)
<b>Payback Period</b>	<b>4 months</b>

Source: the complete text of the Beecher Falls Case Study can be obtained from NEWMOA at (617) 367-8558.

equipment modifications are required to enable proper application. Typical modifications include using higher pressure spray guns or heating the coating to reduce its viscosity.

- C Drying times can be slower with high-solids coatings. Forced air flashoff areas or a drying ovens often are required to maintain production rates.
- C On a per-gallon basis, the cost of high-solids sealer and topcoat is higher than traditional low-solids material. However, less material is needed to produce the same output, offsetting all or most of the increased material cost.
- C High-solids nitrocellulose coatings can generate smaller quantities of emissions, but VHAP- and/or VOC-containing solvents still are used and emissions can be significant.

### Aqueous-Based Coatings<sup>59,60</sup>

Aqueous-based, also known as waterborne, coatings rely on different chemistry than nitrocellulose coatings. Water is used in place of solvent as the carrier liquid; however, some solvents also are added to produce desired characteristics. The VHAP and VOC content of aqueous-based coatings is typically less than 2.0 pounds per gallon, less water. The average VOC content is 0.3 to 0.8 lbs. VOC/ lb. solids for a 24 percent solids coating.<sup>61</sup> Three types of film-forming polymers are used in aqueous-based coatings: water emulsions, water-reducible resins and colloidal dispersions. Water emulsions, also known as latex, contain high molecular weight particles, such as acrylic, dispersed in water. Water-reducible resins are soluble in water or water/solvent mixtures. Colloidal dispersions are somewhere in between emulsions and water reducibles, and contain medium-weight particles that are partially water-soluble and dispersed in the water medium.

Water soluble formulations are the easiest to apply with conventional equipment and have fewer problems with foaming, but they are less durable than emulsion formulations. Emulsion formulations have a lower gloss than water-soluble formulations. Some manufacturers use a hybrid aqueous-based system: the stains and basecoats are traditional solvent-based coatings, and the sealers and topcoats are aqueous-based. Because sealers and topcoats represent 50 to 65 percent of emissions, hybrid systems still can produce substantial emission reductions. High-end furniture manufacturers often are reluctant to use aqueous-based sealers and topcoats, but some have implemented a reverse hybrid system, where stains and basecoats are aqueous-based and sealers and topcoats are nitrocellulose.

Numerous benefits are associated with the conversion to aqueous-based coatings:

- C The solids content of aqueous-based coatings is typically 25 to 30 percent, so combined with the lower HAP and VOC content, emissions from a given coating operation can be reduced by 90 to 95 percent. Aqueous-based coating costs are higher than low-solids nitrocellulose

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<sup>59</sup> U.S. EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

<sup>60</sup> Roots, Kevin G. "A Guide to Waterborne Coatings", Western EcoTec Coatings, Inc. brochure.

<sup>61</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.



coating costs on a per-gallon basis. However, the solids content of aqueous-based coatings is higher, so less material is required to produce the same output, generally offsetting the increased material cost.

- C Aqueous-based finishes are more durable than nitrocellulose coatings, offering greater resistance to moisture, chemical or physical damage, and aqueous-based finishes do not yellow when exposed to sunlight.
- C Aqueous-based coatings that have not dried can be cleaned up with soap and water, eliminating air emissions and employee exposure issues associated with the use of solvents for cleanup.
- C Aqueous-based coatings emit substantially fewer toxins to the air, so large exhaust air flows from the spray booth vents are not needed. This can reduce electricity costs associated with exhaust fan use, and lower the cost of heating the finishing room in colder months.
- C Eliminating or even reducing the quantity of nitrocellulose coatings and cleaning solvent can reduce fire insurance premiums substantially. A facility that uses only aqueous-based coatings reports a 50 percent reduction in fire insurance rates.<sup>62</sup>
- C Because of their low flammability, there are no restrictions on the quantity of aqueous-based coatings that can be stored at the work site. Larger quantities can be stored at the work site, eliminating the time and spill risk associated with transferring coatings to pressure pots.

Facilities should consider several potential drawbacks associated with conversion to aqueous-based coatings when evaluating this alternative. Nonetheless, each of these drawbacks can be overcome with adequate planning and design:

### **New England Woodcraft Forest Dale, Vermont**

New England Woodcraft manufactures oak and cherry furniture for the military, college and retail markets. Following a 1985 fire that destroyed their plant, they installed an automated flatline finishing system that would be compatible with aqueous-based coatings. In 1990, they switched to acrylic aqueous-based emulsion sealers and topcoats. VOC emissions were reduced from 96 to 16 tpy, despite the doubling of production. Hazardous waste generation was cut from 2 ½ 55-gallon drums per week to only 3 drums per year. Fire insurance premiums were also cut in half.

The conversion process was time and resource intensive, requiring extensive pilot testing. However, New England Woodcraft's owner believes "...the economics of the two coating systems may be a wash. The water-based formulations cost more per gallon than nitrocellulose, but you get more mileage out of them; their solids content is higher. We'll also save on insurance and any future taxes on VOCs. And how are you going to put a price on employee health and attitude?"

Sources: "Getting the Most from Water-based Finishes," *Furniture Design & Manufacturing*, January 1991 and "Environmentalism Pays Off for Brandon Company," *Rutland Herald*, April 17, 1996.

<sup>62</sup> "Environmentalism Pays Off for Brandon Company," *Rutland Herald*, April 17, 1996.

- C The success of aqueous-based coatings, particularly stains and color primers, depends on the preparation of the wood prior to coating application. Water is absorbed by all wood and some grain swelling will occur. The severity of swelling depends on the type of wood, with oak presenting the greatest challenge and other woods such as pine, maple, cherry and birch showing a minor effect. As the New England Woodcraft and Great American Oak case studies illustrate, aqueous-based coatings can be used successfully on an oak substrate. To minimize grain raising, the surface should be freshly sanded in stages working up to 150 to 180 grit paper before stain or sealer application. Sanding after staining also can be needed.
- C Aqueous-based coatings can take longer to dry than nitrocellulose coatings, particularly during periods of high humidity. Increased air flow in flashoff areas, drying ovens or humidity control in the finishing room might be needed.
- C The water in the coating can corrode storage tanks, piping and application equipment. The tanks, piping and application equipment might need to be replaced with an appropriate grade of stainless steel or plastic material.
- C Aqueous-based emulsion coatings are more susceptible to foaming. This can be minimized by stirring the coating at a slower speed and by using low pressure application equipment. Manufacturers recommend HVLP spray gun application of aqueous-based coatings.
- C The experience and knowledge operators have with solvent-based coating systems might not be relevant any longer, essentially rendering the most experienced operator a “beginner.” Operator retraining can overcome this disadvantage. Coating and equipment suppliers can be good sources of proper application and troubleshooting information.
- C Aqueous-based coatings can freeze so the temperature of the storage area needs to be maintained above freezing. Aqueous-based coatings also can become contaminated by bacterial growth, making bulk storage more difficult.

**Great American Oak  
Chico, California**

Great American Oak (GAO) manufactures high-quality solid oak and oak veneer home theater furniture. Initially, they used a two-step oil and wax finish, but expanded production needs combined with California's strict VOC emission limits required an alternative finishing system. Now GAO uses all aqueous-based coatings in their four step system (i.e. stain, sealer, sealer and topcoat). The changeover went smoothly because both GAO and its vendor were committed to finding an acceptable system. The new system required the purchase of an HVLP-compliant spray system and a dryer to follow each application step.

There are numerous benefits to the aqueous-based system, including average VOC content of 0.25 lbs. per gallon, better finish resistance to water, chemical and physical abuse, equal or better finish look and feel, lower fire insurance rates, fewer maintenance requirements, no hazardous waste generation and an improved employee work environment. GAO feels the aqueous-based finish is a marketing advantage and adds significant value to their products. Finally, GAO's owner, John Sandoval, is “comfortable with the economics of the switch.”

Source: “Making the Switch to Waterbased Finishes,” *Furniture Design & Manufacturing*, September 1995.

- C Unlike nitrocellulose coatings that dissolve when solvents are applied, aqueous-based coatings do not rewet after they have dried. Therefore, in order to have easy cleanup that uses only water, cleanup must be performed while the coating is still wet. This can require some adjustment of previous housekeeping procedures. Likewise, repair of an inadequate quality coat also must take place before the coating has dried, demanding strict quality control throughout the finishing process.
- C There can be subtle differences in the final appearance of clear aqueous-based coats when compared to nitrocellulose coatings. A common complaint is that aqueous-based coatings lack the clarity and high-gloss of nitrocellulose coatings. Aqueous-based coating technology is continuously improving, and differences are becoming more and more difficult to detect. In addition, many applications, such as institutional furniture finishing, might not require the highest clarity and gloss finish. Adding a customer evaluation of the product to pilot-testing of aqueous-based coatings can provide information about customer requirements and finish acceptance. For pigmented coats, there is essentially no difference in appearance between aqueous-based and nitrocellulose coatings.

After determining that aqueous-based coatings can provide a finish that meets customer requirements, a facility should evaluate the following items to ensure that switching from nitrocellulose to aqueous-based coatings is efficient:

- C existing production process and configuration
- C suitability of existing application equipment
- C new equipment needs (e.g. drying ovens)
- C process reconfiguration requirements
- C staff retraining requirements
- C costs and savings associated with new coatings
- C timing of introduction

### **JB, Inc.**

#### **Long Beach, California**

JB manufactures interior millwork for fast food restaurants. Their wood products are finished with pre-sealer, paint and topcoat. Because of expanded production needs and strict emission limits, JB recently switched from solvent-based coatings and adhesives to aqueous-based.

The switch required installation of stainless steel equipment and the purchase of new HVLP spray guns. Because of the dry climate, the aqueous-based adhesives and coatings dry within 3 minutes without the use of dryers.

### **The Shuttery**

#### **Nanik, Wisconsin**

The Shuttery manufactures custom interior wood shutters. They recently switched to aqueous-based coatings for all their finishes, except their specialized high-performance coatings. VOC emissions dropped by 85 percent. The cost of the conversion was \$72,000 (i.e. mainly for a custom-made drying oven); however, annual savings are estimated at \$32,000, generating a payback period of 2 years and 3 months.

There were many motivations to make the conversion: reduced air emissions, reduced regulatory burden, reduced administrative overhead, improved working environment and improved finish quality.

Source: "Business Spotlight: Reducing VOCs," *Waste Less News*, Wisconsin Department of Natural Resources, May 1996.

## UV-Cured Coatings<sup>63,64</sup>

Two primary reasons that furniture manufacturers install UV-cured coating system are to increase productivity and/or to reduce VOC and HAP air emissions. UV-cured coatings cure through chemical crosslinking of specialized resins. This reaction is initiated by exposure of a photoinitiator catalyst in the coating to ultraviolet light. Full curing occurs within 1 or 2 seconds of exposure to high-intensity UV light and enables fast production rates when compared to other types of wood finishing methods. A UV system eliminates the need for drying, greatly reducing the time and space requirements of a given finishing application and enabling immediate movement to the next finishing step or the stacking of finished product. A typical long finishing sequence that uses traditional low-solids nitrocellulose coatings can take approximately 400 minutes to complete, of which approximately 340 minutes is used for drying.<sup>65</sup> Only 60 minutes is spent in the active manufacturing process. With UV-cured coatings, production cycle times can be decreased significantly.

UV-cured coatings consist of moderate molecular weight resins made from urethane, acrylics, silicones or other polymers that have been chain terminated by acrylates during coating manufacture. UV-cured coatings are liquids with low viscosity that are 100 percent solids and contain no HAPs when shipped from the supplier. Therefore, through chemical reaction 100 percent of the coating dries and little, if any, is lost in the conversion. This eliminates HAP and VOC emissions from the finishing steps where UV-cured coatings are used. Some users add up to 15 percent solvents to reduce viscosity or improve application performance. The addition of solvent introduces VOC and/or HAP emissions. However, the VOC content of an 87 percent solids UV-cured coating is only 0.15 lb. VOC/ lb. solids.<sup>66</sup> Because UV-cured coatings have a high-solids content, they are difficult to apply in the thin coating layers required for stains and washcoats. However, UV-cured coatings can be used for sealer and topcoat finishes. As mentioned in Section 1.2.1, these two finishing steps generate approximately 50 to 65 percent of the air emissions from the entire finishing process, so eliminating emissions from sealer and topcoat applications can produce significant VOC and HAP reductions.

UV-cured coatings usually are applied and cured in an automated flatline process. An automated flatline system allows collection of all the overspray for reuse, creating a TE of essentially 100 percent. A ventilation system is required to control any coating mists and aerosols, and any by-products of the chemical reaction. Relatively little heat is generated by the chemical reaction or the UV lights, and what is generated will be exhausted by the ventilation system.

UV-cured coating systems are used extensively in the manufacture of low-end furniture. The fillers applied to the particleboard substrate and the topcoat are UV-cured. Profitability in the low-end

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<sup>63</sup> R. Kostelnik, "Ultraviolet Coatings for Wood Products: An Overview," *Radtech Report*, July/August 1994.

<sup>64</sup> B.H. Riberi, "UV-Curable Unsaturated Polyester Systems for the Industrial Finishing of Furniture," presented at Radtech International North America conference in Atlanta, Georgia, August 23, 1990.

<sup>65</sup> J. Heltzer, "Wood Furniture Finishing," *Industrial Pollution Prevention Handbook*, edited by H.M. Freeman, McGraw Hill, 1995.

<sup>66</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

market depends on high productivity and no other finishing method allows as high a production rate as UV-cured coating systems. In addition, the design of low-end furniture tends to be simple and low-end furniture is often sold for customer assembly so flatline finishing is feasible. UV-cured coating systems also are used at medium-grade furniture facilities where assembly occurs after finishing such as institutional furniture manufacturing.

Numerous benefits are associated with the use of UV-cured coating systems:

- C Full curing of the coating occurs within seconds of exposure to UV lights, enabling fast production rates. The complete UV application and curing equipment system requires much less floor space than a solvent-based system, because flashoff and drying areas are no longer needed. This can free up potentially valuable space within the facility. Drying ovens are not needed, decreasing utility costs at facilities that used them.
- C VOC and HAP emissions are virtually eliminated, reducing or eliminating regulatory burdens. In addition, high exhaust air flows are not necessary during coating application, reducing utility costs.
- C The per-gallon cost of UV-cured coatings is substantially higher than for other types of coatings. However, because UV-cured coatings are 100 percent solids, much less material is required to achieve the same dry mil thickness. Therefore, UV-cured coatings are actually less expensive than other types of coatings.
- C UV-cured coatings are extremely durable with strong resistance to moisture, and chemical, physical and sunlight damage.
- C UV-cured coatings will not cure unless exposed to UV light. Therefore, they are completely liquid and ready for use even after sitting in the coating reservoir for several days (i.e. as long as the reservoir, conveyance piping and application equipment is protected from incident light

**Hussey Seating  
North Berwick, ME**

Hussey Seating is the world leader in the manufacture of bleacher seating. In 1994, they replaced a brush-applied polyurethane finishing line with an automated UV-cured coating system. VOC emissions were reduced from 50 tpy to only 219 pounds per year, even as production increased from 9,000 units per week to more than 14,000. The finished boards exit the UV system completely cured and ready for immediate stacking. Increased production under the old system would have required construction of new storage space for drying boards, with costs of approximately \$200,000.

The new system requires only one-third the number of employees, significantly reducing labor costs. UV-cured coatings are 100 percent solids so on a per-unit basis coating costs have decreased by approximately 17 percent. Finally, UV-cured coatings are more durable than polyurethane coatings when exposed to sunlight, heavy use and/or water.

	<b>Savings or (Costs)</b>
<b>Labor</b>	\$280,000 per year
<b>Materials</b>	\$55,000 per year
<b>Capital Costs</b>	(\$320,000)
<b>Avoided Const. Cost</b>	\$200,000
<b>Payback Period</b>	<b>4 ½ months</b>

Source: The complete text of the Hussey Seating Case Study can be obtained from NEWMOA at (617) 367-8558.

exposure). This characteristic eliminates the frequent solvent cleaning of equipment that is required with nitrocellulose coatings.

- C The fire and explosion hazard associated with nitrocellulose sealers and topcoats is eliminated, reducing fire insurance rates.

Some potential drawbacks associated with UV-cured coating systems that can limit its application include:

- C The high durability of the cured coating makes repairs difficult once curing has occurred. Therefore, the recovery of off-specification pieces might not be practical.

- C A common complaint within industry is that UV-cured coatings are too glossy, making the product look “plastic.” UV-cured coatings are constantly being improved and less glossy finishes are now available, particularly in polyester-based systems.

- C Exposure to sunlight or other types of lighting can initiate curing of the coating causing it to thicken and eventually harden, clogging the system. To avoid this, care must be taken to keep covers closed and ensure that the coating is always protected from exposure to light throughout the storage, transport and application system. Once the coating hardens, solvents, such as MEK, are needed to remove it.

- C UV-cured coating systems require a significant capital expenditure, typically on the order of \$200,000 to \$250,000 for a complete automated flatline system that applies and cures two finish coats. If a company already uses a traditional flatline system, converting it to a UV system can cost less.

- C Operation of the UV lamps can increase electricity costs. However, if spray booth ventilation and drying ovens are no longer needed, utility costs can actually decrease.

- C UV curing of pigmented coatings is performed extensively in Europe. However, their use requires expensive

### **Lowenstein Pompano Beach, Florida**

Lowenstein is a contract seating manufacturer, finishing 250 varieties of chairs, stools and benches. VOC emissions from the plant were 145 tpy, and they were placed under a consent order to reduce emissions to 100 tpy. In 1988, they installed a three-dimensional UV-curing system for their sealer and topcoat applications. Stains remain traditional formulations. Coatings are applied in electrostatic-disk booths, providing an 80 percent TE. Fully assembled chairs travel through the line on an automated overhead hook conveyor system.

VOC emissions were reduced to less than 40 tpy. The sealer and topcoat are 68 percent solids, enabling a single application of each rather than the two coats needed under the old system. The UV system provides 20 second curing instead of 45 minutes for each coat. The UV line uses 40 percent less floor space, and requires less electricity and fewer employees. Finally, Lowenstein believes the UV-cured coating system produces a better looking, more durable finish.

Sources: “Lowenstein VOC Dip Continues,” *Industrial Finishing*, May 1993 and Lowenstein company literature, “Florida Firm Answers Environmental Concerns with Advanced Technology.”

specialized coatings and UV equipment. UV light can only cure coatings that can “see” it, and the pigments block the penetration of UV rays from typical UV systems. New specialized, but expensive, photoinitiator catalysts have been produced that can absorb longer wavelengths than typical catalysts. Lamps to produce this longer wavelength UV light are also specialized and expensive. A system cannot cure both pigmented and clear coatings, it needs to be designed for one or the other.

- C UV-cured coating systems are generally limited to two-dimensional flatline finishing applications. In order for the coating to cure, it must be directly exposed to UV light, making it difficult to cure three-dimensional items. However, finishing three-dimensional items has been successful using spray gun application of the UV-cured coatings. Employees must be protected from overspray mists and aerosols. Therefore, spray gun application also must be automated and occur in a fully enclosed spray booth or employees must wear fully enclosed supplied-air personal protective equipment. The UV lamps must be carefully configured to fully cure three-dimensional pieces, making it inefficient to apply a UV-cured coating system to a production line that does not finish a single product for a significant period of time (e.g. weeks or months). Spray gun application will generate overspray that most likely will be too contaminated to reuse, and will require collection and exposure to UV light to cure it prior to disposal.
- C UV-cured coatings do present some health risks to employees, but traditional solvent-based coatings also present risks that are potentially more harmful. Exposure to the UV lights can cause damage similar to exposure to the sun, including skin darkening, dryness and/or burning, and potentially severe eye damage. To protect employees from the uncured coating and the UV light, the coating application and curing processes are fully automated and enclosed. In addition, the equipment includes safeguards so that the system cannot be inadvertently opened while the lights are activated. Acrylate resin UV-cured coatings contain acrylate monomers. Direct skin exposure to unreacted UV-cured coatings is associated with potentially severe skin irritation. Studies have shown that uncured UV-cured coatings are not carcinogenic. Once cured, the coatings are non-hazardous and there is no skin irritation associated with handling the coated wood. Regularly updated employee training is essential to prevent harmful exposures.

## Polyester/Polyurethane Coatings<sup>67,68</sup>

Polyester and polyurethane coatings are used extensively in Europe and Japan, but are not popular in the United States. For example, 33 percent of European and Japanese furniture manufacturers use polyurethane coatings as compared to less than 5 percent of manufacturers in the United States. In Europe and Japan, furniture design tends to be simpler, and production tends to be higher volume and more automated than in the United States.

Polyester coatings can cure either through catalytic reaction or exposure to UV radiation. UV-cured polyester coatings are not used by the wood furniture industry. This section presents information about coatings that cure through catalytic reaction. Polyester and polyurethane resins

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<sup>67</sup> American Furniture Manufacturer’s Association, et al, *A Complete Guide to the Wood Furniture CTG and NESHAP*, Copyright 1995.

