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Enforceability Aspects of RACT for Factory Surface Coating of Flat Wood Paneling

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Enforceability Aspects of RACT for Factory Surface Coating of Flat Wood Paneling

by

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SECTION 1

EXECUTIVE SUMMARY

Revised State Implementation Plans (SIP's) must include controls for emissions of volatile organic compounds (VOC's) from the factory surface coating of flat wood paneling. States having nonattainment areas for oxidants must establish controls for this industry in the plans to be issued by July 1, 1980. The U.S. Environmental Protection Agency (EPA) Control Technique Guideline (CTG) for flat wood paneling recommends materials changes, process changes, or add-on controls.[1] Because paneling coaters have not been regulated in the past (except in California), PEDCo was asked to investigate potential enforceability problems associated with the regulation of this industry.

This report identifies the coaters in the flat wood paneling industry, discusses the processes involved in finishing panels, identifies sources of VOC and particulate emissions, estimates VOC emissions, discusses the compatibility of coating operations with control technology, and assesses the ability of the industry to comply with the proposed regulations in the time allowed. Anticipated enforcement problems are then discussed.

The information in this report was obtained from industry directories; Department of Commerce statistics; technical literature; and contacts with state air pollution control agencies, paneling coaters, and coating suppliers. Six plant visits were made.

The VOC emission guidelines apply to printed interior paneling made of hardwood plywood or thin particle board, natural-finish hardwood panels, or hardboard paneling with Class II finishes. Proposed VOC emission limits for these classes of products are 2.9 kg/100 m^2 (6.0 lb/1000 ft^2) from printed interior panels, 5.8 kg/1000 m^2 (12.0 lb/1000 ft^2) from natural-finish plywood panels, and 4.8 kg/100 m^2 (10.0 lb/1000 ft^2) from Class II finishes. The limits do not apply to exterior siding, tile board, particle board used in furniture, or softwood panels. Process descriptions and flow diagrams identifying emission sources are presented in Section 3.1. The various coatings and coating methods are also discussed.

The study identifies 57 coaters of flat wood paneling to which the proposed regulations apply. Most of these manufacturers are located in the South and West. Their distribution by EPA Region is shown in Table 1.

TABLE 1. DISTRIBUTION OF COATING PLANTS BY EPA REGION

EPA Region	Number of coating plants identified
I	1
II	2
III	7
IV	13
V	9
VI	6
VII	0
VIII	1
IX	8
X	10

The CTG indicated a much greater number of coaters than the 57 identified here; however, this study does not include the coating of softwood products or of products other than panels (such as furniture components). The number of coaters has also declined over the last few years.

Sixty-one percent of the 57 plants are in attainment areas for oxidants; 75 percent of the plants are in attainment areas for particulates.

According to information from various coating suppliers, factory surface coating of flat wood paneling emitted a total of about 11,000 tons of VOC in 1978. Emissions in 1970 were estimated at 34,000 tons VOC. These figures show an emission reduction of approximately 70 percent with a production decrease of 15 percent.

Methods currently used to control VOC emissions from factory surface coating of paneling are incineration, use of water-based coatings rather than solvent-based coatings, and use of ultraviolet-curable (UV) and electron-beam-curable (EB) coatings. The advantages and disadvantages of each control method are summarized in Table 2. Carbon adsorption has not been used as a control method in this industry.

TABLE 2. ADVANTAGES AND DISADVANTAGES OF VOC CONTROL METHODS USED IN THE PANELING INDUSTRY

Control method	Advantages	Disadvantages
Water-based coatings	Fewer fumes Greater worker comfort Less fire hazard Lower insurance Easier cleanup	More difficult to dry Requires experimentation to develop satisfactory coating for a particular line Requires some equipment changes Must store above freezing temperatures
Ultraviolet- and electron-beam-curable coatings	Good quality finish Very fast curing	Expensive to buy and operate Requires safety precautions Some adhesion problems with other coatings
Incineration (or afterburners)	Allows use of more solvent while meeting emission standards	Expensive to buy and operate Efficiency may be low

Use of water-based coatings, the most widely applied method, is significantly decreasing VOC emissions. During the last decade, conversion to water-based coatings has been accompanied by experimentation and improvement in product quality. Conversion is likely to continue as coaters improve the technology of the products and as VOC control regulations are adopted.