<sup>68</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

have a lower molecular weight than nitrocellulose resins. To improve the performance of the lower molecular weight resins, catalysts are added to increase crosslinking during curing. These additives make the coating less stable so many coatings are formulated as two pack systems where the additives and resins are stored in separate containers and mixed just prior to application. After mixing, the coatings have a useful life of only a few hours, requiring careful planning of production to minimize wasting unused coating. Sophisticated application equipment can be purchased to mix the two-pack coating components just prior to spray gun application.

There are two types of polyester coatings used by the wood furniture industry: styrene-derived and acrylic polyesters. The styrene-derived coatings are typically 100 percent solids, although not all of the styrene crosslinks during curing and some styrene is emitted. Styrene is considered a VHAP of potential concern, and its use must be monitored in the formulation assessment plan discussed in Section 3.1.1. Acrylic polyesters are typically about 80 percent solids with a VOC content of approximately 0.2 lb./ lb. solids. Polyurethane coatings can be solvent or aqueous-based. Therefore, the solvent content of polyurethane coatings varies with VOC contents ranging from 0.25 to 2.3 lb. VOC/ lb. solids. The solids content of polyurethane coatings is 30 to 80 percent solids. Polyurethane coatings contain polyisocyanates, and respiratory protection for operators can be required.

There are some benefits to using polyester or polyurethane coatings:

- C VHAP and VOC emissions can be significantly reduced; however, polyurethane coatings can contain high levels of VHAPs and/or VOCs depending on the formulation.
- C Coatings provide good build and are resistant to chemical and physical damage.
- C Two-pack coatings are quick drying, although total cure times can be long.

There are also several potential drawbacks associated with polyester and polyurethane coatings:

### **Geiger Brickel Atlanta, Georgia**

Geiger Brickel manufactures high-end office furniture. To increase production and remain within their permitted air emission limit, they switched to a clear, two-coat aqueous-based polyurethane topcoat system on all their vertical surfaces. They still use solvent-based stains on all surfaces and solvent-based polyurethane topcoats on horizontal surfaces.

Switching to aqueous-based polyurethanes required several changes:

- C new spraying technique
- C more precise mixing ratios
- C addition of drying ovens
- C use of a presealer prior to

water-

based sealer

- C different sanding abrasives
- C different clean-up practices
- C stainless steel equipment

Overall, VOC and HAP emissions from the facility have been reduced by a minimum of 25 percent. Production throughput times have increased because of the use of the drying ovens. Geiger Brickel believes the aqueous-based polyurethanes are comparable to solvent-based polyurethanes in terms of gloss, smoothness and other aesthetic elements.

Source: "Geiger Brickel Dives Into Waterbased," *Furniture Design & Manufacturing*, June 1996.



- C Their durability and chemical resistance makes coating repair difficult.
- C Styrene-derived polyester coatings emit styrene, a VHAP of potential concern. Polyurethane coatings contain polyisocyanates, another hazardous compound, and also can contain high concentrations of VOC and HAP solvents as well.
- C Prior to curing, the coatings are susceptible to contamination from dirt and dust. Therefore, a “clean” room environment can be required.
- C Useful life (i.e. “pot life”) of two-pack coatings is short (i.e. hours).
- C Additional space can be needed for drying and curing.
- C A common complaint is that the finish is too glossy and not appropriate for all applications.

## A Combination of the Above Pollution Prevention Options

To comply with the NESHAP, many wood furniture manufactures probably will choose to implement one or more of the above P2 options for some of their finishing operations and continue to use low-solids solvent-based coatings for others. The firms that choose this direction will comply by the averaging method, achieving a maximum weighted average across all coating materials of 1.0 lb. VHAP/ lb. solids for existing sources and 0.8 lb. VHAP/ lb. solids for new sources. With the exception of some high-solids nitrocellulose and some polyurethanes, the alternative coatings discussed in this Manual all have a low VHAP content so using them to replace some finishing steps should offset the high VHAP emissions from the remaining low-solids solvent-based applications. If high-solids nitrocellulose or polyurethane materials are selected, they need to be of sufficiently low VHAP concentration so that the facility meets the averaging requirements. The number of replacement steps required to bring a facility into compliance is site-specific and depends primarily on the coating formulations, and the type and number of finish applications used.

Most of the alternatives to low-solids solvent-based coatings apply to some but not all of types of coatings used in wood furniture finishing. Sealers and topcoats can be replaced by any of the alternatives - high-solids nitrocellulose, aqueous, UV-cured, polyester and polyurethane - but there are few options for replacing low-solids solvent-based stains. Stains are used to impart and even out color, and enhance the natural wood grain without adding any noticeable coating thickness (build). With the exception of aqueous-based coatings, all of the other alternatives are of such a high solids content that it is not possible to avoid significant build. The use of aqueous-based stains can cause grain raising problems depending on the type of wood substrate and the quality of its surface preparation. Nevertheless, as presented in the previous section on aqueous-based coatings, manufacturers have made the transition to aqueous-based materials for all, or most, of their coating applications.

Because of the nature of high-end furniture manufacturing, automated flatline finishing is most likely not feasible. This typically eliminates UV-cured coatings as an option. However, all of the other options can still be feasible, even with the strict quality standards of high-end furniture manufacturers. Most likely, for the averaging option, traditional solvent-based formulations will still be used for stains, washcoats and fillers, and it will be the sealer and topcoat applications that

are replaced with low/no VHAP materials. If the wood is painted instead of stained, aqueous-based primer and paint can be used and will provide the same finish appearance as solvent-based primer and paint. Under this option, an aqueous or other type of alternative sealer and topcoat can be applied.

In the manufacture of medium-grade furniture, there are more feasible alternatives to low-solids nitrocellulose coatings because of the different aesthetic and performance requirements. Most medium-grade furniture is finished with three finish coats (i.e. stain, sealer and topcoat) and the application can be automated. Most facilities using the averaging option will still use traditional stains and replace the sealer and topcoat applications with any one of the alternatives: high-solids nitrocellulose, aqueous, UV-cured, polyester or polyurethane.

## 3.2 Application Equipment

As mentioned in Section 1.3.2, coating application equipment can have a large effect on the emissions from wood furniture finishing. Conventional air spray guns have a low TE under actual application situations, often as low as 20 percent. Therefore, the NESHAP has prohibited the use of conventional air spray guns, except under the limited circumstances presented in Section 3.2.1. There are several alternatives to conventional air spray guns: HVLP guns, airless guns, air-assisted airless guns and flatline continuous coating systems. All of these options can be considered pollution prevention when compared to conventional air spray guns. Many wood finishing facilities have already switched to HVLP spray guns, but might benefit from switching to an even higher TE application technique. Pollution prevention opportunities in coating application are presented in Section 3.2.2.

### 3.2.1 NESHAP Requirements

As stated above, the NESHAP specifies that the use of conventional air spray guns is no longer permitted. The NESHAP defines conventional air spray guns as those that use compressed air to atomize the coating material at a pressure greater than 10 psi at the point of atomization. Conventional air spray gun use is still permitted under several circumstances:

1. To apply finishing materials with a VOC content <1.0 lb. VOC/ lb. solids.
2. For touch up and repair if it occurs after completion of finishing operations or after application of stain but before any other finishing application and the container has a volume of no more than 2 gallons.
3. If the spray gun is automated.
4. When emissions are captured by a control device.
5. The cumulative total use of finishing material applied by conventional air spray guns is less than 5 percent of total gallons of finishing material used in that semiannual period.

6. To apply stain on a part that is technically or economically infeasible to cover by any other method. Valid reasons include high production speed, part shape too complex for one operator and there is not enough space for more than one, and excessively large vertical area makes it difficult to avoid sagging or runs in stain. Documentation must be submitted to the permitting agency to support the infeasibility claim.

### 3.2.2 P2 Technologies<sup>69,70,71,72,73</sup>

Two broad types of coating application technologies are manual spray gun and automated finishing. Approximately 87 percent of the industry uses manual spray gun application. Several types of spray gun technologies are used: conventional air spray, HVLP, airless, air-assisted airless and electrostatic systems. Each of these spray gun technologies is covered in the next few sections.

Conventional air spray guns typically use compressed air at 50 to 90 psi. Conventional guns provide good atomization of the coating resulting in a high quality finish. The coating application rate is high, enabling high production rates and good operator control and flexibility. As stated in previous sections, conventional guns have a low TE, only 20 to 40 percent under actual line conditions. Therefore, 60 to 80 percent of coating material costs are wasted, and VOC and HAP emissions are high. The low TE also results in large quantities of overspray so spray booth filters and the spray booths themselves require frequent cleaning. Frequent cleaning increases labor requirements, solvent use and waste generation, which translates into expenses that could be minimized with a higher TE application method. Therefore, there can be strong financial benefits associated with switching from conventional air spray technology in addition to the environmental benefits of lower VOC and HAP emissions.

Approximately 60 to 80 percent of coating material costs are wasted with conventional air spray guns. Their low TE results in large quantities of overspray so spray booths and filters require frequent cleaning, creating high labor requirements, solvent use and waste generation. These expenses can be minimized by using another type of gun with a higher TE. Higher TE guns can pay for themselves in a very short time through reduced coating use.

<sup>69</sup> Cleveland Advanced Manufacturing Program's NIST Great Lakes Manufacturing Technology Center, *Spray Painting: Improvements and Alternatives*, June 8, 1994.

<sup>70</sup> U.S. EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

<sup>71</sup> P.J. Dambek, et al, "A Guide to Pollution Prevention for Wood Furniture Finishing," Capstone Project, Tufts University, August 1992.

<sup>72</sup> Graco, Inc of Golden Valley, MN, presentation materials from "Wood Finishing Technology Update", Vermont Technical College, Randolph, VT, June 14, 1996.

<sup>73</sup> J. Bransfield, "Back to Basics Seminar," Norris-Wiener Spray Finishing Supply, Billerica, MA.

There can be a significant variation in TE among different manufacturers of a particular type of spray gun. Therefore, guns from several different manufacturers should be pilot tested under actual line conditions when a facility is contemplating making an equipment change. Most spray gun application is performed manually. Therefore, operator technique affects the TE realized by up to  $\pm 20$  percent. Proper operator technique is discussed in Section 3.5, Operator Training. The TE of a spray gun also is affected by the type of coating applied, type of equipment used, air pressure, nozzle adjustment, and size and shape of the item to be finished. The size and shape of the item being finished is considered fixed, with a large table top resulting in a higher TE than an intricately cut chairback. Finishing small part sizes can decrease TE by 20 to 30 percent.

There can be a significant variation in TE among different manufacturers. It is important to test guns from several different manufacturers.

Spray gun efficiency can be optimized by the size and shape of the gun nozzle and tip used. Nozzle and tip size and shape can affect TE by  $\pm 20$  percent. A rule of thumb is that the lower the viscosity of the fluid, the smaller the inner diameter of the fluid tip. Generally five considerations are involved with selecting the gun nozzle and tip: type of gun, size of object to be coated, desired line speed and finish quality, type and viscosity of coating to be sprayed, and the available air volume and pressure. TE can also be affected  $\pm 10$  percent by the spray booth air flow with high air flows decreasing TE.

TE is affected by:

Operator Technique	$\pm 20$ percent
Nozzle/Tip Size & Shape	$\pm 20$ percent
Spray Booth Air Flow	$\pm 10$ percent
Finishing Small Items	-20+ percent

In some cases, a furniture piece that is assembled and then finished can be amenable to automated flatline finishing of pieces prior to assembly. Flatline finishing systems have a high TE, essentially 100 percent, because overspray is minimized and what is generated is captured and recycled.

### HVLP Spray Gun

With HVLP spray guns, the pressure at the point of coating atomization should be less than 10 psi. HVLP spray guns use either low pressure compressed air or a high-speed turbine that generates high volumes of air. Turbine systems use approximately one-third the electricity required by compressed air systems and are well suited for use with HVLP guns because they produce a high volume of warm dry air that helps coating flow and aids in drying. However, turbines have trouble generating air pressures above 7 psi. Therefore, production rates are low.

#### Ethan Allen Beecher Falls, Vermont

Beecher Falls replaced 25 conventional air spray guns with HVLP guns and realized a 39 percent reduction in the quantity of coating sprayed from the new guns. For a \$8,125 capital cost, more than \$145,000 in annual coating purchase costs was saved with a payback period of 3 weeks.

Source: The complete text of the Beecher Falls Case Study can be obtained from NEWMOA at (617) 367-8558.

If HVLP guns are replacing conventional air spray guns, air compressor equipment will already be available at the site, and its continued use can be more economical than purchasing a turbine system. An HVLP gun costs approximately \$300 to \$600, and a new pressure pot and turbine system costs \$1,000 to \$1,200.

HVLP spray guns have a TE of 40 to 60 percent in practice, reducing overspray. Therefore, HAP and VOC emissions substantially over conventional air spray guns. Less overspray decreases spray booth cleanup requirements, reducing the use of cleaning solvents and further reducing VOC and HAP emissions. There is less accumulation of lacquer dust, and filter replacement (or cleaning) and removal of the strippable spray booth lining is less frequent, reducing solid and/or hazardous waste generation. The lower pressure reduces coating “bounceback,” reducing operator exposure. The guns are portable and easy to clean. They provide good coverage and performance, and are good at penetrating recessed areas. Operators have good control over coating application from HVLP guns.

The main drawback to HVLP guns is that coating flow rates are not high so achieving a fast production rate is difficult. HVLP guns can only deliver up to approximately 16 to 20 ounces of liquid per minute. HVLP guns cannot spray high-solids coatings at ambient temperature. Heating is required to lower the viscosity. In-line electrical heating systems are available to heat high viscosity coatings to the proper temperature just before the coating reaches the gun. The HVLP spray gun tip and nozzle settings should be optimized for the coating to be sprayed. Because of their high TE, low cost and versatility, equipment suppliers recommend that manufacturers pilot test HVLP guns first before considering other types of higher TE spray guns.

## Airless Spray Gun

### **Ethan Allen Old Fort, North Carolina**

Old Fort replaced their conventional air spray guns with HVLP guns. TE was increased, reducing VOC emissions. Filter cleaning and replacement is less frequent, because overspray was reduced. For a \$3,000 investment, Old Fort realized \$15,000 to \$20,000 annual savings in coating material costs with a payback period of 2 ½ months.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

### **Henredon Furniture Morganton, North Carolina**

Henredon switched to HVLP spray guns for stain, sealer and topcoat application. The increased TE reduced VOC emissions by 63 tpy, and reduced annual coating material costs by \$120,000 with a payback period of 3½ months.

Source: D.B. Williams, “Incentives and Techniques for Pollution Prevention in Furniture Coating Operations,” presented at The Furniture Industry and the Environment, Hickory, NC, November 18, 1992.

### **Thomson Crown Mocksville, North Carolina**

Thomson Crown manufactures wood and wood-finish television cabinets. They had air-assisted airless spray guns using 55 psi of air pressure that produced a low TE. By switching to HVLP guns, equalizer, sap stain and toner use each dropped by 65 percent, and glaze and no-wipe penetrating stain use dropped by 35 percent. The upfront equipment cost of \$21,000 produced annual coating material savings of \$137,000 with a payback period of 2 months.

Source: *Pollution Prevention for the Wood Finishing Industry*, U.S. EPA/SEDESOL Pollution Prevention Workgroup, May 1994.

Airless spray guns atomize coating material by forcing it through a small opening with hydraulic pressure instead of air pressure. Hydraulic pressures are high in airless guns, between 500 and 4,500 psi. Airless guns have a high rate of paint flow, enabling high line speeds with fewer operator passes needed to achieve build. Airless guns can deliver up to 40 ounces of coating per minute and are particularly appropriate if thick finish coats are desired. The high flow rate produces a lower TE (i.e. 30 to 50 percent) when compared to other gun types. However, the high flow rate enables application of most coatings, including high viscosity coatings such as high-solids nitrocellulose, polyester or polyurethane coatings. Finally, the gun handles well, and operator mobility is improved because there is a coating line and no air line.

There are several drawbacks to airless technology. The greatest danger is severe operator injury from skin injection because of the high fluid pressures involved. Firms must maintain strict workplace safety procedures. OSHA requires that airless guns with pressures over 1,000 psi have tip guards to prevent injection. Maintenance of the application equipment is increased when operating at such high pressures. The high flow rate results in relatively poor coating atomization and reduced operator control over coating application. Coating bounceback is significant with airless application, further increasing employee exposure. The quality of the finish is lower than with other types of spray guns unless thick coats are desired. An airless gun costs approximately \$300, and the required hydraulic pump system is another \$2,500 to \$4,000.

### Air-assisted Airless Spray Gun

Air-assisted airless technology maintains the benefits of airless technology while reducing its drawbacks. A specialized fluid nozzle tip uses primarily hydraulic pressure to partially atomize the coating with air jets assisting in the atomization. The system can operate within the limits of HVLP, that is, less than 10 psi of air pressure. This pressure is supplemented with approximately 350 psi of fluid pressure. The lower hydraulic pressure is safer and generates less equipment wear than airless technology. When compared to airless technology, air-assisted airless guns produce less overspray and a better looking finish, particularly with thinner coats. Operator control over coating application is better than with airless guns, but less than with HVLP guns.

Air-assisted airless guns produce a TE of 45 to 60 percent and generate low coating bounceback when low air pressures are used (e.g. around 10 psi). If higher air pressures are used, the TE of air-assisted airless guns is lowered. Air-assisted airless guns produce good coating atomization and can apply fluids of varying viscosities. The main benefit of air-assisted airless guns over HVLP guns is that higher production rates are possible. Air-assisted airless guns can deliver up to 30 ounces of coating per minute, almost twice that of standard HVLP guns. However, like airless guns, there is a danger of skin injection, requiring operator training. In addition, air-assisted airless equipment is more expensive than HVLP. The guns cost \$600 to \$750 each, and the hydraulic and air pump system is \$2,500 to \$4,000. When HVLP guns will not perform well for a given situation, equipment manufacturers usually recommend testing air-assisted airless guns. Air-assisted airless guns can be the most appropriate option for spraying sealer and topcoats, and tend not to work as well with stains.

## Electrostatic Application

Electrostatic systems apply a negative charge to the coating as it is atomized. The furniture piece is grounded or given a positive charge. The negatively charged coating particles are strongly attracted to the furniture piece, increasing TE to between 60 and 80 percent. The charged particles tend to cover the sides of the item effectively, and particles that pass the item are attracted to its back.

Electrostatic systems can use electrostatic spray guns (i.e. modified conventional air, airless or air-assisted airless guns), or a rotary atomizer disc or bell system. In disc and bell application, the coating is accelerated by centrifugal force to the edge of a negatively charged rotating disc or bell-shaped nozzle. Disk and bell rotary atomizers are not hand-held. Therefore, automated application is required. In automated application, either all the pieces are the same size and shape, or a sophisticated computer operated system is used to detect changes in geometry. With spray guns, coating particles are given a negative charge by an electrode at the tip of the gun. Because of the enhanced TE, fewer passes with the spray gun are required to adequately coat the item, decreasing the time needed for that coating application and enabling high production rates.

Electrostatic application is not well suited for items that have recessed areas. Because of the Faraday cage effect<sup>74</sup>, particles will tend to congregate around the top of recessed areas, making manual non-electrostatic touchup necessary. However, this effect sometimes can be overcome by careful adjustment of electrostatic charge and spray velocity.

The main drawback to electrostatic application is that the piece of furniture must have a sufficient moisture content to carry an electrical charge. This usually requires pre-treatment of the piece with a fine water mist or a sensitizer solution that will attract humidity to the wood surface. Sensitizer solutions typically contain solvents and increase air emissions. Sensitizers do not work well when the humidity is less than 40 percent. Therefore, humidity control in the finishing room can be required. Other drawbacks are electrostatic spray gun equipment is bulkier to use and

### Sun Tui St. Paul, Minnesota

Sun Tui makes futon mattresses and frames. In an effort to reduce emissions and maintain a high production level and product quality, Sun Tui replaced their conventional air spray gun application of aqueous-based coatings with an automated electrostatic spray line. TE increased by 30 to 35 percent, and the final product quality is superior.

Frame parts proceed through the line on an overhead hook conveyor system that is grounded. Photosensors measure the length and width of the piece. A fine water atomized mist is sprayed on the furniture to make the surface more conductive. Computers control the operation of the electrostatic bells for optimum coating efficiency. The finish is cured in an infrared oven, and the process is repeated.

Source: "Futon Maker Plugs into Electrostatic Finishing System," *Wood & Wood Products*, January 1993.

<sup>74</sup> The Faraday cage effect is the tendency for electrostatic fields to distribute the charge over the outside surface of a hollow object. With recesses, coating particles will tend to congregate on the surface with few penetrating into the recess where the electrostatic field does not reach.

easier to damage than other types of spray equipment, the charging equipment presents a safety and fire hazard if not used properly, and the finishing room needs to be clean so that dirt particles are not attracted to the furniture piece. Electrostatic systems are expensive, with guns priced at approximately \$4,500 each and modified pressure pots at \$2,000 each. However, significant coating cost savings are associated with the high TE.

## Flatline Continuous Coating Systems

Flatline continuous coating systems are limited to coating flat pieces that are assembled after the parts are finished. Standard automated equipment accommodates pieces with widths up to 48 inches, but wider equipment can be custom-made. Pieces travel through the system on a conveyor and the coating is applied within an enclosure. Most flatline systems are continuous coaters, meaning that excess coating is collected within the enclosure and recycled, producing a TE of nearly 100 percent. In many automated systems, a drying oven follows the coating application enclosure. The coating application occurs inside a relatively confined structure, making the use of an emission control device such as thermal oxidation more economically feasible than it is with manual spray application. With an automated system, VOCs and HAPs are emitted into a much smaller quantity of air and production rates are higher, producing a more constant, higher concentration waste stream to be treated.

The four main types of flatline finishing systems are roll coating, vacuum coating, curtain coating and spray coating. All are automated systems. Therefore, line speeds can be high and labor requirements low. Automated systems are considered expensive, with the conveyor, application equipment, enclosure and coating reuse system costing approximately \$50,000 to \$100,000. A drying oven can cost another \$25,000 to \$40,000. However, considerable savings also can be associated with flatline systems because of the much higher TE (i.e. lower material use), lower labor requirements and faster production rates. Virtually all UV-cured coatings are applied using automated flatline systems. The UV lamps add additional costs to an automated system.

Manufacturers that are currently finishing flat pieces with a spray gun, or those that finish assembled furniture consisting mainly of flat pieces, might find flatline finishing to be an attractive method to reduce emissions, increase production rates and decrease finishing costs. The choice of flatline system depends on the type of coating to be applied, the physical characteristics of the piece and the desired finish quality. Table 3.4 provides a matrix of these attributes. More information about the four systems is provided in the subsections that follow.

**Table 3.4 Flatline Finishing System Strengths and Limitations**

Equipment	Coating Limitations	Physical Limitations	Finish Quality
<b>Roll</b>	High viscosity coatings best	Piece must be absolutely flat	Low
<b>Vacuum</b>	Not suitable for solvent-based coatings. Good for aqueous-based and UV.	Must have constant width and height dimensions. Can accommodate recesses.	Medium
<b>Curtain</b>	Can apply a wide range	Piece must be flat or slope outwards so coating cannot pond	Low to medium



<b>Spray</b>	High viscosity coatings difficult	Can accommodate items that are not flat, including recesses	Medium
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**Roll Coating:** Roll coating can apply high-solids coatings that are difficult to spray. Coating is continuously applied to the rollers to ensure uniform application. Coating can be applied to the top and bottom of a piece simultaneously. The main limitation is that roll coating cannot coat hard-to-reach surfaces, recessed areas or sides/edges. In other words, the piece must be absolutely flat. Another limitation is that the finish resulting from roll coating application is considered “low quality.” Roll coating often is used in low-end furniture to apply the simulated wood grain pattern.

**Vacuum Coating:** In vacuum coating, the enclosure contains the coating material and the openings on either side are just barely larger than the piece to be coated. The coating does not leave the chamber through the openings because of the vacuum within the enclosure. The piece is covered with coating on all sides as it passes through the enclosure. As it leaves, the excess coating is drawn off the piece by an air jet. Coating thickness is controlled by varying the coating’s viscosity, the magnitude of the vacuum and the air jet intensity. Because the enclosure openings need to be only slightly larger than the item, vacuum coating is limited to finishing pieces that are of a constant width and shape (i.e. only the length can vary). In addition, vacuum coating is not ideal for solvent-based coatings because the vacuum will prematurely draw off the solvents. Vacuum coating is well suited to aqueous-based and UV-cured coating application.

**Curtain Coating:** In curtain coating the flat item passes through a continuous “waterfall” of coating. Only the top and sides of an item are coated as it passes through the curtain. The piece needs to be flat or outwardly sloped so that coating does not pond in recesses. Curtain coating produces a better looking finish than roll coating, with uniform coating thickness possible. Application is difficult with high viscosity fluids.

**Spray Coating:** The main benefit of flatline spray coating systems is that the spray nozzles can be located such that edges and recesses can be finished. However, overspray can accumulate on the sides and top of the enclosure, reducing TE and requiring frequent filter replacement. Finish appearance is considered better than with roll, vacuum or curtain coating, but lower than with manual spray finishing.

## Dip Coating

Dip coating is not limited to flat pieces. In fact, dip coating is used widely to coat assembled chairs because of their shape and the excessive overspray generated from spray application. The only limitations are the size of the tank and the final appearance desired. Generally, dip coating produces a poor to fair quality final appearance. The appropriateness of dip coating depends on coating viscosity, and is most appropriate for low viscosity coatings such as stains. Excess coating is collected and reused; however, allowing the dipped item to drip slows production rates when compared to other flatline methods. Dip coating is not suitable for pieces with hollows or cavities because the coating can pond there. If solvent-based coatings are used, the coating tank emits VHAPs and VOCs when it is not covered (i.e. throughout the work day) and presents a fire hazard. Color change is slow unless multiple tanks are used. If solvent-based coatings are used, color changes also involve the use of solvents to clean the tank, increasing air emissions and

hazardous waste generation. Dip coating with solvent-based finishes generates significant VHAP and/or VOC emissions and is not a P2 alternative.

## 3.3 Gluing Operations

The wood furniture NESHAP contains provisions limiting the HAP content of contact adhesives. As discussed in Section 1.3.3, the manufacturer of kitchen cabinet countertops, store partitions and fixtures, and some other types of furniture applies a laminate to an MDF or particleboard core using contact adhesives. Contact adhesives also are used in upholstery operations to glue fabric to a wooden frame, and to hold the foam to the fabric. Traditionally, contact adhesives contain significant concentrations of solvents that are released to the environment when they are applied. The NESHAP requirements are presented in Section 3.3.1 and alternatives to traditional solvent-containing adhesives are discussed in Section 3.3.2.

### 3.3.1 NESHAP Requirements

The NESHAP contains emission limits for certain adhesives used in furniture manufacturing. The adhesive standard applies only to contact adhesives, that is, adhesives that bond without requiring clamping, pressure or airing. Glues used to aid in holding the structural pieces of furniture together (e.g. table legs to a table top) are not regulated by the NESHAP.

There are two options for complying with the adhesive emission limit: compliant adhesives or a control device. The control device must operate at an efficiency equivalent to emissions of no greater than 1.0 lb. VHAP/ lb. solids for existing sources and 0.2 lb. VHAP/ lb. solids for new sources. A control device might not be economically feasible because of the nature of adhesive application in furniture production (i.e. emissions into a large volume of air create a relatively dilute concentration for treatment). Therefore, most facilities probably will meet the emission standard using compliant adhesives.

Three criteria apply to the compliant adhesive approach. All limits are based on VHAP content, as applied:

1. For aerosol contact adhesives and contact adhesives applied to nonporous substrates (e.g. metal, rigid plastic, vinyl and rubber), there are no limits on the VHAP content.
2. For foam adhesives (i.e. adhesives used for upholstery operations to glue foam to foam, foam to fabric, or fabric to wood) that are used on products that meet flammability requirements for upholstered seating, the VHAP content must be 1.8 lb. VHAP/1.0 lb. solids or less for existing sources and 0.2 lb. VHAP/1.0 lb. solids or less for new sources.
3. For all other contact adhesives, including those used on products that do not meet flammability requirements, the maximum VHAP content is 1.0 lb. VHAP/1.0 lb. solids for existing sources and 0.2 lb. VHAP/1.0 lb. solids for new sources.

### 3.3.2 P2 Technologies

Four primary P2 options for contact adhesives are hot melt, heat seal, aqueous-based and PVA. Each of these are discussed in this section.

#### Hot Melt

Hot melt adhesives are 100 percent solids adhesives that cure when they cool. Hot melt adhesives are primarily used for edgbanding applications.<sup>75</sup> Polyurethane refractive (PUR) hot melts are a common wood furniture hot melt adhesive.

Hot melts will rewet when heated. As their name implies, hot melts are applied hot in a molten form. Hot melts are applied to a wide variety of laminates, typically using automated systems that both melt and apply the adhesive. For paper laminates, hot melt adhesive often is applied by the laminate manufacturer and is then heat activated during application to the substrate at the furniture manufacturing facility.

## Heat Seal

Heat seal adhesives generally are applied to the back of flexible laminates by the laminate manufacturer and then heat sealed with low temperature and pressure to panels by an automated roller or press system at the furniture manufacturer. Heat seal adhesives differ from hot melts in that they will not reflow if reheated. They can be used to laminate a wide variety of flexible overlays to substrates. Heat seal adhesives can be solvent or aqueous-based when applied by the laminate manufacturer. There might be little in the way of emissions at the furniture facility; however, emissions at the laminate manufacturer can be significant if solvent-based heat seal adhesives are used. To reduce emissions for the lifecycle of the product, the laminate manufacturer should use an aqueous-based system.

### **Haworth Holland, Michigan**

Haworth is a large manufacturer of all types of office furniture. Haworth switched to a two-component, aqueous-based, formaldehyde-free contact adhesive for the manufacture of fabric-wrapped flipper doors for overhead storage compartments. Haworth had to purchase new spray equipment to apply the two-part adhesive. The new adhesives instantly bond a variety of fabrics. Haworth believes the new adhesive system produces a more consistent quality product.

Drying ovens are no longer needed, and spray booth exhaust is now filtered and directed back into the plant. Combined, these greatly reduce utility requirements. In addition, removing ovens and exhaust stacks has freed up roughly 600 square feet of floor space and allowed easier layout changes.

The new system has many benefits. Haworth realized an 88 percent reduction in VOC emissions and a 33 percent reduction in adhesive use. Utility savings are estimated at \$16,000 per year. Quality improvements result in approximately \$18,000 in savings per year.

Source: "Solvent-Free Switch Yields Savings," *Upholstery Design & Manufacturing*, July 1996.

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<sup>75</sup> S. Razor, Memorandum to Madeleine Strum of U.S. EPA, Research Triangle Park, NC, November 9, 1994.

## Aqueous-based

Aqueous-based adhesives are used in both laminating and upholstery operations. Aqueous-based adhesives typically are applied with spray guns, either manually or with an automated system. Aqueous-based contact adhesives often are applied using conventional air spray guns; however, the use of HVLP guns can be appropriate and can increase TE, reducing material use and lowering air emissions.

Aqueous-based adhesives can take 30 minutes or more to adequately set before bonding of the laminate to the MDF substrate can occur, and 6 hours or more for a total cure time after bonding. However, some aqueous-based adhesives can set and cure in times comparable to solvent-based adhesives. To speed drying by removing condensed water from the adhesive coat after it is applied, a standard fan works better than compressed air.<sup>76</sup> Compressed air tends to dry the adhesive too quickly. As with aqueous-based coatings, the suitability of aqueous-based adhesives can vary widely among suppliers. Therefore, multiple vendors should be contacted to pilot test their material with the actual laminates and substrates used at the facility.

Some aqueous-based adhesives are urea-formaldehyde resin systems. As discussed in Section 1.3.3, urea-formaldehyde resin adhesives emit the formaldehyde, a VHAP, that is not bound in the adhesive during curing. Adhesives with lower free formaldehyde contents are available, or the use of one of the other contact adhesives discussed in this section might be possible.

## Polyvinyl Acetate (PVA)

PVA glues are aqueous-based synthetic latex systems. The vinyl acetate monomer is a VHAP; however, it makes up less than 0.4 percent of the adhesive, so emissions are

### **Hussey Seating North Berwick, Maine**

Hussey uses adhesives to aid in attaching fabric to chair seats and backs during the upholstery operation. Hussey also makes wooden seats and backs by gluing several thin pieces of wood together. Traditionally, all of the adhesives used at the facility were solvent-based. These contributed to Hussey's VOC and HAP emissions, as well as potential air quality problems within the plant.

In 1995, Hussey switched all of the adhesives used at the plant to PVA glues. No air emission or safety concerns are associated with the new adhesives. In addition, the glue manufacturer takes back all the waste glue and cleanup rinse water to use in their production process. Therefore, Hussey no longer has any glue or rinse wastewater disposal issues or costs.

Source: The complete text of the Hussey Seating Case Study can be obtained from NEWMOA at (617) 367-8558.

<sup>76</sup> "Waterbased Products Meet Tough Regulations," *Furniture Design & Manufacturing*, September 1996.

low.<sup>77</sup> PVA is similar to the white glue used by children and is often applied using a squeeze bottle-type applicator rather than a spray gun. PVA adhesives are widely used in furniture assembly, but their use in veneering and laminating is increasing.

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<sup>77</sup> S. Rasor, Memorandum to Madeleine Strum of U.S. EPA, Research Triangle Park, NC, November 9, 1994.

## 3.4 Cleaning Operations

Approximately 10 percent of the solvent emissions from a wood furniture finishing facility are generated during the various cleaning operations associated with wood finishing. In addition, spent solvents are considered a hazardous waste. Therefore, their storage, transport and disposal are regulated, requiring extensive paperwork and expense. Off-site treatment or disposal of wastes creates an ever-present potential liability for environmental problems that can develop at the treatment, storage or disposal facility (TSDF).

In an effort to reduce solvent use and subsequent emissions from cleaning operations, the U.S. EPA has included five cleaning-related requirements in the work practice standard part of the NESHAP: a solvent accounting system, chemical composition restrictions, and spray booth, gun and line cleaning procedure restrictions. The NESHAP also contains an emission limit for the material applied as a strippable coating for spray booths. All of these cleaning-related standards can be considered pollution prevention efforts. In addition to the standards in the NESHAP, Section 3.4.2 describes several other pollution prevention opportunities related to cleaning such as the use of automatic spray gun cleaners.

### 3.4.1 NESHAP Requirements

In the work practice standards, the five elements to the cleaning operation standards are development of a solvent accounting system, solvent chemical composition and spray booth cleaning restrictions, and line and gun cleaning. There is also one emission limit that applies to cleaning of spray booths. The following list presents each of these cleaning-related standards. The requirements are the same for both existing and new sources:

#### Cleaning-Related Standards

- C solvent accounting system
- C chemical composition restrictions
- C strippable spray booth material VOC content restrictions
- C spray booth, gun and line cleaning procedure restrictions

1. At many facilities, management is not aware of the amount of solvent used or waste generated. The NESHAP requires the development of a organic solvent accounting system to raise awareness of solvent use, and encourage minimization efforts. A solvent accounting form must be developed and record these items:

- i. type and quantity of organic solvent used each month for washoff and cleaning
- ii. number of pieces washed off, and the reason for the washoff
- iii. quantity of spent solvent generated each month and how it is handled (e.g. recycled on site, recycled off site or disposed off site)

All completed solvent accounting forms are to be kept with the work practice implementation plan described in Section 1.4.2.

2. The NESHAP also contains chemical composition restrictions for the solvents used for cleaning and washoff. Solvents containing any of the pollutants listed in Appendix D, Table D-3

cannot be used if the concentration of a listed pollutant is high enough to require MSDS reporting under OSHA.

3. The NESHAP restricts the VOC content of solvents used to clean spray booth components to 8 percent or less by weight. If solvent is used for cleaning conveyors, continuous coaters and their enclosures, or metal filters, there is no restriction on VOC content. If the spray booth is being refurbished (i.e. replacement of the spray booth coating layer), then the standard requires that no more than 1.0 gallon of organic solvent can be used per booth.
4. Lines that supply the finishing material to the spray guns typically are flushed out with solvent when there is a change of coating type or color. The line cleaning standard is simply that all organic solvent that is used to clean lines is to be pumped or drained into a container that is closed when not in use.
5. Spray guns typically are cleaned at the end of each work day to prevent residual coating from drying and clogging the gun. The NESHAP requires that all gun cleaning organic solvents are collected and stored in a container that is closed when not in use.

There is also a cleaning-related emission standard that pertains to the strippable spray booth material, that is, the material used to line spray booth surfaces to make it easier to remove overspray and clean. The NESHAP requires that spray booth coating can contain no more than 0.8 lb. VOC/ lb. solids, as applied.

### 3.4.2 P2 Technologies

The NESHAP covers many of the P2 opportunities available for cleaning. A written accounting of solvent use can make users more aware of consumption behaviors and provides information to management to target wasteful practices. The chemical composition restrictions, aimed primarily at the traditional use of methylene chloride for washoff, will promote substitution of less-hazardous chemicals. Requiring that all solvents used for gun and line cleaning be collected in a container that is covered when not in use will likely reduce a substantial source of fugitive emissions. Instead of discharging line cleaning solvents into the air, operators will have to collect them, perhaps lowering solvent use and certainly solvent emissions. Gun cleaning typically is performed by taking the gun apart and soaking the pieces in a bucket of solvent. By keeping the bucket covered, evaporative emissions will be reduced. There are a couple of additional gun/line cleaning-related P2 activities that can be implemented to reduce air emissions, which are presented in the subsection below.

The NESHAP also contains two P2 activities related to spray booth cleaning. Restrictions are placed on the VOC content of solvents used for spray booth cleaning, promoting the use of cleaning materials that will generate lower air emissions. Restricting the quantity of solvents that can be used will reduce waste and emissions. Finally, requiring a low VOC content in the strippable spray booth coating that is sprayed on the booth ensures emission reductions and encourages facilities to switch to an aqueous-based coating. There are several other P2 measures related to spray booth cleaning that should be considered, mainly to reduce solid and hazardous waste generation. These are discussed further in Section 3.6, Housekeeping.

#### Gun/Line Cleaning



If guns and lines are used for more than one color of coating, production should be planned such that lighter colors are applied first, and darker colors are applied next. This eliminates the need to use solvents to clean out the line between each color change. The line simply is flushed with the darker color. To reduce coating waste and associated emissions when changing coating type or color or at the end of the day, operators can back-flush coating from the line into the pressure pot/tank by bleeding the tank pressure, putting a rag over the air cap and pulling the trigger.<sup>78</sup> This will reduce the quantity of coating that needs to be flushed from the line at the beginning of the day or for a coating type or color change.

Another recommended P2 option is the use of an automatic gun washer. Rather than having the operator take apart the gun, soak it and wipe it clean, the fully assembled gun can be placed in the gun washer. There are numerous benefits to using a gun washer. Gun washers are fully enclosed, greatly reducing solvent emissions and operator exposure. Reducing solvent evaporation conserves solvent, lowering solvent use for gun cleaning by approximately 50 percent.<sup>79</sup>

In addition, because gun teardown typically is not required, gun cleaning requires much less operator time, adding to the savings.

Typically, a facility will have one centrally located gun washer or, if it is a large plant, perhaps one for each major coating function. Because gun washing is centrally located, versus a bucket at each operator's station, the system lends itself more easily to solvent recycling. Solvent recycling is a money-saving waste management practice that is discussed further in the Section 3.6, Housekeeping. A gun washer that cleans four guns at a time costs approximately \$1,000.

Automatic gun washer benefits include:

- ∩ reduce solvent emissions and operator exposure
- ∩ reduce solvent use by up to 50 percent
- ∩ less operator time

### 3.5 Operator Training

Operator training can significantly reduce the quantity of coating used and the quantity of air emissions. Therefore it is a form of pollution prevention. A test comparing TE between a novice and experienced operator and between types of spray guns found that "...the differences in transfer efficiency due to painter skill level with a single gun type were often larger than differences between gun types."<sup>80</sup> For example, an experienced operator (i.e greater than 10 years of experience) using an HVLP gun had a TE of approximately 35 percent, whereas an inexperienced operator (less than 1 year of experience) spraying the same material on the same object with the

<sup>78</sup> J. Bransfield, "Back to Basics Seminar," Norris-Wiener Spray Finishing Supply, Billerica, MA.

<sup>79</sup> Graco, Inc of Golden Valley, MN, presentation materials from "Wood Finishing Technology Update," Vermont Technical College, Randolph, VT, June 14, 1996.

<sup>80</sup> L. Snowden-Swan, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992, page 6.

same gun had a TE of approximately 18 percent.<sup>81</sup> Other parameter configurations (e.g. coating type, gun type and target geometry) generally produced less dramatic differences; however, in 90 percent of the tests performed, the experienced operator produced a noticeably increased TE over that of the inexperienced operator.

Spray gun operators control many of the factors that affect TE, including coating flow rate and pressure, air flow pressure and velocity, distance between spray gun and object, width of spray pattern, and how neat or sloppy the application is. In addition, operators typically perform their own line, gun and spray booth cleaning. Therefore, the level of training an operator receives regarding proper application technique and equipment settings can have a significant impact on the quantity of material used to coat a given item and the quantity of cleaning solvent used. Recognizing the significance of the operator, the NESHAP requires that all facilities develop a formal operator training program.

Spray gun operators control many of the factors that affect TE, including:

- Ⓒ coating flow rate and pressure
- Ⓒ distance between spray gun and object
- Ⓒ width of spray pattern
- Ⓒ how neat the application is

### 3.5.1 NESHAP Requirements

The NESHAP requires that facilities develop a formal operator training program. All existing employees who are involved with finishing, gluing, cleaning and washoff operations or who use manufacturing equipment as well as those responsible for implementation of the NESHAP, must be trained within 6 months of the applicable compliance date for the facility (i.e. May 21, 1998, for sources emitting more than 50 tons in 1996 or June 7, 1999, for sources emitting less than 50 tons). New facilities (i.e. those constructed after December 6, 1994) must train all applicable employees upon startup. All new employees must be trained upon hire. Refresher training is required for all applicable employees annually. At a minimum, the training program must contain these elements:

1. List of all current personnel required to be trained, including name and job title
2. Outline of subjects to be covered in initial and refresher training
3. Lesson plans for courses covering application techniques, cleaning and washoff procedures, equipment setup and adjustment, and management of wastes
4. Methods to demonstrate and document completion of training

The training program and related documents are to be kept with the work practice implementation plan discussed in Section 1.4.2.

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<sup>81</sup> L. Snowden-Swan, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992.

### 3.5.2 P2 Opportunities

Operators can adjust the settings on spray guns often in ways that lower TE and increase overspray. If the operator does not believe that he/she can get the proper fluid flow from the gun, it is more efficient to change the gun tip and nozzle size rather than increasing the air and/or fluid pressure. Higher pressure can produce a finer mist and increase coating velocity; however, it also increases coating bounce-back and decreases TE. Therefore, air and/or fluid pressures should be kept as low as possible, and the pressure should be set at the pressure tank, rather than by adjusting the gun.<sup>82</sup>

The fan pattern should be adjusted for the geometry of the target with narrow fan patterns for narrow items and wider patterns for larger objects. Operators should release the gun trigger at the end of each stroke, rather than leave the gun spraying until the item is fully coated as is often done. Operators should use their legs and entire arm and shoulder during each stroke and avoid arching or tilting the gun. Finally, the distance from the spray gun nozzle to the item being sprayed should be approximately 8 inches, which is less than commonly is observed.

At each spray booth, the most appropriate equipment settings and spray technique parameters for each spray gun and for each coating combination should be identified and agreed upon by the operator. These agreed upon parameters should be written down and posted at the spray booth for easy operator reference and for quick confirmation of proper application by supervisors.<sup>83</sup> Good operator spray techniques are:<sup>84</sup>

- Ⓒ hold spray gun perpendicular to the surface of the part being sprayed
- Ⓒ trigger the gun slightly before and after each pass
- Ⓒ overlap each stroke by 50 percent
- Ⓒ maintain a constant distance between the gun tip and the part
- Ⓒ spray with a suitable speed

#### **Ethan Allen Old Fort, North Carolina**

Traditionally, spray gun operators were trained on-the-job by a co-worker. Old Fort reevaluated this approach and implemented a more formal training program that includes using video equipment to tape each operator's technique. After taping, the operators meet in small groups with a coating technique expert to discuss possible improvements. The operators then are retaped, and the before and after techniques compared. Old Fort recommends holding the training program twice each year.

Benefits of the formal training program include reduced overspray, material use and air emissions, and a higher quality finish. Material use was reduced by 8 to 10 percent for an annual savings of \$50,000 to \$70,000.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

<sup>82</sup> J. Bransfield, "Back to Basics Seminar," Norris-Wiener Spray Finishing Supply, Billerica, MA.

<sup>83</sup> Ibid.

<sup>84</sup> P. Pagel, "Reduce Costs of Finishing Operations by Empowering Spray Operators," *MnTAP Source*, Summer 1996.

- C adjust the air and fluid pressures and select the correct tip size for the coating and gun used

Training might not produce optimal results if management does not monitor and encourage proper technique on an ongoing basis. The NESHAP requires annual retraining; however, facilities might want to repeat the training more often. Equipment suppliers can be helpful in providing training materials and should be used to the fullest extent possible.

At each spray booth, the most appropriate equipment settings and spray technique parameters should be identified, agreed upon by the operator, and written down and posted at the spray booth for easy reference.

## 3.6 Housekeeping

The benefits of improved housekeeping can be difficult to quantify, but simple housekeeping improvements can provide low-to no-cost opportunities for reducing waste and emissions. Preventive maintenance and proper equipment and materials management can ensure that equipment is operating as efficiently as possible, and also can minimize opportunities for leaks, spills, evaporative losses and other releases of potentially toxic chemicals. The NESHAP contains three requirements relating to housekeeping as summarized in the next section.

### 3.6.1 NESHAP Requirements

The NESHAP work practice standard requires facilities to implement a formal leak detection and repair program, and keep washoff and liquid storage containers covered. Each of these requirements are described below.

The NESHAP requires implementation of a formal leak detection and repair program, including the development of a written plan and record keeping to document compliance. The leak detection and repair plan is to be kept with the work practice implementation plan described in Section 1.4.2. At a minimum, the leak detection and repair plan must contain these elements:

1. A visual inspection schedule with a minimum inspection frequency of 1 month
2. Methods to document the date and results of each inspection
3. The timeframe between identifying a leak and its repair with the following minimum requirements:
  - i. The first attempt at a repair is to be made within 5 calendar days of leak identification
  - ii. Final repairs are to be completed within 15 calendar days of leak detection, unless it requires purchase of new equipment in which case, 3 months is allowed

The standard relating to washoff states simply that tanks used for washoff must be covered when not in use. Also, dripping should be minimized by tilting or rotating the item so that the solvent drains back into tank. The work practice standard covering storage requires that the materials used for finishing, gluing, cleaning and washoff be stored in containers that normally are kept closed when not in use.

### 3.6.2 P2 and Recycling Technologies

Inspecting tanks and pipes for leaks can lead to immediate reductions in air emissions and material use at little or no cost. Frequent inspections can identify problems before they become significant. A facility should inspect material storage and finishing areas regularly to identify leaks in storage containers, piping systems and application equipment. Implementation of a leak prevention program can increase up-front labor costs but reduce long-term risk and costs. A facility can reduce emissions and waste in several ways in addition to leak detection and repair: developing spill prevention and cleanup procedures; controlling the purchasing and handling of raw materials; recycling cleaning solvents, lacquer dust and rags; and simply covering all volatile liquids whenever possible.

#### Spill Prevention

Spills can be reduced by training personnel in improved material handling and spill prevention methods. Training should include how to use spouts and funnels during coating transfer to pressure pots; proper procedures for mixing coatings; proper liquid levels and coating drip methods for dip coating and washoff tanks to reduce overflow and excess dripping; and proper use of rags, mops or absorbents to clean up spills.

#### Purchasing and Handling of Raw Materials

Controlling the purchasing and handling of materials can reduce waste generation significantly. Many companies allow their operators to enter the materials storage area and take the supplies that they need, often relying on the operator to log out the material. However, this is not always done reliably. One fine furniture manufacturer decided to put a lock on the storage room door and assign one person the responsibility of retrieving needed materials and maintaining the use log.<sup>85</sup> This company found that they now have useful data to identify areas where material is being used wastefully. Consequently, operators are more conscientious of how they are using the materials.

Coatings that have passed their expiration date become a waste and should not be used. Therefore, facilities should purchase coatings in as small a quantity as practical to avoid exceeding expiration dates. Facilities should label materials with shelf life dates and have a first-in, first-out policy to ensure that they have not degraded. Finally, management should work with suppliers to take back off-spec and empty containers.

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<sup>85</sup> R. Tivnan, "Nichols & Stone: One Firm's Experience," *TURP Talk*.

## Solvent Recycling

Several sources of solid and hazardous waste are associated with the various cleaning operations that occur in the finishing room. Spent cleaning solvents are generated from gun and line cleaning, and spray booth cleaning. The U.S. EPA and the states classify spent solvents as a hazardous waste. A solvent distillation unit allows reuse of spent solvents and can prove economical.<sup>86</sup> Solvent recycling lowers virgin solvent purchase costs and hazardous waste disposal costs for spent solvents.

## Lacquer Dust Recycling

Sealer and topcoat applications generate substantial quantities of nitrocellulose lacquer dust. Because of its flammability, lacquer dust is a hazardous waste. Lacquer dust accumulates on spray booth filters as well as all over the floor and other surfaces in the spray booth. This accumulated dust presents a fire hazard and needs to be removed every day to the extent possible. Rather than just disposing of the dust, screen separate impurities from the lacquer dust and add solvents to reformulate a topcoat material. This coating material might not be acceptable for use over fine finishes, but can be used to coat other surfaces such as the inside of drawers, the underside of tables or the backs of bookcases. The savings from reduced hazardous waste disposal combined with reduced virgin material requirements can make lacquer dust recycling economical.

### **Ethan Allen Old Fort, North Carolina**

A 7-gallon batch distillation unit was installed at a cost of \$4,500. The still recovers 5 gallons of useable solvent from each 7-gallon batch. This has reduced the quantity of hazardous waste requiring disposal by 1,900 pounds per year. Old Fort estimates an annual savings of \$3,200 for a payback period of less than 18 months.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

### **Ethan Allen Beecher Falls, Vermont**

Beecher Falls brushes the metal filters in sealer and topcoat spray booths at the end of each day to collect lacquer dust. Lacquer dust also is collected from the spray booth floor. After screen separation, solvent is added to make a topcoat material that is used to coat the interior of drawers and the backs of items.

Beecher Falls uses approximately three 55-gallon drums of reclaimed lacquer dust each week, diverting them from disposal. Including the avoided cost of disposal, the 3 to 4 hours of labor spent on the reclamation effort each day and the cost of the solvent used for reconstitution, Beecher Falls estimates that it costs them approximately \$4 per gallon to reclaim their lacquer dust, much less than the cost of purchasing new sealer or topcoat.

Source: The complete text of the Beecher Falls Case Study can be obtained from NEWMOA at (617) 367-8558.

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<sup>86</sup> Some states regulate on-site recycling of solvents. Contact the facility's permitting authority to determine any restrictions.

## Metal Filters

Disposable paper, polystyrene or polyester spray booth filters can be replaced with metal filters. The main drawback is that solvents are needed to clean the metal filters, increasing air emissions and spent solvent generation. Metal filters should not be cleaned by spraying solvent, but rather by soaking in an enclosed container. The elimination of new disposable filter purchase costs and the reduction of used filter disposal costs should be evaluated against the costs associated with increased solvent use and the one-time purchase cost of the metal filters.

## Other Substitutions

Polyethylene can be substituted for cardboard on pallets to catch dripping and overspray underneath the pieces of furniture as they travel through the plant on the conveyor. Dried overspray can be peeled off the polyethylene so only the overspray is disposed. The disposal volume added by the cardboard is eliminated. Absorbent materials used to prevent liquid overspray from running out of the spray booth can be replaced with a polyethylene-lined trough fabricated to collect the overspray. Waste volume reduction is substantial with only the collected liquid drummed for disposal.

### **Ethan Allen Old Fort, North Carolina**

Old Fort replaced all their paper filters with metal filters. Lacquer dust is brushed off the filters and sent off site for recycling into topcoat material. The metal filters then are cleaned in a tank where solvent is circulated with a diaphragm pump. The solvent/coating mixture is distilled so the solvent can be reused and only the waste coating is drummed for disposal.

The investment in metal filters was \$57,000 and saves Old Fort \$48,125 per year. Recycling lacquer dust required an investment of \$1,500, but saves more than \$6,150 each year.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.

### **Ethan Allen Old Fort, North Carolina**

Old Fort replaced cardboard pallet covers with polyethylene and replaced the absorbent and wood shavings used in spray booths with a sloped polyethylene-lined trough. Investing in polyethylene pallet covers cost \$2,050 and saves \$7,450 in disposal costs each year. The polyethylene trough was fabricated on site for only \$400 and saves Old Fort \$38,430 in disposal costs each year.

Source: Case Study: Ethan Allen, Inc., North Carolina Waste Reduction Resource Center, December 1993.





## CHAPTER 4: CONCLUSIONS

The wood furniture manufacturing industry traditionally has been a significant source of VHAPs and VOCs. Therefore, each of the Northeast states have regulated the wood furniture industry in some capacity in the past. Recently, the U.S. EPA issued new regulations that are different than the existing state regulations. This Manual details the requirements of the new wood furniture NESHAP and presents an overview of the new wood furniture CTG. Both of these federal requirements recognize that an add-on equipment pollution control strategy is not technically or economically feasible for most sources in the wood furniture industry, emphasizing a pollution prevention approach instead. The purpose of this Manual is to promote the maximum emission reductions possible by presenting the many P2 options available and to illustrate the benefits of P2 to wood furniture manufacturers and those who regulate them.

The new wood furniture NESHAP and CTG require that manufacturers that are major sources of air emissions reduce emissions from their coating operations and implement numerous work practice standards. These new rules can provide a catalyst for manufacturers to make some positive changes to their operations. Reducing air emissions improves the environment both inside and outside of the plant. Environmental improvement combined with efficiency improvements and cost savings is an ideal “win - win” situation for a company. As this Manual illustrates, wood furniture manufacturers of all sizes can implement numerous “win - win” P2 projects.

### **Pollution Prevention Benefits**

A pollution prevention project or group of projects can lower VHAP and/or VOC emissions, facilitate compliance with the NESHAP and CTG, and benefit public health and the environment. Improved working conditions within the facility can translate into increased employee productivity and company loyalty. This Manual demonstrates several other important themes about pollution prevention.

#### Cost Savings

Pollution prevention projects often can save a furniture manufacturer money over time by:

- Ⓒ reducing coating and/or solvent use
- Ⓒ improving productivity
- Ⓒ reducing permit fees and record keeping and reporting burdens
- Ⓒ reducing insurance premiums
- Ⓒ reducing or eliminating waste treatment and/or disposal costs

#### Increased Efficiency

Pollution prevention projects improve process efficiency and product quality. Therefore, P2 should be integral to all of the strategies that businesses implement to stay competitive such as continuous improvement programs.

### Reduced Regulatory Burden

A pollution prevention project or group of projects might lower VHAP and/or VOC emissions to levels where NESHAP, CTG and/or other state requirements no longer apply. Emission reductions must occur before the facility's NESHAP and/or CTG compliance date in order for the facility to be exempt from the federal requirements.<sup>87</sup> Manufacturers of all sizes should keep the proper records to demonstrate that the regulation does not apply. In addition, a facility might lower the use of VHAPs and other volatile chemicals such that future regulatory changes will not affect their operations.

### Qualitative Benefits

There are also many less quantifiable benefits from pollution prevention projects that can become real economic benefits such as:

- C improved employee health and safety
- C reduced long-term liability associated with hazardous material storage, use and disposal
- C improved public image
- C reduced regulatory headaches
- C "green" marketing potential

### **Technical Recommendations**

The case studies in Chapter 3, Pollution Prevention Opportunities, illustrate the numerous ways that pollution prevention projects can save a company substantial amounts of money, increase process efficiency, improve product quality and reduce air emissions. Some of the cases describe projects that required an upfront investment, but payback periods are typically short, sometimes only weeks and often less than 2 years. The primary technical recommendations are:

#### Partnering with Vendors

Partnering with coating and equipment vendors is essential when making changes. Multiple vendors should be contacted to ensure that the best system is found in terms of product quality, VHAP and VOC reductions, and capital and operating costs. The style of furniture, the type of wood used and the finish appearance differs among manufacturers so changes that work for one furniture manufacturer might not produce an acceptable finish at another facility. Facilities should look for vendors that are willing to work toward their particular goals.

#### Resist Solvent-based Reformulation

Because of the numerous benefits associated with low- or non-solvent based coatings, manufacturers should use them, and resist reformulating coatings using non-HAP and/or non-VOC solvents such as acetone. There are many drawbacks to acetone use, including increased volatility and flammability, and potential health effects to employees. Generally, alternative coatings do not have these problems and their use is associated with better working conditions for employees, and a lower risk of explosion and fire.

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<sup>87</sup> The U.S. EPA "once in, always in" policy is subject to change. Contact the state permitting authority for the current policy.

### Evaluate Today's Alternative Coatings

The finish appearance of alternative coatings, such as aqueous-based and UV-cured, has improved in recent years. Furniture manufacturers should evaluate today's alternative coatings. Firms should not rely on past negative experiences with alternative coatings or anecdotes about another firm's past negative experiences. Newer alternative coatings not only can produce a high quality finish and improve the work environment within the facility, but also might reduce air emissions to below regulated levels and save the facility money.

### Increase Application Equipment Transfer Efficiency

Application equipment has a large impact on TE and the amount of coating used, and on air emissions and solid and/or hazardous waste generation. Low TE equipment (i.e. conventional air spray and most airless guns) wastes 70 to 80 percent of the coating sprayed and should be replaced. HVLP guns can apply a wide range of coatings, and are relatively inexpensive, paying for themselves often in a few weeks or months because of reduced coating use. If HVLP guns cannot keep up with the production rate, low air pressure air-assisted airless guns are an effective alternative. If possible, firms should switch to a continuous coating (i.e. automated flatline) system with a TE of nearly 100 percent.

### Operator Training

Operator skill also can significantly affect TE in practice. An annual operator training program is required under the NESHAP. A semi-annual program can be even more beneficial because maintaining the highest possible TE saves money by minimizing coating costs.

### Efficiency Improvements

For manufacturers that continue to use solvent-based coatings, many other efficiency improvements can be made that save money and help reduce air emissions:

- C use an automated gun washer
- C replace disposable filters with metal filters and wash metal filters in an covered enclosure
- C recycle solvents on site using a small distillation unit
- C collect lacquer dust and reconstitute a finish to use on less critical surfaces such as inside drawers
- C replace cardboard pallet covers with polyethylene

There are numerous options to improve air quality and comply with the NESHAP and CTG that also save money through reduced virgin material use, increased production efficiency, reduced regulatory burden and/or improved product quality. Manufacturers should take advantage of as many of the ideas presented in this Manual as is feasible. In addition to current vendors, numerous outside resources, including those listed in Appendix E, can be used to obtain information, evaluate alternatives and implement options.

# APPENDIX A

## History of the Clean Air Act Amendments of 1990

The first federal law governing air pollution, the Air Pollution Control Act, was enacted in 1955. At the time, Congressional sentiment was that local and state governments should be responsible for ensuring air quality. However, Congress recognized a role for the federal government in supporting research and training, both on the causes and effects of air pollution as well as methods of air pollution control. By the early 1960s the public recognized that the automobile was a significant source of air pollution. In 1962, Congress amended the Act to require the Surgeon General to study the effects of motor vehicle exhaust on health. In 1963, the Clean Air Act (CAA) was passed. The original CAA encouraged the automotive and fuel industries to work toward preventing air pollution. The 1963 CAA also required the development of air quality criteria for use in setting air quality and emission standards. The 1963 Act also stipulated that the federal government could intervene in interstate conflicts.

In 1967, the Air Quality Act was passed. The 1967 Act required state and local agencies to develop air quality standards within a fixed timeframe. The 1967 Act required development of air quality criteria for specific pollutants upon which to base the air quality standards. The 1967 Act authorized the federal government to set the standards themselves if the state or local agency did not act within the required timeframe. The 1967 Act also designated the establishment of interstate or intrastate air quality control regions with each region to determine the nature and extent of its air quality problems. Finally, the 1967 Act required the development of recommended air pollution control techniques.

The main precursor to the current Clean Air Act was the Clean Air Amendments Act passed by Congress in 1970. The 1970 Act established national, as opposed to state or local, ambient air quality standards (NAAQS) and also contained deadlines for compliance. NAAQSs were set for six "criteria" pollutants: carbon monoxide, hydrocarbons, nitrogen dioxide, photochemical oxidants, particulate matter and sulfur dioxide. In 1976 lead was added, and in 1979 ground-level ozone replaced photochemical oxidants. The 1970 Act also required EPA to list each HAP that was likely to cause an increase in deaths or serious illness, and then establish NESHAPs for sources of each listed HAP. The NESHAPs applied to both new and existing sources. The 1970 Act also established performance standards for new stationary sources of air pollution, requirements that industry monitor emissions and maintain records available for inspection on demand, fines and criminal penalties for violations, standards for automobile and aircraft emissions and provisions for citizens to bring suit "against any person, including the United States, alleged to be in violation of emission standards or an order issued by the [EPA] administrator."<sup>88</sup> The states were responsible for meeting the requirements of the 1970 Act and developing a state implementation plan (SIP) for approval by the EPA.

The CAA was amended again in 1977. The main addition was the requirement that states that did not meet all the NAAQSs develop plans known as new source review (NSR) requirements. For areas that had met or exceeded the NAAQS, the SIP had to ensure that there was no significant

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<sup>88</sup> K. Wark and C. Warner, *Air Pollution, Its Origin and Control*, Harper & Row, Publishers, 1981, p. 48.

deterioration of air quality, or prevention of significant deterioration (PSD). Therefore, since the 1977 Act all new sources of air pollution or major modifications of existing sources have to undergo a preconstruction approval process; NSR for facilities in non-attainment areas and PSD for those in attainment areas.

By 1990, many cities in the United States still did not meet the criteria pollutant NAAQSs that were established by the 1970 Act. For example, 96 cities had not attained the national standard for ground-level ozone, 72 had not attained the particulate standard and 41 did not meet the carbon monoxide standard.<sup>89</sup> The 1970 Act also stipulated the development of HAP standards using risk-based analysis. Setting risk-based standards created significant controversy and led to legal challenges. In the first 20 years of the air quality program, the EPA only established air emission standards for seven HAPs: asbestos, benzene, beryllium, inorganic arsenic, mercury, radionuclides and vinyl chloride.

Prior to the Bush administration Congress made some attempts to amend the CAA, but the White House was solidly opposed to any legislation that would strengthen the CAA or add any provisions to control acid rain. However, by the 1988 presidential election, the public was very concerned about the environment and the effects of pollution on health. In addition, by the late 1980s the regional and global problems of acid rain deposition and the depletion of the atmospheric ozone layer also had surfaced and Canada was pressuring the United States to take measures to curb acid rain. Facing the twin realities that the goals of NAAQS and HAP programs were not being met, President Bush proposed legislation to redesign the CAA, which Congress began to debate in 1989. Although Congress could not come to agreement in 1989, all of these forces aligned to prevail in 1990, and President Bush signed the new Clean Air Act Amendments (CAAA) on November 15, 1990. A general description of the requirements of the 1990 CAAA is presented in the following section.

## General Requirements of the Clean Air Act Amendments of 1990

The Clean Air Act Amendments of 1990 (CAAA) direct the EPA to establish national ambient air standards and to establish programs to achieve the standards. The CAAA consists of the following eleven Titles:

Title I: Establishes NAAQS for the criteria pollutants: ground-level ozone, particulates, carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. Geographic areas that meet NAAQS are classified as "attainment" areas, whereas areas that do not are classified as "non-attainment" areas. Non-attainment areas for ozone are further classified as extreme, severe, serious, moderate and marginal depending on the degree of non-compliance. Each state must develop a SIP that determines the major sources of pollutants and describes the measures that will be taken to bring non-attainment areas into attainment. Title I also contains the NSR and PSD provisions, which are emission standards for new stationary sources within specific industrial categories.

A major component of the ground-level ozone control strategy is the reduction in VOC emissions. The VOC limitation requirements of the Title I program apply to non-

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<sup>89</sup> Reilly, William K. "The New Clean Air Act: An Environmental Milestone," *EPA Journal*, January/February 1991.

attainment areas. With the exception of Vermont, all of the Northeast states contain areas that are classified as in non-attainment. The entire area of the states of Connecticut, Massachusetts, New Jersey, and Rhode Island are non-attainment areas, as well as the coastal portion of Maine, the southern portion of New Hampshire and the metropolitan New York City portion of New York. All of the Northeast states also are part of U.S. EPA's designated Ozone Transport Region. This region also contains the states of Pennsylvania, Delaware and Maryland, as well as the Washington, DC metropolitan area. All areas in the Ozone Transport Region, even those designated as being in attainment, are subject to many of the same requirements as non-attainment areas.

Title II: Covers mobile sources of pollutants such as cars, trucks and airplanes. Title II sets vehicle emission standards and requires items such as reformulated gasoline and emission control devices depending upon attainment status.

Title III: The requirements of Title III amend the NESHAP program, section 112, in Title I of the 1970 CAA. Under Title III, EPA is required to regulate emissions of 189 listed toxic air pollutants<sup>90</sup> by focusing on industries that are major sources of the listed pollutants. A list of source categories to be regulated was to be published by November 15, 1991. Standards for 25 percent of the listed industries were to be promulgated by November 15, 1994, another 25 percent by November 15, 1997, and the remaining 50 percent by November 15, 2000.

On July 16, 1992, EPA published a list of 174 industry source categories to be regulated.<sup>91</sup> The CAAA requires that the EPA develop NESHAPs for each source category. Each source category NESHAP specifies emission control measures, known as maximum achievable control technology (MACT), that industry must implement. For existing sources, the minimum MACT (commonly known as the MACT floor) is established by surveying the source category to determine the average emission limitation achieved by the best 12 percent of the industry in terms of pollution control. EPA can propose a standard above the MACT floor. For new sources, the MACT standard represents the emission limit achieved in practice by the best controlled similar source. The level of control specified in the NESHAP is based upon the MACT for that industry. Therefore, the NESHAP often is referred to as the MACT standard. The EPA is to evaluate the residual cancer risk remaining after the MACT standards have been implemented and report to Congress whether additional control measures are needed to protect public health.

The U.S. EPA promulgated the wood furniture NESHAP under Title III of the CAAA.<sup>92</sup> The wood furniture NESHAP was developed through a regulatory negotiation process (called a reg-neg) that included a total of 25 representatives from the wood furniture manufacturing industry, the coatings production industry,

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<sup>90</sup> Caprolactam was removed from the HAP list on June 6, 1996. There are 188 listed HAP chemicals.

<sup>91</sup> EPA revised their original list of sources categories on June 4, 1996, removing 6 categories, renaming 2 categories, moving 3 categories to different industry groups, subsumption of 2 categories into other existing categories, and adding 8 categories. The list contains 175 source categories.

<sup>92</sup> Title III amends the NESHAP program, section 112, in Title I of the 1970 CAA.

environmental groups, and state government, as well as U.S. EPA staff.<sup>93</sup> The wood furniture negotiation and NESHAP development began in July 1993, and the draft NESHAP was published on December 6, 1994. After public comment, the U.S. EPA published the final wood furniture NESHAP in the *Federal Register* on December 7, 1995.

- Title IV: Addresses acid rain by establishing a program to reduce sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) emissions from stationary sources, primarily the power production industry.
- Title V: Establishes the operating permit program for all major sources regulated under the 1990 CAAA. One permit should cover all air emissions at the facility. The permit programs are to be designed and implemented by individual states with EPA approval. Title V outlines the minimum state program requirements for administrative procedures, permit application content and operating permit content.
- Title VI: Implements the Montreal Protocol for protecting the stratospheric ozone layer. It phases out the manufacture of certain ozone-depleting chemicals and regulates their use.
- Title VII: Contains the enforcement provisions, including establishing civil penalties (up to \$25,000 per day per violation), criminal fines and imprisonment criteria, administrative penalty authority, provisions for public involvement in settlements and citizen-suit criteria.
- Title VIII: Contains miscellaneous provisions such as changes to grant funding limits, incentives for renewable energy and energy conservation, and requirements to analyze the costs and benefits of the CAAA.
- Title IX: Establishes clean air research programs. These range from researching clean alternative fuels to ecosystem implications to western states acid deposition.
- Title X: Addresses disadvantaged business concerns.
- Title XI: Provides employment training assistance to workers displaced from their jobs as a direct result of the implementation of the CAAA. This title was designed primarily to aid coal industry workers who lose their jobs as a result of Title IV provisions.

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<sup>93</sup> In a reg neg, the participants try to achieve consensus on the concepts and principles that should be included in the NESHAP and provide input throughout the regulatory development process.

# APPENDIX B

## General Information on the Wood Finishing Process

Appendix B has been included in this Manual to provide additional background information to those not familiar with the wood furniture industry and manufacturing process. Section B-1 profiles the wood furniture industry in the Northeast and the information was not presented in Chapter 1. The information in Section B-2.1 contains more detailed information on the wood furniture finishing process and is intended to substitute for Section 1.3.1 of this Manual. Section B-2.2 provides additional information on coating application equipment and can replace Section 1.3.2 of this Manual.

### B-1 The Wood Furniture Industry in the Northeast<sup>1</sup>

In total, the wood furniture industry in the eight Northeast states employs approximately 26,000 people and generates sales of approximately \$2.8 billion. With the exception of a few firms, this industry is made up primarily of small companies, often with less than 5 employees. A large percentage of the rest has less than 20. The largest manufacturing facilities in the region employ 200 to 550 persons. EPA estimates of the total number of facilities in the Northeast, and the number with 20 or more employees, are shown in Table B-1.

**Table B-1 Number of Facilities in the Northeast<sup>2</sup>**

State	Total Facilities	20 or More Employees
Connecticut	147	35
Maine	20	7
Massachusetts	272	72
New Hampshire	52	14
New Jersey	447	65
New York	748	150*
Rhode Island	11	5
Vermont	31	13
<b>Total</b>	<b>1,728</b>	<b>361*</b>

\* Estimate (because the number of facilities with 20 or more employees in New York was incorrect in the source document)

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<sup>1</sup> All data presented in this section was obtained from a search of the Dun & Bradstreet database, performed on June 6, 1996, unless otherwise noted.

<sup>2</sup> U.S. EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.



The overall economic significance of the wood furniture industry to the region is illustrated in Table B-2. In total numbers, employment in the wood furniture sector is highest in Connecticut, Massachusetts, New Jersey, New York and Vermont. However, when normalized for population, all states, with the exception of Vermont, have approximately the same proportion employed, ranging from 0.047 to 0.086 percent of the total state population. In Vermont the proportion of total population employed in the wood furniture industry is 0.38 percent, almost 10 times greater than the other Northeast states.

**Table B-2 Sales and Employment in the Wood Furniture Industry by State**

State	Sales (in millions)	Employment
<b>Connecticut*</b>	\$740	2,600
<b>Maine</b>	\$40	800
<b>Massachusetts</b>	\$265	3,600
<b>New Hampshire</b>	\$65	950
<b>New Jersey</b>	\$320	3,600
<b>New York</b>	\$1,020	11,600
<b>Rhode Island</b>	\$45	650
<b>Vermont</b>	\$60	2,150
<b>Total</b>	<b>\$2,555</b>	<b>25,950</b>

\* Ethan Allen has all of its manufacturing plants in other states, including New York and Vermont; however, the corporate headquarters are in Connecticut and all sales are reported there (i.e. approximately \$510 million in 1996).

### B-1.1 Types of Wood Furniture Produced in Northeast

Furniture manufacturers can be separated by the type of furniture they produce. Under the SIC codes, generally six types of furniture are made from wood: wood household (e.g. tables, chairs and bureaus); upholstered wood household (e.g. sofas and chairs); wood office (e.g. desks, bookcases and tables); wood cabinets (e.g. television, stereo and sewing); wood kitchen cabinets; and wood office and store fixtures, partitions, shelving and lockers. With few exceptions, each of the Northeast states produce all six types of wood furniture. In each of the states, one sector of furniture dominates over the others in terms of sales and employment, often by a factor of three to five. The top three sectors in each state are presented in the Table B-3.

**Table B-3 Top Three Wood Furniture Manufacturing Sectors by State**

State	Dominant Sector	Second Sector	Third Sector
Connecticut*	Kitchen cabinets	Partitions and fixtures	Wood household
Maine	Wood household	Kitchen cabinets	Partitions and fixtures
Massachusetts	Wood household	Partitions and fixtures	Kitchen cabinets
New Hampshire	Wood household	Partitions and fixtures	Kitchen cabinets
New Jersey	Partitions and fixtures	Kitchen cabinets	Wood household
New York	Wood household	Partitions and fixtures	Office furniture
Rhode Island	Partitions and fixtures	Kitchen cabinets	Wood household
Vermont	Wood household	Partitions and fixtures	Kitchen cabinets

\* Ethan Allen's contribution was removed because all sales for all types of furniture are reported in the database under the upholstered furniture category.

### B-1.2 Wood Furniture Quality Classifications

Wood furniture manufacturing also can be separated into three general quality classifications: high-, medium- and low-end. High-end furniture is constructed of high-quality solid wood such as maple or cherry, or wood veneers, and is finished to show the natural wood grain. Medium-grade furniture can be made from lower-quality solid wood such as pine, composite material such as fiberboard or particleboard, or a combination of solid wood and composite material. Most composite materials used today are MDF. Medium-grade furniture can be finished to show the wood grain or painted. Medium-grade kitchen cabinets, office furniture, and partition and fixtures typically are constructed either fully or partially with MDF covered by a plastic laminate. Low-end furniture typically is made from MDF, with some plastic and/or wood components. Typically, a filler is used to smooth the rough surface, which is then painted or printed with a simulated wood grain, or the surface is finished by laminating colored paper that is sometimes printed with a simulated wood grain. Alternatively, low-end furniture may consist of MDF covered with a simulated wood grain plastic laminate.

Manufacturers in the Northeast produce furniture of all three grades; however, most concentrate on high- and/or medium-end products. The manufacture of each of the three quality grades can involve different processes. Generally, the manufacture of high-end furniture, cabinets, partitions and fixtures involves many finishing steps all performed by hand and generates the largest quantities of air emissions. Manufacturers of high-end furniture can range from small shops of one or two persons up to large facilities employing more than 400 persons. The manufacture of medium-grade household furniture involves substantially fewer finishing steps, which often can be automated. Because of lower price markups, the high capital costs associated with automation and the subsequent need for high productivity, most medium-grade furniture is manufactured at facilities with more than 20 employees. The manufacture of medium-grade partitions and fixtures, and some household furniture involves covering a fiberboard/particleboard core with a plastic laminate, and no coating steps. However, the lamination process does involve the use of adhesives that create air emissions. The manufacture of cabinet countertops involves laminating a formica layer over a particleboard core.

With slight variations, manufacturing furniture for each of the important sectors in each state involves one of two finishing processes: application of multiple coating layers to solid wood or application of a plastic laminate over an MDF core. Air emission issues are associated with each of these types of furniture finishing. The two traditional wood finishing processes and their associated pollution problems are discussed in the next section. The manufacture of low-end furniture is not a significant component of the wood furniture industry in the Northeast. Therefore, the use of fillers and paper laminates in the manufacturing process for low-end furniture is not discussed in detail in this Manual.

## B-2 Typical Wood Furniture Finishing Process and Pollution Problems

Environmental releases from the wood furniture manufacturing process are overwhelmingly to the air. Of the wood furniture companies in the U.S. that reported to the TRI database,<sup>3</sup> approximately 90 percent of the waste generated was emitted to the air with the remaining 10 percent going into wastewater or becoming a solid or hazardous waste that was recycled, treated, processed for energy recovery or disposed in a landfill.<sup>4</sup>

The vast majority of air emissions are generated from the coatings used in the wood finishing process. The quantity of coatings used and the emissions generated, also correlate with the application equipment. Some air emissions also arise from the use of solvents to clean spray guns, spray booths and other equipment. A generalized process flow diagram showing air emissions and solid and/or hazardous waste sources from traditional solvent-based coating application and cleaning techniques is presented in Figure B-1. The emissions and wastes generated are similar for each coating application so they are shown for one application only. Therefore, the more coating layers applied, the more times a piece of furniture cycles through the diagram and the greater the air emissions and solid and/or hazardous wastes generated.

In the manufacture of partitions and fixtures and other types of wood furniture products that involve covering a fiberboard/particleboard core with a plastic laminate, the adhesives generate significant air emissions. In addition, the solvents used to clean equipment and remove excess adhesive also contribute to air emissions. All of these components of the finishing process are described in Chapter 1 of this Manual. Additional information on the solid wood finishing sequence and coating formulations, and coating application equipment is included in the following sections.

### B-2.1 Solid Wood Finishing Sequence and Coating Formulations

Wood requires finishing to protect it from physical or chemical damage and natural degradation. In furniture manufacturing, finishing also serves to enhance the natural beauty of the wood and to provide an attractive appearance for the consumer. A series of finishes are applied to the wood to

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<sup>3</sup> EPCRA established a list of more than 300 chemicals that are subject to reporting to the TRI. All manufacturing facilities in SIC codes 20 to 39 that employ more than 10 persons, manufacture or process more than 25,000 pounds and/or use more than 10,000 pounds of any listed chemical must report all releases of listed chemicals to the TRI each year.

<sup>4</sup> EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995, from the 1993 TRI database.



obtain the desired result. Solids are resins and pigments and are the portion of the wet coating material that remains on the object once it has dried. In most facilities, the item being finished is moved through the facility mechanically, using a tow line and pallet system or an overhead hook system.

## Finishing Sequence

The exact type and number of finishing operations depends upon several factors, primarily the type of wood, the type of furniture and the desired quality. Generally, the higher the quality, the greater the number of finishing steps with several repeated one or more times. Typically, a short wood finishing operation involves the following three step application sequence:

**stain ! sealer ! topcoat**

A typical long finishing sequence involves at least the following 7 coating application steps with more than 15 steps in even longer sequences:

**stain ! stain ! washcoat ! filler ! sealer ! topcoat ! topcoat**

The first finishing step in either of these sequences is the application of a stain material with the purpose of imparting color, enhancing the natural grain of the wood, evening out wood color and/or improving the penetrating capability of the coating materials that follow. Stains are transparent color coats that are applied directly to the wood and have a solids content by weight, of no more than 8 percent.<sup>5</sup> An alternative to staining is painting. Paint contains more pigment, which imparts an opaque color to the wood, and essentially covers the wood grain. Typically, a primer material is applied under the paint coat. Traditionally, stains, paints and primers are solvent-based.

In the longer finishing sequence, the next step is the application of a washcoat. Washcoats are used to fill in depressions and even out color, as well as help seal the wood and provide a surface for sanding. Often, the washcoat is formulated at the facility by diluting purchased sealer material with a solvent. Washcoats have a solids content of less than 12 percent by weight.<sup>6</sup> Washcoats often are followed by fillers, which are high pigment, high solids coatings that are thinned on-site using solvents to a solids content of 10 to 40 percent.<sup>7</sup> The filler often is worked into the wood by hand with the excess wiped off using cloth rags, which is called a wiping stain. Typically, washcoats and fillers are solvent-based.

The next step is sealing. Sealers improve adhesion and provide a foundation for the final coating application(s). The final finishing application(s) is the topcoat. Lacquer topcoats provide a clear finish to protect the other finishing layers and are often high-gloss. There are different types of sealers and topcoats such as nitrocellulose, conversion coatings and polyurethane. Therefore, there is not a standard solids content for sealers and topcoats. Traditionally, all types of sealers and

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<sup>5</sup> American Furniture Manufacturer's Association, et al, *A Complete Guide to the Wood Furniture CTG and NESHAP*, Copyright 1995.

<sup>6</sup> American Furniture Manufacturer's Association, et al, *A Complete Guide to the Wood Furniture CTG and NESHAP*, Copyright 1995.

<sup>7</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

topcoats are solvent-based. The most commonly used sealers and topcoats are nitrocellulose with a solids content in the range of 18 to 24 percent. Enamels serve the same purpose as lacquers (i.e. protection and gloss) except that they are opaque color coats. The relative percentage of total VOC emissions from the finishing process contributed by each of the application steps is shown in Table B-4.

**Table B-4 Relative VOC Emissions<sup>8</sup>**

<b>Application Type</b>	<b>Long Sequence (in percent)</b>	<b>Short Sequence (in percent)</b>
<b>Stain</b>	26	32
<b>Washcoat</b>	4	
<b>Filler</b>	3	
<b>Wiping stain</b>	8	
<b>Sealer</b>	18	32
<b>Highlight</b>	1	
<b>Topcoat</b>	40	36
<b>Total</b>	100	100

In the short sequence, VOC emissions are divided almost evenly among the stain, sealer and topcoat. In the longer sequence, the stain, sealer and topcoat still contribute the largest VOC emissions relative to the other steps, although the percentages are altered. Washcoat, filler, wiping stain and highlight coats combine for only 16 percent of VOC emissions with sealer 18 percent, stain 26 percent and topcoat 40 percent. Overall, emissions from long sequences are higher than those from short sequences because the total number of finishing steps (i.e. amount of coating applied) is greater.

Finish coats typically are applied using a manual spray gun. Application occurs in a spray booth that actively draws air from the booth through filters to control the material that does not adhere to the item, which is known as overspray, and to remove harmful air emissions from the employee workspace. The spray booth is the source of approximately 84 to 95 percent of the air emissions from the application of finishing material depending upon the type of coating material being applied.<sup>9</sup> Large operations typically have one or more spray booths for each finishing step, whereas smaller operations may have only one or two booths that are used for all of the steps.

For coatings that volatilize, drying between finishing steps is known as flashoff. Items are moved from the spray booth to a flashoff area before entering another spray booth. The flashoff areas between each application stations usually is open. A typical fine furniture long finishing sequence can take approximately 400 minutes to complete, of which approximately 340 minutes is used for

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<sup>8</sup> EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA/310/R-95/003, September 1995

<sup>9</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

drying.<sup>10</sup> Only 60 minutes is spent undergoing an active manufacturing process. To reduce drying times, flashoff areas can be ventilated using forced air in areas known as forced flashoff areas. Emissions from flashoff areas generally are uncontrolled and produce approximately 5 to 16 percent of air emissions from a finishing application.<sup>11</sup>

To cure the finish and significantly reduce the time required for drying, the object can be placed in a drying oven between coats. Most drying ovens are steam heated using either wood-, coal-, or gas-fired boilers.<sup>12</sup> Typically, facilities that produce a significant quantity of wood waste during the manufacture of furniture items burn that waste material in the boilers. Drying ovens are heated to between 100 and 250 degrees Fahrenheit, depending on the type of coating, or may use infrared energy.<sup>13</sup> The use of an oven reduces flashoff emissions from a finishing application to 3 to 11 percent with the ovens emitting the remaining 2 to 5 percent of total air emissions from an application step.<sup>14</sup>

The spray booths and ovens have exhaust systems, actively drawing air from the finishing area to the atmosphere and creating a negative pressure in the finishing room compared to surrounding areas. Typically, there is no treatment or removal of VOCs or HAPs prior to exhausting the air to the ambient environment. Combined, the spray booth and oven exhausts remove approximately 90 percent of the air emissions from the facility.<sup>15</sup> The remaining 10 percent leaves the finishing area through other openings such as doors and windows. Overspray particulate is controlled in a spray booth by actively drawing air through a filter system. The filter medium is typically paper, styrofoam, polyester or metal. Water curtain filter systems are still in use in some older facilities. With the evolution of more stringent water pollution control and hazardous waste disposal regulations, many older facilities with water curtain filter systems have replaced them with dry filters.

Sanding is usually performed between the finishing steps, particularly between the sealer and topcoat applications. If a defect occurs during finishing, the finish often can be repaired in a process called washoff. Generally, the coating layers are removed from the problem area or from the entire piece by dipping the item in a container of solvent, which is known as a washoff tank. Methylene chloride often is used for washoff by the wood furniture industry. After most of the coating layers are removed, the area is sanded down to bare wood and the finishing sequence is repeated to produce a satisfactory product.

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<sup>10</sup> J. Heltzer, "Wood Furniture Finishing," *Industrial Pollution Prevention Handbook*, edited by H.M. Freeman, McGraw Hill, 1995.

<sup>11</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>12</sup> Ibid.

<sup>13</sup> EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

<sup>14</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>15</sup> Ibid.

## Formulation of Coating

Two main types of coating materials are used by the wood furniture industry: those that dry through solvent loss or those that dry (i.e. cure) through chemical cross-linking. Nitrocellulose coatings dry through solvent loss. Conversion coatings contain a catalyst and cure mainly by chemical reaction. Nitrocellulose coatings are used by approximately 75 percent of the wood furniture industry because they are easy to apply and repair, and are quick drying at ambient temperatures.<sup>16</sup> Nitrocellulose coatings also produce the final product appearance that consumers are accustomed to. Approximately 15 percent of the wood furniture industry, primarily kitchen cabinet manufacturers, use acid-catalyzed conversion coatings.<sup>17</sup> These two traditional finishing materials are discussed in the following sections. The remaining 10 percent of the industry uses other types of coatings such as UV-cured, aqueous-based, or polyester or polyurethane-based. These alternative finishing materials are discussed in Chapter 3 of this Manual.

### *Nitrocellulose Coatings*

Nitrocellulose coatings contain solids (i.e. resins and pigments) that remain as the coating on the item and solvents that permit handling and application. Nitrocellulose is a resin that acts as a binder in the coating. Various solvents are added to dissolve the nitrocellulose resin and to control evaporation of the coating after application. Drying of the coating occurs through volatilization of the solvents.

Proper drying is essential to maintaining product quality and efficient production levels. If the dry time is too fast, bubbling of the finish can occur which requires repair. If drying is too slow, the production process is less efficient than necessary. A thinner solvent sometimes is added to purchased coating materials to adjust the viscosity of the coating for optimal application, or to increase or decrease the drying time required. The type and amount of thinner added depends on such factors as ambient temperature and humidity. Traditionally, inexpensive, high vapor pressure solvents such as toluene and xylene are used in coatings and as thinners in the wood furniture industry.

Traditional nitrocellulose coatings contain a low percentage of solids, typically ranging from 10 to 30 percent for sealers and lacquers.<sup>18</sup> Only the solids remain as the dried coating on the finished piece of furniture. Therefore, depending on the coating formulation, 70 to 90 percent of the liquid that is applied to the item ends up as air emissions. As stated above, many of the compounds emitted from the finishing materials are VOCs and/or HAPs as defined by the CAAA. Substantial quantities of solvent emissions are generated by the nitrocellulose solvent-based finishing process. A typical nitrocellulose coating with 16 percent solids contains approximately 6 pounds of VOCs per gallon not including water,<sup>19</sup> or, in other units, a typical 20 percent solids lacquer contains approximately 4 pounds of VOC per pound of solids.<sup>20</sup> In addition, because solvents dissolve

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<sup>16</sup> EPA, *Profile of the Wood Furniture and Fixtures Industry*, EPA 310-R-95-003, September 1995.

<sup>17</sup> Ibid.

<sup>18</sup> Ibid.

<sup>19</sup> P.J. Dambek, et al, *A Guide to Pollution Prevention for Wood Furniture Finishing*, Capstone Project, Tufts University, August 1992.

<sup>20</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.



nitrocellulose, cleanup is accomplished by adding solvent to the dried coating. Therefore, the cleanup of nitrocellulose coatings generates more solvent emissions.

The MSDS for a low VOC clear nitrocellulose lacquer contains the hazardous ingredients shown in Table B-5:

**Table B-5 Hazardous Ingredients of a Low VOC Clear Nitrocellulose Lacquer<sup>21</sup>**

Compound	Percent by Weight
xylol (xylenes)	21.83
methyl isobutyl ketone (MIBK)	23.5
methyl isoamyl ketone	4.28
methyl ethyl ketone (MEK)	14.68
isopropyl alcohol	5.92
butanol	2.83

All of the compounds listed are considered VOCs, and combine to make up 73.5 percent of the coating by weight. The VOC content of this coating is 5.8 lbs./gallon. Three of the six compounds are also HAPs: xylol, MIBK and MEK. These are the three compounds present in the greatest quantities, accounting for 60 percent of the total coating weight and more than 80 percent of the VOCs.

Three main drawbacks offset the benefits of nitrocellulose coatings: nitrocellulose is highly flammable; nitrocellulose requires the use of solvents that are toxic and volatile, creating large quantities of potentially harmful emissions; and the dried nitrocellulose finish is not highly durable, is easy to damage, is ruined by water, and turns yellow when exposed to sunlight.<sup>22</sup>

### *Conversion Coatings<sup>23</sup>*

Acid-catalyzed conversion coatings are used in the cabinet-making industry and by some other segments of the furniture industry because the finish is especially durable and chemical-resistant. The trend away from formal dining and toward more casual dining has increased demand for durable coatings. Many manufacturers of functional dining furniture now are using conversion coatings. Another user of conversion coatings is the institutional furniture sector. Conversion coatings are used for sealer and topcoat applications. Stains and other undercoats remain non-conversion materials, meaning they dry through coating evaporation.

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<sup>21</sup> MSDS for #5-42 Low VOC Hot Spray Clear Nitrocellulose Lacquer, made by Industrial Finishing Products, Brooklyn, New York.

<sup>22</sup> EPA/SEDESOL Pollution Prevention Workgroup, *Pollution Prevention for the Wood Finishing Industry*, May 1994.

<sup>23</sup> P.J. Dambek, et al, *A Guide to Pollution Prevention for Wood Furniture Finishing*, Capstone Project, Tufts University, August 1992 and EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996..

There are many types of catalyzed coatings, of which acid-catalyzed conversion coatings are one type. Other types of catalyzed coatings used by the wood furniture industry include UV-cured coatings and polyester coatings. These are discussed in Chapter 3 of this Manual. Acid-catalyzed conversion coatings are the most popular catalyzed coatings used by the wood furniture industry.

Acid-catalyzed coatings are formulated as "one-pack" or two-pack" coatings. In one-pack coatings, the catalyst is pre-mixed with nitrocellulose and a small amount of urea resin in a solvent base. Curing times for one pack coatings are comparatively slow, up to 3 or 4 weeks for some formulations. Two-pack coatings contain urea or melamine-based resins in one pack, and the catalyst in the other. The two packs are mixed at the facility, just prior to application. Because they have a higher catalyst content, curing times are significantly shorter, typically minutes to hours. However, the shelf life (i.e. pot life) of two pack coatings is relatively short (i.e. on the order of days) when compared to one pack coatings (i.e. weeks to months) and nitrocellulose coatings (i.e. months to years).

The durability and chemical-resistance of acid-catalyzed conversion coatings make touchup and repair difficult to perform. Acid-catalyzed conversion coatings typically have a lower VOC content and a higher solids content than nitrocellulose coatings. For example, a 40 percent solids conversion varnish contains 4.75 lbs. VOC per gallon.<sup>24</sup> A 35 percent solids conversion varnish contains 1.9 lbs. VOC per lb. solids.<sup>25</sup> Air emissions are still significant and acid-catalyzed conversion coatings emit some hazardous compounds, such as formaldehyde, that are different from those emitted from nitrocellulose coatings.<sup>26</sup> Users of acid-catalyzed conversion coatings will need to comply with the NESHAP and CTG emission limits, and should consider the alternatives presented in Chapter 3 of this Manual.

## B-2.2 Coating Application Equipment

To avoid possible damage to the finish during assembly, wood furniture typically is partially or fully assembled before the coatings are applied. This makes the finishing process somewhat cumbersome because the furniture is bulky and may have awkward corners or crevices. Finish is typically applied to these pieces using a manual spray gun. Spray gun application is used by approximately 87 percent of the industry.<sup>27</sup> All sizes of furniture manufacturers use spray gun application of coatings, from 500-person facilities to the single-person business operating out of a garage.

Some items are assembled after coating, typically those consisting only of flat pieces (such as kitchen cabinets, simple office furniture or customer assembly kits). These are finished as pieces, often using an automated system. Automated finishing, which is known as flatline finishing, is used

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<sup>24</sup> Architectural Woodwork Institute, "Catalog and Evaluation of Compliant Wood Coatings For New York State Woodwork Manufacturers," Copyright 1994.

<sup>25</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>26</sup> J. Heltzer, "Wood Furniture Finishing," *Industrial Pollution Prevention Handbook*, edited by H.M. Freeman, McGraw Hill, 1995.

<sup>27</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

by approximately 13 percent of the industry.<sup>28</sup> Because of the higher capital expense, automated finishing generally is used only at larger operations, typically those with 20 or more employees.

## Spray Gun Application

Spray gun finishing application is performed in a spray booth where volatile solvents are emitted to a relatively large volume of air, limiting the economic feasibility of using a treatment system such as incineration. In addition, spray booths are not a total enclosure, but rather a covered, three-walled station where the coating is applied in the direction of the back wall that contains the overspray particulate filters. At facilities that use a conveyor system, spray booth side walls have large openings to permit the movement of furniture in and out on the conveyor.

Because of their high flammability, fire codes mandate that for each nitrocellulose coating, the facility can only locate at the work site the amount of coating that is needed for a single day's worth of production. Larger quantities must be stored in a fire-resistant room in a remote area. Materials applied in large quantities typically are located in 55-gallon drums or larger containers and connected to the spray gun(s) via a pressurized piping system. Materials used in smaller quantities are usually transferred to a pressure pot, that is a smaller pressurized container of 3 to 10 gallons which is connected directly to the spray gun at the application site.

In general 30 to 60 percent of the liquid exiting the spray gun nozzle actually adheres to the wood furniture item. The percentage of sprayed material that contacts the item is called the transfer efficiency (TE) of the application technology. While drying, overspray emits the same VOCs and HAPs as the coating on the furniture item. The lower the TE, the more virgin material that is consumed to coat a given item, the greater the amount of overspray generated and the larger the quantity of total air emissions. Therefore, spray application technology can have a significant impact on the amount of finishing materials used, and the emissions of VOCs and HAPs.

The TE of spray application is affected by a number of variables, including:<sup>29</sup>

- Ⓒ size and geometry of the target (e.g. finishing a large tabletop generates less overspray than coating an intricately cut chair back)
- Ⓒ skill of the operator (i.e. both spray technique and equipment adjustment)
- Ⓒ type of application equipment
- Ⓒ type of coating
- Ⓒ atomizing air pressure
- Ⓒ fluid flow rate
- Ⓒ air velocity and flow direction in spray booth

The size and geometry of the item being finished is assumed to be fixed. However, a company can improve the TE of their spray application through optimizing the other variables. Optimizing each of the variables is discussed in Chapter 3 of this Manual.

Conventional air spray guns have the lowest TE of all the spray application technologies, but they still are used widely in the wood furniture industry because they have been used for decades and

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<sup>28</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>29</sup> Ibid.

are the familiar technology. Conventional air spray application equipment is defined as air spray technology "... in which the coating is atomized by mixing it with compressed air and applied at an air pressure greater than ten pounds per square inch (gauge) at the point of atomization."<sup>30</sup> Conventional air spray application has a TE in the range of 30 to 40 percent;<sup>31</sup> however, transfer efficiencies as low as 20 percent are not unusual.<sup>32</sup> Therefore, 60 to 80 percent of coating purchase costs are wasted. In addition, the wasted coating ends up on spray booth filters, walls and floors requiring more frequent cleaning and disposal than if the TE were higher.

Other types of spray guns used in the industry include HVLP, airless, air-assisted airless and electrostatic. These application technologies have higher TEs than conventional air spray guns and are discussed in Chapter 3 of this Manual.

## Automated Finishing

In automated flatline finishing, the flat wood pieces travel on a conveyor to each finishing station. The system applies the coating material using rollers, by passing the item through a curtain (cascade) of coating, or using an automated spray technique. In all of these techniques, the excess coating can be collected below the conveyor and recirculated to the coating reservoir for reuse. Industry calls these "continuous coaters."<sup>33</sup> TEs in flatline finishing are significantly higher than for spray gun application with continuous coating systems essentially at 100 percent because all excess coating is reused. The coating application stations in flatline finishing systems are often enclosed, offering the potential opportunity to use an air emission control device. The flashoff area between each application station is generally not enclosed.

Another type of automated system is dip coating. Assembled furniture or pieces are hung from an overhead conveyor and dipped into an open reservoir of coating. Excess coating is collected as the item drips and is returned to the reservoir, creating a high TE. However, the open reservoir generates significant air emissions if solvent-based coatings are used because the solvent can freely evaporate. Approximately 55 percent of automated finishing systems are dip coating with the other 45 percent flatline systems - 14 percent applying coating with rollers (roll coating) and 14 percent by passing the item through a curtain of coating (i.e. curtain coating).<sup>34</sup> The remaining 17 percent generally use a form of automated spray application.

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<sup>30</sup> EPA, "National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions from Wood Furniture Manufacturing Operations," *Federal Register*, December 7, 1995, pg 62937.

<sup>31</sup> DeVilbiss Industrial Coating Equipment Company informational brochure, "HVLP all you want to know about high volume low pressure finishing," copyright 1994.

<sup>32</sup> L. Snowden-Swan, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992.

<sup>33</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

<sup>34</sup> EPA, *Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations*, EPA/453/R-96/007, April 1996.

# Appendix C

## Summary of State Rules Affecting Wood Furniture Industry

Most states in the Northeast<sup>1</sup> have regulations that currently apply to the wood furniture industry. Some of the states have regulations that apply to all coating operations, and others have developed rules specifically for the wood furniture industry. In general, states have developed their own rules in response to federally mandated ground-level ozone control programs. Therefore, the most state-specific regulations are aimed at VOC control and not VHAP control, although VHAPs and VOCs often are one and the same. Most Northeast states have risk-based air toxics control programs that have the potential to affect wood furniture manufacturers on a case-by-case basis.

The Title V permit program and the MACT and/or RACT requirements eventually will affect all wood furniture manufactures that are major sources of HAPs and/or have the potential to emit more than 25 tons of VOCs per year. States are required to use the CTG and RACT to develop their own VOC regulations that are at least as strict as the federal recommendations. The federal VHAP control standards are in addition to the VOC control requirements and will take effect in November 1997 or December 1998, depending upon the actual emissions of the facility. States have the ability to enact VHAP regulations that are more stringent than the federal standards and several Northeast states currently are evaluating standards for major source wood furniture manufacturers that require Title V permits that are more strict than the current federal regulations.

Many states in the Northeast have regulations that apply to the wood furniture industry. Existing state regulations will continue to apply until they are modified in response to the wood furniture CTG and NESHAP. As of July 1997, only Rhode Island has developed their own wood furniture regulation in response to both the new CTG and NESHAP. Rhode Island's interim emission limits are detailed in Section C-7 of this Appendix. The State of New Hampshire has developed a VOC RACT rule based on the CTG, but not the NESHAP. New Hampshire's regulations are described in Section C-4. The current status of air emission requirements in each Northeast state is detailed in the following sections. In addition, many of the Northeast states have pollution prevention planning requirements that also apply to wood furniture manufacturers. These requirements also are presented in the following sections.

### **C-1 Connecticut**

Connecticut has not adopted regulations specific to wood furniture surface coating operations. However, Connecticut does have general HAP regulations applying to any source that emits one of the more than 850 chemicals on the state's list.<sup>2</sup> All new sources must comply with the Maximum Allowable Stack Concentration (MASC) for all 850 HAPs. Existing sources must comply with MASC for only known human carcinogens (Table 29-1 only). All sources must reduce emissions if any Hazard Limiting Value (HLV) is exceeded at the property line and is solely attributed to the

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<sup>1</sup> In this Manual, Northeast refers to the states of: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont.

<sup>2</sup> Listed in Tables 29-1, 29-2 and 29-3 of the Regulations of Connecticut State Agencies (RCSA), Section 22a-174-29.

source. The current regulations do not contain any monitoring, record keeping or reporting requirements. However, the Commissioner has the authority to require sources to monitor, keep records, and submit reports and any other information deemed necessary.<sup>3</sup>

New sources that meet the applicability requirements for new source review must apply for a new source review permit.<sup>4</sup> Connecticut is currently preparing a new general permit to construct and/or operate a surface coating operation that may become final in the future. This general permit contains emission limits, application equipment restrictions and work practice standards, and would apply to wood furniture manufacturing operations if it becomes final.

Connecticut does not have any toxic use reduction or pollution prevention planning requirements.

## **C-2 Maine**

Maine has VOC regulations pertaining to certain surface coating facilities that mandated compliance by May 31, 1995. At that time, only coating of flatwood paneling was included in the area of wood finishing. Flatwood paneling is not regulated under the wood furniture NESHAP or CTG. Maine currently is revising their regulation to include all wood coating operations. In Maine, all sources of 40 tpy of VOC emissions currently are subject to Maine's Chapter 134 VOC RACT rule. The VOC RACT rule required reductions from 1990 VOC emission levels by 1995 of 80 percent or more because of alternative formulation, 85 percent or more because of use of a control technology, or the company could propose an alternative to the DEP.

In April 1990, Maine passed an act to reduce the use of toxics, the production of waste and releases of toxics to the environment. The law encourages toxic use reduction and requires a reduction in hazardous waste generation and releases to the environment. At each facility, hazardous waste generation and the release of toxics to the environment must be reduced by 10 percent by 1994, 20 percent by 1996 and 30 percent by 1998 (i.e. relative to the average of 1987 and 1989 data for hazardous waste, and the average of 1990 and 1991 data for releases). The requirements apply to all releasers of toxic materials that are required to report under Title III, Section 313 of the federal Superfund Amendments and Reauthorization Act of 1986 (SARA), and all generators of hazardous waste as defined by the federal RCRA or Maine. The reduction in the use of toxics is expected to occur voluntarily once companies complete the planning process and determine cost-effective opportunities.

The minimum planning requirements are:

- C development of a facilitywide management policy for the reduction of toxics use, release and waste generation.

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<sup>3</sup> RCSA 22a-174-4, subsections a(2) and c(1).

<sup>4</sup> RCSA 22a-174-3.

- C a production unit analysis that:
  - < characterizes the toxics used and released, and the hazardous waste generated
  - < identifies and evaluates appropriate use and release reduction techniques
  - < proposes a strategy for implementing selected reduction technologies, including a schedule
  - < identifies available markets for recycling the hazardous waste generated
  - < establishes a record keeping program
  
- C an employee awareness and training program

Many wood furniture manufacturers are required to report under SARA 313, including those that are not major sources by the NESHAP definition. Therefore, all of those wood furniture manufacturers subject to the NESHAP should have completed the planning requirements and already reduced air emissions by 20 percent, relative to 1990/1991 data, by 1996, with another 10 percent planned by 1998. Facilities should contact Maine DEP for guidance on compliance with Maine's pollution prevention act.

### C-3 Massachusetts

Massachusetts has adopted VOC regulations specific to wood coating operations.<sup>5</sup> The regulation is limited to those facilities that have the potential to emit 50 tpy of VOCs or more before the application of air pollution control equipment. All facilities subject to the regulation are required to submit an emissions control plan to the DEP for approval. There are also record keeping requirements to demonstrate compliance on a daily basis. The emission limits for Massachusetts are in units of pounds VOC per gallon of solids, as applied and are presented in Table C-1.

**Table C-1 Massachusetts Wood Furniture VOC Limits**

<b>Finishing Material</b>	<b>VOC Limit (lbs. VOC/gallon solids)</b>
<b>Semitransparent stain</b>	89.4
<b>Washcoat</b>	35.6
<b>Opaque stain</b>	13.0
<b>Sealer</b>	23.4
<b>Pigmented coat</b>	15.6
<b>Clear lacquer topcoat</b>	23.4

To convert from Massachusetts' compliance units (lbs. VOC/gallon solids) to the NESHAP and CTG units (lbs. VOC/ lb. solids) the pounds of solids per gallon of solids is needed, or two other characteristics of the coating such as the weight of 1 gallon of coating, the percent solids in the coating (by weight), and the volume of solids in 1 gallon of coating. Each coating formulation is different so standard conversion factors are not available. In general, the NESHAP emission limits are more strict than the Massachusetts regulations, assuming all VOCs are also HAPs. The new CTG VOC emission limits also tend to be stricter than the current Massachusetts rule.

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<sup>5</sup> 310 CMR 7.18(23)(e)1, applicable on January 1, 1994.

Massachusetts passed the Toxic Use Reduction Act (TURA) in 1989. TURA requires that large quantity toxics users (i.e. manufacturing or processing 25,000 pounds per year, or otherwise using 10,000 pounds per year) develop a toxic use reduction (TUR) plan. The goal of the planning process is to identify TUR opportunities that are cost-effective so as to stimulate companies to implement them voluntarily. The TUR plan should:

- ☒ examine how toxic chemicals are used and lost during production
- ☒ calculate the cost of toxic chemical usage
- ☒ identify potential TUR techniques
- ☒ evaluate the feasibility of the TUR techniques
- ☒ evaluate the costs and savings of implementing the various TUR techniques

For users of coatings that contain solvents, the solvent is considered “otherwise used” because it serves as a carrier that evaporates and will not remain in the product. Therefore, wood furniture manufacturers in Massachusetts that use more than 10,000 pounds (5 tons) of a toxic substance are required to prepare a TUR. Acetone is included on the Massachusetts list of toxic substances. Contact the Massachusetts DEP or the Office of Technical Assistance (OTA) for more information about TURA requirements.

#### **C-4 New Hampshire**

New Hampshire has adopted new VOC emission control regulations for coatings in the wood furniture industry. New Hampshire also regulates burial casket manufacturing and wooden gun handle finishing under their wood furniture rule. The regulations apply to manufacturers of wood furniture that have the potential to emit more than 25 tpy of VOCs, burial caskets with the potential to emit of 50 tpy of VOCs, and gunstocks with a potential to emit of 50 tpy of VOCs. The regulations are basically the same as those contained in the wood furniture CTG described under Section 1.5.1 except that an averaging approach is allowed, provided it is approved in advance by the state. For gunstock coating, the allowable VOC limits are 2.0 lb. VOC/ lb. solids for lacquer topcoats and 2.3 lb. VOC/ lb. solids for sealers.

In addition to the VOC regulations, New Hampshire has an air toxic control program that may affect wood furniture manufacturers. The program sets 24 hour and annual ambient air limits (AALs) at the property line for approximately 600 toxic substances. Any source in the state that emits one or more of the regulated substances must demonstrate compliance with the AALs.

New Hampshire does not have any toxic use reduction or pollution prevention planning requirements.



## C-5 New Jersey

New Jersey first began regulating VOC emissions in 1975.<sup>6</sup> The regulation applies to all surface coating operations where more than ½ gallon of coating material is used in any 1 hour, or more than 2 ½ gallons of coating material are used in a day. The regulation specifies that new surface coating installations cannot apply coatings that do not deliberately contain water unless the transfer efficiency of the application is at least 60 percent. The regulation also specifies the maximum allowable VOC content (in pounds per gallon) for wood furniture coating presented in Table C-2.

**Table C-2 New Jersey's Wood Furniture VOC Limits**

Type of Coating	Maximum VOC Content (lbs. VOC/gallon)
Semitransparent stain	6.8
Washcoat	6.1
Opaque stain	4.7
Sealer	5.6
Pigment Coat	5
Clear Lacquer topcoat	5.6

Compliance with the emission standards can be accomplished through the use of all compliant coatings or a control device. If more than one formulation is used within one particular type of coating (e.g. lacquer topcoats) and one or more of them are not in compliance, then the daily mean of the VOC content of the coatings, as applied, can be used to satisfy the requirements.

To convert from New Jersey's compliance units (lbs. VOC/gallon) to the NESHAP and CTG units (lbs. VOC/ lb. solids) the pounds of solids per gallon of coating is needed, or two other characteristics of the coating such as the weight of one gallon of coating and the percent of solids in the coating by weight. Each coating formulation is different so standard conversion factors are not available. However, for many formulations, it appears that the CTG is more strict than New Jersey's requirements. For example, a New Jersey compliant clear lacquer topcoat containing 5.55 lbs. VOC/gallon has 3.0 lbs. VOC/ lb. solids, greatly exceeding the CTG limits.<sup>7</sup>

Specific to wood furniture surface coating, New Jersey sets minimum requirements for application equipment. For facilities emitting less than 50 tpy VOC, application technology must be either airless, air-assisted airless, or heated airless, or an alternative technology approved by EPA or New Jersey as having a minimum transfer efficiency of 40 percent. For facilities with emissions greater than 50 tpy VOC, application technology must be approved as having a transfer efficiency of at least 65 percent (i.e. airless, air-assisted airless, heated airless, electrostatic spray, flatline finishing or another approved technology).

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<sup>6</sup> Under Title 7m, Chapter 27, Subchapter 16 of the New Jersey Administrative Code, with the latest revision dated July 17, 1995. Surface coating and graphic arts operations are regulated under Section 7:27-16.7.

<sup>7</sup> Architectural Woodwork Institute, "Catalog and Evaluation of Compliant Wood Coatings For New York State Woodwork Manufacturers," Copyright 1994.

New Jersey also has a risk-based air toxics program. All sources that emit one or more of the chemicals on the state's Risk Screening list of chemicals must complete the state's Screening Risk Assessment Worksheet. This list includes some of the chemicals that a wood furniture manufacturer may emit such as formaldehyde, methylene chloride and styrene. If the facility risk determined in the screening is greater than 1 increased cancer death in 1 million, then a more detailed Air Quality Modeling effort is required, unless the facility can reduce emissions to reduce the excess cancer risk to less than 1 in 1 million. If the facility cannot adequately reduce emissions, the Air Quality Modeling effort evaluates a much greater list of chemicals than the Screening Risk Assessment Worksheet and includes many of the chemicals typically used in large quantities by wood furniture manufacturers such as toluene, xylenes, MEK and MIBK. If the Air Quality Modeling effort indicates an excess cancer risk of greater than 1 in 10,000, the facility must undertake efforts to reduce the risk. If the excess cancer risk is between 1 in 10,000 and 1 in 1 million, the facility is evaluated by a special risk committee to determine if operations need to be modified to reduce risk.

Finally, New Jersey has a comprehensive pollution prevention planning requirement. Facilities that are required to file at least one Form R under the federal Emergency Planning and Community Right-to-Know Act (EPCRA) must prepare a P2 plan. The chemicals that must be considered in the plan are those listed under Title III, Section 313 of SARA for TRI reporting under EPCRA and are used, manufactured or processed at the facility in a quantity greater than 10,000 pounds per year. The goal of New Jersey's mandatory planning program is that companies will discover economically attractive source reduction opportunities that they will implement voluntarily. New Jersey requires the following elements in a P2 plan:

- C list of chemicals used or manufactured in quantities greater than 10,000 pounds per year
- C inventory data for each chemical to show annual inputs
- C inventory data for each chemical to show annual outputs
- C out-of-process recycling data for each chemical
- C release data for each chemical
- C quantities used for each chemical
- C description of each production process using or generating a listed chemical
- C inventory data for each process showing the amount of hazardous substance:
  - < contained in the product
  - < consumed by the process
  - < used by the process
  - < generated as NPO from the process
  - < released from the process
  - < sent for recycling from the process
- C hazardous waste information, including total quantities generated, treated, recycled, stored, and disposed, as well as identification of off-site TSDFs used
- C type(s) and quantity of hazardous waste produced by each production process
- C comprehensive financial analysis for each production process
- C description of processes targeted for P2
- C quantification of nonproduct output for each targeted process
- C list of available P2 opportunities for each targeted process
- C technical analysis of each option
- C a comprehensive comparative financial analysis of each option
- C a discussion of all options that are technically and financially feasible

- C identification of numeric 5-year goals for the facility to reduce use and/or generation of each hazardous substance, the facility's impact on releases, and the reduction of per unit use and/or generation of each hazardous substance
- C a schedule for implementation of feasible P2 techniques

Wood furniture manufacturers that use/emit 5 tpy or more of any SARA 313 substance are subject to New Jersey's P2 planning requirements.

## C-6 New York

New York has regulated the VOC content of surface coating materials since 1979.<sup>8</sup> In 1988, standards specific to wood furniture coating were adopted for all operations in the New York City metropolitan area. In 1992, the standards were adopted statewide for all facilities with the potential to emit more than 50 tpy VOCs. The regulations mandate VOC limits for wood finishing materials presented in Table C-3.<sup>9</sup>

**Table C-3 New York's Wood Furniture VOC Limits**

<b>Finishing Material</b>	<b>VOC limit (lbs. VOC / gallon)</b>
<b>Semitransparent stain</b>	6.8
<b>Washcoat</b>	6.1
<b>Opaque stain</b>	4.7
<b>Sealer</b>	5.6
<b>Pigmented coat</b>	5
<b>Clear lacquer topcoat</b>	5.6

To convert from New York's compliance units (lbs. VOC/gallon) to the NESHAP and CTG units (lbs. VOC/ lb. solids) the pounds of solids per gallon of coating is needed, or two other characteristics of the coating such as, the weight of 1 gallon of coating and the percent solids in the coating by weight. Each coating formulation is different so standard conversion factors are not available. However, for many formulations, it appears that the CTG is more strict than the current New York standard. For example, a New York compliant clear lacquer topcoat containing 5.55 lbs. VOC/gallon has 3.0 lbs. VOC/ lb. solids, greatly exceeding the CTG.<sup>10</sup>

All new sources and modifications of existing sources of emissions from surface coating operations also undergo a risk rating as part of New York's permit evaluation. The permit reviewer assigns a risk rating of A, B, C or D with A being the highest potential risk based upon parameters such as the toxicity of the chemical(s), the quantity of emissions, and the location of the source and its proximity to populated areas. Most of the listed HAPs are of sufficient toxicity that most users would receive an A rating. When a surface coating source receives an A rating, Part

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<sup>8</sup> Table 2 of 6 NYCRR Part 228.

<sup>9</sup> Architectural Woodwork Institute, "Catalog and Evaluation of Compliant Wood Coatings For New York State Woodwork Manufacturers," Copyright 1994.

<sup>10</sup> Ibid.

212 applies and the source must install 99 percent efficient pollution control equipment or reformulate the coating(s) to reduce the risk rating. Existing surface coating sources that do not modify their operations and all surface coating sources that receive a B, C, or D risk rating are not subject to Part 212.

New York has had a Waste Reduction Policy since 1987, which established the following hazardous waste management hierarchy:

- C reduction or elimination of hazardous waste generation
- C recover, reuse or recycle wastes that are produced
- C detoxify, treat or destroy wastes that cannot be recovered, reused or recycled
- C land disposal

In July 1990, the Hazardous Waste Reduction Act (HWRA) was signed into law. The law requires that generators of 25 tons or more of hazardous waste per year prepare and submit to the state a Hazardous Waste Reduction Plan (HWRP). The HWRP is to be implemented according to a phased schedule. The HWRP is to be updated biennially and annual status reports are to be submitted. The requirements of the HWRA apply to manufacturers that have RCRA hazardous waste generation of 25 tpy or more. Therefore, most wood furniture manufacturers will not be affected by HWRP requirements.

## **C-7 Rhode Island**

Rhode Island promulgated VOC and HAP control regulations for the wood furniture industry on March 7, 1996, and amended them on July 7, 1996. The RI regulations are slightly different from the NESHAP and CTG requirements. For the NESHAP, the emission limits are identical; however, the initial compliance dates are sooner for many facilities: March 7, 1998, for all existing facilities regardless of actual emission levels, and March 7, 1996, for new facilities. The record keeping and reporting requirements are similar, except that Rhode Island adds extensive operation and maintenance requirements to the leak detection and repair plan. Finally, Rhode Island's requirements for exemption from regulation of HAPs are different. Facilities that have not emitted more than 10 tons of any one HAP or more than 25 tons of any combination of HAPs, including emissions from source categories other than wood products, in any 12-month period since December 1994 may apply for an exemption from certain subsections of the regulations provided two conditions are met:

- C Average monthly emissions for any consecutive 12-month period shall not exceed 1,666 pounds of any one HAP, or 4,166 pounds of a combination of HAPs. If these emission limits are exceeded, then the emission limits and requirements of the MACT are immediately applicable).
- C Records are maintained for 5 years that contain the name; identification number; and amount of each finishing, gluing, and washoff material used each month at the facility; CPDSs showing the VOC and HAP content of each of the finishing, gluing and washoff materials used; the type and amount of solvents and thinners used at the facility each month; and the average monthly emissions of each HAP from the facility, calculated monthly for the previous 12 months.

For VOC control, Rhode Island has implemented emission limits different from the CTG, effective March 7, 1996. After March 7, 1998, the CTG emission limits, discussed in Section 1.5.1, become effective. Rhode Island's interim emission limits are summarized in Table C-4.

**Table C-4 Rhode Island's Wood Furniture VOC Limits**

<b>Finishing Material</b>	<b>VOC Limit (lbs. VOC/gallon, minus water and exempt compounds)</b>	<b>VOC Limit (lbs. VOC/ lb. solids)</b>
<b>Clear lacquer topcoats (containing HOC)</b>	4.6	1.2
<b>Clear lacquer topcoats (without HOC)</b>	5.7	2.5
<b>Fillers</b>	4.2	1
<b>High solids stains</b>	5.8	2.7
<b>Low solids stains, toners, and washcoats (containing HOC)</b>	4	0.9
<b>Low solids stains, toner, and washcoats (without HOC)</b>	6.7	7.5
<b>Inks</b>	4.2	1
<b>Multi-colored coatings</b>	5.7	2.5
<b>Pigmented coatings</b>	5	1.6
<b>Sealers (containing HOC)</b>	4.6	1.2
<b>Sealers (without HOC)</b>	5.7	2.5

NOTE: HOC = halogenated organic compound

A facility can meet these limits by using one or a combination of a control device; coatings that are all compliant; or a combination of coatings, some compliant and some not such that the average emission within a particular finishing material category is compliant per the requirements set forth in Section 35-6.2(a) of the regulation.

Rhode Island has no toxic use reduction or pollution prevention planning requirements.

## **C-8 Vermont**

Currently, Vermont specifically exempts the surface coating of wood from its VOC control rules. However, the state plans to issue VOC emission limit rules for the wood furniture industry in accordance with the CAAA Title I requirements by 1998. With regard to hazardous air contaminants, sources are regulated on a case-by-case basis. If a facility emits any air contaminant on the state's list at a level above the state's established action level, the facility is required to inform the state of the quantity emitted of each listed contaminant. The state then determines the hazardous most stringent emission rate (HMSER) for that facility based on feasible emission reduction technology, including control technology and pollution prevention techniques. The most

commonly used solvents in the wood furniture industry - xylene, toluene, MEK and MIBK - are all on the list. Vermont's action levels are summarized in Table C-5.

**Table C-5 Vermont's Hazardous Air Contaminant Action Levels**

<b>Hazardous Air Contaminant</b>	<b>Action Level (lbs. / 8 hours)</b>
<b>MEK</b>	248
<b>MIBK</b>	25
<b>Toluene</b>	464
<b>Xylene</b>	86.3

Under Act 100, passed in 1991, Vermont requires that facilities that use toxic substances and/or generate hazardous waste develop a pollution prevention plan. All facilities that manufacture, process or use more than 10,000 pounds per year of a toxic substance are required to develop a plan, as well as facilities that use more than 1,000 pounds per year if that amount accounts for more than 10 percent of the total toxic substances manufactured, processed or used. A toxic substance is defined as those listed under Title III, Section 313 of SARA. Generators of hazardous waste are required to plan if they generate more than 2,200 pounds of hazardous waste in any one month or if they generate more than 2,640 pounds per year. The P2 plan should include the following:

- C general information about the facility, including a description of the products made and production levels
- C description of the management policy, and employee training and awareness program regarding P2
- C description of current and past P2 efforts
- C listing of toxic substance use in each product, including total quantity used and production level (for those required to file because of toxic substance use), or a list of hazardous waste generation by production process (for those required to file because of hazardous waste generation)
- C detailed description of each process using toxic substances or producing hazardous waste, including input and outputs (i.e. process flow diagram)
- C list of P2 opportunities for each process
- C technical feasibility analysis for each opportunity
- C economic feasibility analysis for each opportunity
- C list of selected P2 opportunities and performance goals (i.e. level of reduction and schedule)

The state requires that facilities submit the summary of their P2 plan for public record. The full plan is to be maintained at the facility and made available on site to state inspectors on request. Wood furniture manufacturers that emit/use more than 1,000 pounds (½ ton) per year of a SARA 313 substance are subject to Vermont's P2 planning requirements.

# APPENDIX D

(Source: *Clean Air Compliance for Wood Furniture Manufacturers*,  
The University of Tennessee, Center for Industrial Services, 1996)

**TABLE D-1: VHAPs Arranged Alphabetically**

**TABLE D-2: Pollutants Excluded from Use in Cleaning and Washoff Solvents**

**TABLE D-3: VHAPs of Potential Concern**

Part 1. Pollutants Identified by Industry

Part 2. Pollutants Listed in the NESHAP

A) "Non-threshold" Pollutants

B) "High Concern" Pollutants

C) "Unrankable" Pollutants

**Table D-1: VHAPs Arranged Alphabetically**

Chemical Name	CAS No.	Chemical Name	CAS No.
1,1-Dimethylhydrazine	57147	2,4-Dinitrotoluene	121142
1,1,2-Trichloroethane	79005	2,4-Toluenediamine	95807
1,1,2,2-Tetrachloroethane	79345	2,4,5-Trichlorophenol	95954
1,2-Dibromo-3-chloropropane	96128	2,4,6-Trichlorophenol	88062
1,2-Diphenylhydrazine	122667	3,3'-Dichlorobenzidine	91941
1,2-Epoxybutane	106887	3,3'-Dimethoxybenzidine	119904
1,2-Propylenimine (2-Methyl aziridine)	75558	3,3'-Dimethylbenzidine	119937
1,2,4-Trichlorobenzene	120821	4-Aminobiphenyl	92671
1,3-Butadiene	106990	4-Dimethylaminoazobenzene	60117
1,3-Dichloropropene	542756	4-Nitrobiphenyl	92933
1,3-Propane sultone	1120714	4-Nitrophenol	100027
1,4-Dichlorobenzene	106467	4,4'-Methylenediphenyl diisocyanate (MDI)	101688
1,4-Dioxane (1,4-Diethyleneoxide)	123911	4,4'-Methylenebis(2-chloroaniline)	101144
2-Acetylaminofluorine	53963	4,4'-Methylenedianiline	101779
2-Chloroacetophenone	532274	4,6-Dinitro-o-cresol, and salts	na
2-Nitropropane	79469	Acetaldehyde	75070
2,2,4-Trimethylpentane	540841	Acetamide	60355
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	Acetonitrile	75058
2,4-D (2,4-Dichlorophenoxyacetic acid, including salts and esters)	94757	Acetophenone	98862
2,4-Dinitrophenol	51285		

Acrolein	107028
<b>Chemical Name</b>	<b>CAS No.</b>
Acrylamide	79061
Acrylic acid	79107
Acrylonitrile	107131
Allyl chloride	107051
Aniline	62533
Benzene	71432
Benzidine	92875
Benzotrichloride	98077
Benzyl chloride	100447
beta-Propiolactone	57578
Biphenyl	92524
Bis(2-ethylhexyl)phthalate (DEHP)	117817
Bis(chloromethyl)ether	542881
Bromoform	75252
Caprolactam	105602
Carbon tetrachloride	56235
Carbon disulfide	75150
Carbonyl sulfide	463581
Catechol	120809
Chloroacetic acid	79118
Chlorobenzene	108907
Chloroform	67663
Chloromethyl methyl ether	107302
Chloroprene	126998
Cresols (isomers and mixture)	1319773
Cumene	98828
DDE (1,1-Dichloro-2,2-bis (p-chlorophenyl)ethylene)	72559
Diazomethane	334883
Dibenzofuran	132649
Dibutylphthalate	84742
Dichloroethyl ether (Bis(2-chloroethyl)ether)	111444
Diethanolamine	111422
Diethyl sulfate	64675
Dimethyl phthalate	131113
Dimethyl sulfate	77781
Dimethylcarbamoyl chloride	79447
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	106898
Ethyl acrylate	140885
Ethyl carbamate (Urethane)	51796
Ethyl chloride (Chloroethane)	75003
Ethylbenzene	100414
Ethylene dibromide (Dibromoethane)	106934
Ethylene glycol	107211
Ethylene dichloride (1,2-Dichloroethane)	107062

Ethylene oxide	75218
Ethylenethiourea	96457
Ethylidene dichloride (1,1-Dichloroethane)	75343
Formaldehyde	50000
<b>Chemical Name</b>	<b>CAS No.</b>
Glycol ethers (footnote "a")	na
Hexachloro-1,3-butadiene	87683
Hexachlorobenzene	118741
Hexachloroethane	67721
Hexamethylene-1,6-diisocyanate	822060
Hexamethylphosphoramide	680319
Hexane	110543
Hydrazine	302012
Hydroquinone	123319
Isophorone	78591
m-Xylene	108383
m-Cresol	108394
Maleic anhydride	108316
Methanol	67561
Methyl tert-butyl ether	1634044
Methyl chloride (Chloromethane)	74873
Methyl ethyl ketone (2-Butanone)	78933
Methyl iodide (Iodomethane)	74884
Methyl isocyanate	624839
Methyl bromide (Bromomethane)	74839
Methyl chloroform (1,1,1-Trichloroethane)	71556
Methyl methacrylate	80626
Methyl isobutyl ketone (Hexone)	108101
Methylene chloride (Dichloromethane)	75092
Methylhydrazine	60344
N-Nitroso-N-methylurea	684935
N,N-Dimethylformamide	68122
N-Nitrosomorpholine	59892
N-Nitrosodimethylamine	62759
N,N-Dimethylaniline	121697
Naphthalene	91203
Nitrobenzene	98953
o-Anisidine	90040
o-Cresol	95487
o-Xylene	95476
o-Toluidine	95534
p-Phenylenediamine	106503
p-Cresol	106445
p-Xylene	106423
Phenol	108952
Phosgene	75445
Phthalic anhydride	85449
Polychlorinated biphenyls (Aroclors)	1336363
Polycyclic Organic Matter (footnote "b")	na
Propionaldehyde	123386



Propoxur (Baygon)	114261
Propylene dichloride (1,2-Dichloropropane)	78875
Propylene oxide	75569
Quinone	106514
Styrene oxide	96093
Styrene	100425
<b>Chemical Name</b>	<b>CAS No.</b>
Tetrachloroethylene (Perchloroethylene)	
	127184
Toluene-2,4-diisocyanate	584849
Toluene	108883
Trichloroethylene	79016
Triethylamine	121448
Trifluralin	1582098
Vinyl bromide	593602
Vinyl chloride	75014
Vinyl acetate	108054
Vinylidene chloride (1,1-Dichloroethylene)	75354
Xylenes (isomers and mixture)	1330207

**Footnotes:**

- a. Includes mono- and di-ethers of ethylene glycol, diethylene glycols and triethylene glycol;  
R-(OCH<sub>2</sub>CH<sub>2</sub>)<sub>n</sub>RR-OR where:  
n = 1, 2, or 3,  
R = alkyl or aryl groups  
R' =R, H, or groups which, when removed, yield glycol ethers with the structure: R-(OCH<sub>2</sub>CH<sub>2</sub>)<sub>n</sub>-OH. Polymers are excluded from the glycol category.
- b. Includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100EC.

**Table D-2: Pollutants Excluded from Use in  
Cleaning and Washoff Solvents**

<b>Chemical Name</b>	<b>CAS No.</b>	<b>Chemical Name</b>	<b>CAS No.</b>
1,1-Dimethyl hydrazine	57147	Chlordane	57749
1,2 - Diphenylhydrazine	122667	Chlorobenzilate	510156
1,2-Dibromo-3-chloropropane	96128	<b>Chemical Name</b>	<b>CAS No.</b>
1,2-Propylenimine (2-Methyl aziridine)	75558	Chloroform	67663
1,2:7,8-Dibenzopyrene	189559	Chromium compounds (hexavalent)	-
1,3-Butadiene	106990	Chrysene	218019
1,3-Dichloropropene	542756	Coke Oven Emissions	99999908
1,3-Propane sultone	1120714	DDE (1,1-p-chlorophenyl 1-2 dichloroethylene)	72559
1,4-Dichlorobenzene(p)	106467	Dibenz (ah) anthracene	53703
1,4-Dioxane (1,4-Diethyleneoxide)	123911	Dichloroethyl ether (Bis (2-chloroethyl)ether)	111444
2-Acetylaminoflourine	53963	Dichlorvos	62737
2-Nitropropane	79469	Diethyl sulfite	64675
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	Dimethyl aminoazobenzene	60117
2,4-Dinitrotoluene	121142	Dimethyl carbamoyl chloride	79447
2,4-Toluene diamine	95807	Dimethyl formamide	68122
2,4,6-Trichlorophenol	88062	Epichlorohydrin	106898
3,3'-Dichlorobenzidine	53963	Ethyl carbamate (Urethane)	51796
3,3'-Dimethoxybenzidine	119904	Ethyl acrylate	140885
3,3'-Dimethyl benzidine	119937	Ethylene dichloride (1,2-Dichloroethane)	107062
4-Aminobiphenyl	92671	Ethylene oxide	75218
4,4'-Methylene bis(2-chloroaniline)	101144	Ethylene thiourea	96457
4,4'-Methylenedianiline	101779	Ethylene dibromide(1,2-Dibromoethane)	106934
7, 12-Dimethylbenz(a)anthracene	57976	Formaldehyde	50000
Acetaldehyde	75070	Heptachlor	76448
Acetamide	60355	Hexachlorobenzene	118741
Acrylamide	79061	Hexamethylphosphoramide	680319
Acrylonitrile	107131	Hydrazine	302012
Aniline	62533	Indeno(1,2,3-cd)pyrene	193395
Antimony trioxide	1309644	Lindane (hexachlorcyclohexane, gamma)	58899
Arsenic and inorganic arsenic compounds	99999904	Methyl hydrazine	60344
Benz(c)acridine	225514	Methylene chloride (Dichloromethane)	75092
Benzene	71432	N-Nitrosomorpholine	59892
Benzidine	92875	N-Nitroso-N-methylurea	684935
Benzo (a) anthracene	56553	N-Nitrosodimethylamine	62759
Benzo (b) fluoranthene	205992	Nickel subsulfide	12035722
Benzo (a) pyrene	50328	Nickel refinery dust	-
Beryllium compounds	7440417	o-Anisidine	90040
Beryllium salts	-	o-Toluidine	95534
Bis(2-ethylhexyl)phtalate (DEHP)	117817	Pentachlorophenol	87865
Bis(chloromethyl)ether	542881	Polychlorinated biphenyls (Aroclors)	1336363
Bromoform	75252	Propoxur	114261
Cadmium compounds	-	Propylene dichloride (1,2-Dichloropropane)	78875
Captan	133062		
Carbon tetrachloride	56235		

Propylene oxide	75569
Selenium sulfide (mono and di)	7488564
Styrene oxide	96093
Tetrachloroethylene (Perchloroethylene)	127184
<b>Chemical Name</b>	<b>CAS No.</b>
Toxaphene (chlorinated camphene)	8001352
Trichloroethylene	79016
Vinyl bromide (bromoethene)	593602
Vinyl chloride	75014

## Table D-3: VHAPs of Potential Concern

### Part 1. Pollutants Identified by Industry

CAS Number	CHEMICAL NAME	EPA DE MINIMIS, tons/yr
11422	Diethanolamine	5.0
50000	Formaldehyde	0.2
68122	Dimethyl formamide	1.0
75092	Methylene chloride	4.0
78591	Isophorone	0.7
79469	2-Nitropropane	1.0
100425	Styrene monomer	1.0
108952	Phenol	0.1
109864	2-Methoxyethanol	10.0
111159	2-Ethoxyethyl acetate	5.0

### Part 2. Pollutants Listed in the NESHAP

#### A) "NONTRESHOLD" POLLUTANTS

Chemical Name	CAS No.	Chemical Name	CAS No.
1,1-Dimethyl hydrazine	57147	4-Nitrobiphenyl	92933
1,1,2-Trichloroethane	79005	4,4'-Methylene bis(2-chloroaniline)	101144
1,1,2,2-Tetrachloroethane	79345	4,4'-Methylenedianiline	101779
1,2 - Diphenylhydrazine	122667	7, 12-Dimethylbenz(a)anthracene	57976
1,2 - Epoxybutane	106887	Acetaldehyde	75070
1,2-Dibromo-3-chloropropane	96128	Acetamide	60355
1,2-Propylenimine (2-Methyl aziridine)	75558	Acrylamide	79061
	189559	Acrylonitrile	107131
1,2:7,8-Dibenzopyrene	106990	Allyl chloride	107051
1,3-Butadiene	542756	Aniline	62533
1,3-Dichloropropene	1120714	Benz(c)acridine	225514
1,3-Propane sultone	106467	Benzene	71432
1,4-Dichlorobenzene(p)	123911	Benzidine	92875
1,4-Dioxane (1,4-Diethyleneoxide)	53963	Benzo (a) pyrene	50328
2-Acetylaminoflourine	79469	Benzo (a) anthracene	56553
2-Nitropropane	1746016	Benzo (b) fluoranthene	205992
2,3,7,8-Tetrachlorodibenzo-p-dioxindioxin	121142	Bis(2-ethylhexyl)phthalate (DEHP)	117817
	95807	Bis(chloromethyl)ether	542881
2,4-Dinitrotoluene	95954	Bromoform	75252
2,4-Toluene diamine	88062	Captan	133062
2,4,5 - Trichlorophenol	53963	Carbon tetrachloride	56235
2,4,6-Trichlorophenol	119904	Chloramben	133904
3,3'-Dichlorobenzidine	119937	Chlordane	57749
3,3'-Dimethoxybenzidine	92671	Chlorobenzilate	510156
3,3'-Dimethyl benzidine		Chloroform	67663
4-Aminobiphenyl		<b>Chemical Name</b>	<b>CAS No.</b>

Chloroprene	126998
Chrysene	218019
Cresols/Cresylic acid (isomers and mixture)	1319773
DDE (1,1-p-chlorophenyl 1-2 dichloroethylene)	72559
Diazomethane	334883
Dibenz (ah) anthracene	53703
Dichloroethyl ether (Bis (2-chloroethyl)ether)	111444
Dichlorvos	62737
Diethyl sulfate	64675
Dimethyl aminoazobenzene	60117
Dimethyl carbamoyl chloride	79447
Dimethyl formamide	68122
Epichlorohydrin	106898
Ethyl acrylate	140885
Ethyl carbamate (Urethane)	51796
Ethylene thiourea	96457
Ethylene dibromide(1,2-Dibromoethane)	106934
Ethylene dichloride (1,2-Dichloroethane)	107062
Ethylene oxide	75218
Ethylidene dichloride (1,1-Dichloroethane)	75343
Formaldehyde	50000
Heptachlor	76448
Hexachlorobenzene	118741
Hexachlorobutadiene	87683
Hexachloroethane	67721
Hexamethylphosphoramide	80319
Hydroquinone	123319
Indeno(1,2,3-cd)pyrene	193395
Isophorone	78591
Lindane (hexachlorcyclohexane, gamma)	58899
m-Cresol	108394
Methyl iodide (Iodomethane)	74884
Methyl chloride (Chloromethane)	74873
Methylene chloride (Dichloromethane)	75092
N-Nitrosodimethylamine	62759
N-Nitroso-N-methylurea	684935
N-Nitrosomorpholine	59892
o-Anisidine	90040
o-Cresol	95487
o-Toluidine	95534
p-Cresol	106445
Pentachloronitrobenzene (Quintobenzene)	82688
Pentachlorophenol	87865
Polychlorinated biphenyls (Aroclors)	1336363
Propoxur	114261

Propylene dichloride (1,2-Dichloropropane)	78875
<b>Chemical Name</b>	<b>CAS No.</b>
Propylene oxide	75569
Quinoline	91225
Styrene oxide	96093
Styrene (footnote "a")	100425
Tetrachloroethylene (Perchloroethylene)	127184
Toxaphene (chlorinated camphene)	8001352
Trichloroethylene	79016
Trifluralin	1582098
Vinyl acetate	108054
Vinyl chloride	75014
Vinyl bromide (bromoethene)	593602
Vinylidene chloride (1,1-Dichloroethylene)	75354

**B) "HIGH-CONCERN" POLLUTANTS**

<b>Chemical Name</b>	<b>CAS No.</b>
2-Chloroacetophenone	532274
2-Methoxy ethanol	108864
2,4-Dinitrophenol	51285
2,4 - Toluene diisocyanate	584849
4,6-Dinitro-o-cresol, and salts	534521
Acetophenone	98862
Acrolein	107028
Benzotrichloride	98077
Benzyl chloride	100447
beta-Propiolactone	57578
Carbon disulfide	75150
Chloroacetic acid	79118
Chloromethyl methyl ether	107302
Cobalt carbonyl	10210681
Dimethyl sulfate	77781
Ethylene imine	151564
Ethylene oxide	75218
Fluomine	62207765
Hexachlorocyclopentadiene	77474
Maleic anhydride	108316
Mercury, (acetato-o) phenyl	62384
Methyl isocyanate	624839
Methyl bromide (Bromomethane)	74839
Methyl hydrazine	60344
Methylcyclopentadienyl manganese	12108133
Methylene diphenyl diisocyanate	101688
N,N-Dimethylaniline	121697
Nickel Carbonyl	13463393
Nitrobenzene	98953
Parathion	56382
Phenol	108952
Tetraethyl lead	78002
Tetramethyl lead	75741

**C) "UNRANKABLE" POLLUTANTS**

<b>Chemical Name</b>	<b>CAS No.</b>
2,2,4-Trimethylpentane	540841
4-Nitrophenol	100027
Carbonyl sulfide	463581
Catechol	120809
Dibenzofurans	132649
Diethanolamine	11422
Glycol ethers (footnote "b")	-
Hexamethylene-1,6-diisocyanate	822060
Phthalic anhydride	85449
Polycyclic organic matter (footnote "c")	-
Propionaldehyde	123386
Quinone	106514

**Footnotes:**

- The EPA does not currently have an official weight-of-evidence classification for styrene. For purposes of this rule, styrene is treated as a "nonthreshold" pollutant.
- Except for 2-ethoxy ethanol, ethylene glycol monobutyl ether, and 2-methoxy ethanol.
- Except for benzo(b)fluoranthene, benzo(a)anthracene, benzo(a)pyrene, 7,12-dimethylbenz(a)anthracene, benz(c)acridine, chrysene, dibenz(ah) anthracene, 1,2:7,8-dibenzopyrene, indeno(1,2,3-cd)pyrene, but including dioxins and furans.

# APPENDIX E

## Information Resources

### **Coating Vendors:**

Rashed Kanaan  
C.E. Bradley Laboratories  
PO Box 8238  
Brattleboro, VT 05304  
(802) 257-7971  
(Aqueous-based Coatings)

Rick Piro  
Lilly Industries  
PO Box 2358  
High Point, NC 27261  
(800) 395-7047, Ext 234  
(Solvent and Aqueous-based Coatings)

Alexander Ross  
Radtech International  
400 N. Cherry  
Falls Church, VA 22046  
(703) 534-9313  
(UV-Cured Coatings)

Stephen Salvato  
H.B. Fuller  
3530 Lexington Ave. N.  
St. Paul, MN 55126  
(612) 481-1588  
(Contact Adhesives)

Kevin Roots  
Western Ecotec Coatings  
708 W. Mill Street, Suite D  
San Bernardino, CA 92410  
(909) 889-6655  
(Aqueous-based Coatings)

### **Equipment Vendors:**

Wayne Travis  
Graco, Inc.  
4050 Olson Memorial Hwy  
Golden Valley, MN 55422  
(612) 623-6668

Jack Bransfield  
Norris-Wiener  
90 Chelmsford Road  
N. Billerica, MA 01862

(508) 670-5633

### **Trade Associations:**

Larry Runyan  
American Furniture Manufacturers Assoc.  
P.O. Box HP-7  
High Point, NC 27261  
(910) 884-5000

Brad Miller  
Business and Institutional Furniture Manufctrs Assoc.  
2680 Horizon Drive S.E.  
Gran Rapids, MI 49546  
(616) 285-3963

Dick Titus  
Kitchen Cabinet Manufacturers Association  
1899 Preston White Drive  
Reston, VA 22091-4326  
(703)264-1690

Philip A. Bibeau  
Wood Products Manufacturers Association  
175 State Road East  
Westminster, MA 01473  
(508) 874-5445

### **Trade Journals**

*Furniture Design and Manufacturing*

*Kitchen and Bath Business*

*Kitchen and Bath Design News*

*Upholstery Design and Manufacturing*

*Wood and Wood Products*

### **EPA Federal Air Regulation Information:**

Janet Bowen  
U.S. EPA Region I  
JFK Federal Building (CAP)  
Boston, MA 02203  
(617) 565-3595





Umesh Dholakia  
U.S. EPA Region II  
290 Broadway  
New York, NY 10007  
(212) 637-3725

Paul Almodovar  
U.S. EPA  
Emission Standards Division (MD-13)  
Research Triangle Park, NC 27711  
(919) 541-0283

**Northeast States Air Regulation and Technical Assistance Information:**

***Connecticut:***

Dennis Demchak  
CT DEP Bureau of Air Management  
79 Elm Street  
Hartford, CT 06106-5127  
(860) 424-3446

David Westcott  
CT DEP Bureau of Waste Management  
79 Elm Street  
Hartford, CT 06106  
(860) 424-3666

***Maine:***

Kim Hibbard  
ME DEP Bureau of Air Quality Control  
State House Station #17  
Augusta, ME 04333  
(207)287-4855

Chris Rushton  
ME DEP Office of Innovation and Assistance  
State House Station #17  
Augusta, ME 04333  
(207) 287-2437

***Massachusetts:***

Yi Tian  
MA DEP Division of Air Quality Control  
One Winter Street, 7th Floor  
Boston, MA 02108  
(617) 292-5871

George Frantz  
MA Office of Technical Assistance  
Executive Office of Env. Affairs  
100 Cambridge Street, Room 2109  
Boston, MA 02202

(617) 727-3260, Ext. 631

Paul Walsh  
MA DEP Toxics Use Reduction Program  
One Winter Street, 7th Floor  
Boston, MA 02108  
(617) 556-1011

***New Hampshire:***

Michele Andy  
NH DES Air Resources Division  
64 North Main Street  
P.O. Box 2033  
Concord, NH 03302-2033  
(603) 271-1370

Rudolph Cartier  
NH Small Business TAP  
64 North Main Street  
Concord, NH 03034  
(603) 271-1379

***New Jersey:***

William Etherington  
NJ DEP Bureau of New Source Review  
401 E. State Street, 2nd Floor  
CN 027  
Trenton, NJ 08625-0418  
(609) 633-8245

Mike DiGiore  
NJ DEP Office of Pollution Prevention  
401 East State Street CN 423  
Trenton, NJ 08625  
(609) 777-0518

Douglas Kretkowski, NJ TAP  
NJ Institute of Technology  
CEES Building  
323 King Blvd.  
Newark, NJ 07102  
(201) 596-5863

***New York:***

Frances Craner  
NY DEC Division of Air Resources  
50 Wolf Road  
Albany, NY 12233  
(518) 457-7688

Sharon Rehder  
NY DEC Pollution Prevention Unit  
50 Wolf Road, Room 202

Albany, NY 12233-8010  
(518) 457-2553

***Rhode Island:***

Gina Friedman  
RI DEM Division of Air and Hazardous Materials  
291 Promenade Street  
Providence, RI 02908  
(401) 277-2808, Ext. 7016

Richard Girasole  
RI DEM Office of Environmental Coordination  
235 Promenade Street  
Providence, RI 02908  
(401) 277-3434, Ext. 4414

***Vermont:***

Brian Fitzgerald  
VT DEC Air Pollution Control Division  
103 South Main Street, Bldg. 3 South  
Waterbury, VT 05671-0402  
(802) 241-3848

Paul VanHollebeke  
VT DEC Pollution Prevention Division  
103 South Main Street  
Waterbury, VT 05671-0404  
(802) 241-3629

Judy Mirro  
VT DEC Small Business Compliance Assistance  
103 South Main Street  
Waterbury, VT 05671  
(802) 241-3745

**Other Technical Assistance Providers:**

Jennifer Griffith, P.E.  
NEWMOA and NESCAUM  
129 Portland Street, 6th Floor  
Boston, MA 02114  
(617) 367-8558, Ext. 303

Allan Butler  
Concurrent Technologies Corporation  
510 Washington Ave, Suite 120  
Bremerton, WA 98337-1844  
(360) 405-5408

Lynn Corson and Alice Smith  
Indiana Clean Manufacturing Technology and Safe  
Materials Institute (CMTI)  
2655 Yeager Road, Suite 103  
West Lafayette, IN 47906-1337  
(765) 463-4749

Katy Wolf  
Institute for Research and Technical Assistance  
2800 Olympic Blvd., Suite 101  
Santa Monica, CA 90404  
(310) 453-0450

Tim Piero  
KSU Pollution Prevention Institute  
133 Ward Hall  
Manhattan, KS 66506-2508  
(785) 532-6501

Darrell Soyars  
Nevada Small Business Development Center/032  
University of Nevada at Reno  
Reno, NV 89557-0100  
(702) 784-1717

Gary Hunt and David Williams  
North Carolina Office of Waste Reduction  
PO Box 29569  
Raleigh, NC 27626  
(919) 715-6500

Chris Motovino  
Pacific Northwest P2 Resource Center  
1326 Fifth Ave, Suite 650  
Seattle, WA 98101  
(206) 223-1151

Richard Illig  
Pennsylvania DEP Office of P2 & Compliance Assist.  
208 W. Third Street  
Williamsport, PA 17701  
(717) 327-3568

Larry Watkins  
South Coast Air Quality Management District  
21865 E. Copley Drive  
Diamond Bar, CA 91765-4182  
(909) 369-3246

Tom Griffin  
Virginia DEQ Office of Pollution Prevention  
629 E. Main Street, 5th Floor  
Richmond, VA 23219  
(804) 698-4545

Phillip (Jack) Annis  
Solid and Hazardous Waste Education Center  
University of Wisconsin-Extension  
2420 Nicolet Drive ES-317  
Green Bay, WI 54311-7001

Jon Heinrich

Wisconsin Bureau of Air Management  
AM/10-PO Box 7921  
Madison, WI 53707  
(608) 267-7547