Water-based coatings are desirable for several reasons. The coating emits fewer fumes because its organic content is low; worker comfort is increased and fire hazards are reduced, which in turn reduce equipment and insurance costs. Finally, plants are more likely to meet air pollution standards.

In the years of experimentation, many quality control problems have been solved but few satisfactory water-based inks and topcoats have been developed. Suppliers expect their development to require several more years. Conversion also means substantial investments for new or modified drying ovens, as well as changes in equipment (such as coating trays that are plated to minimize corrosion).

Coatings that are cured by ultraviolet light or an electron beam nearly eliminate VOC emissions. The systems are capital intensive, however, which has slowed their adoption.

Incinerators are rarely used because fuel costs are prohibitive; only one plant in the survey uses afterburners on its drying ovens.

In general, particulate emissions from sanders and groove cutters at coating plants are easily controlled by cyclones and fabric filters. These controls were used in all the plants visited.

The EPA guideline document for this industry allows up to 2 years for the reduction of VOC emissions.[2] About half of the industry people who commented on the compliance schedule felt that it was realistic. Some expressed concern over the costs of meeting VOC emission standards within this time. A smaller number (17 percent) believed that the standards were too stringent for a 2-year time period, primarily because of the need for technology development.

Enforcement of standards for coating plants in the paneling industry is not expected to require a major effort, for the following reasons:

The number of plants is relatively small. Most are in attainment areas for oxidants (61 percent) and particulates (75 percent).

The amounts of VOC and TSP emissions are also relatively small.

Widespread use of water-based coatings is significantly reducing VOC emissions. This trend is expected to continue.

Growth in the industry is slow. Few new plants will be added to the inventory in the next few years, and small plants will continue to close.

SECTION 2

INTRODUCTION

2.1 BACKGROUND

Regulations published in the Federal Register of August 28, 1979 (Vol. 44, No. 168) require states to submit revised State Implementation Plans by July 1, 1980, reflecting volatile organic compound (VOC) regulations for (among others) factory surface coating of flat wood paneling. As a result, state and local agencies will become involved with an industry that had not previously been regulated for VOC emissions (except in California).

In June 1978, a Control Technique Guideline (CTG) was published for control of VOC from factory surface coating of flat wood paneling.[1] The CTG provides emission limitations that can be achieved through the application of reasonably available control technology (RACT). In the flat wood finishing industry, RACT consists mainly of the use of water-based and high-solids coatings. Other RACT options include add-on devices, either incineration or adsorption, and process changes, specifically ultraviolet or electron-beam curing.

Because VOC emissions from the industry have not generally been regulated in the past, this study is designed to characterize the industry and to evaluate its ability to comply with the proposed regulations. Our intention is to review the coating processes and to assess the compatibility of the unit operations with various RACT options. We have reviewed problems or successes encountered by some plants that have already adopted RACT options, and have included some industry comments. We have also reviewed the compliance schedule in the guideline document.[2]

2.2 PURPOSE AND SCOPE

The Division of Stationary Source Enforcement (DSSE) of the U.S. Environmental Protection Agency (EPA), under Contract No. 68-01-4147, authorized PEDCo to conduct a 6-month study of the enforceability aspects of RACT for factory surface coating of flat wood paneling. The purpose of the study was to identify problems that the industry will face in adopting RACT when VOC regulations are enacted by individual states.

The project includes five subtasks:

1. Develop information on the population and geographic distribution of the industry, estimating annual emissions for a reasonable range of production rates.
2. Review the processes and the emission control methodologies for the purpose of identifying problems in matching process equipment to control equipment.
3. Based on items 1 and 2, recommend realistic compliance schedules for the industry.
4. Investigate existing control methodologies for the industry and determine potential problem areas.
5. Prepare a final report of the findings of the first four subtasks.

2.3 SOURCES OF INFORMATION

Many sources, as listed below, were used to identify coaters:

Directory of Panel Plants - USA (Forest Industries)[3]

County Business Patterns (U.S. Dept. of Commerce)[4]

Directory of Hardwood Plywood Prefinish Industry (Hardwood Plywood Manufacturers Association)[5]

Compliance Data System (Quick Look Report)[6]

Control of Volatile Organic Emissions from Existing Stationary Sources - Volume VII: Factory Surface Coating of Flat Wood Paneling (EPA)[1]

Guidance to State and Local Agencies in Preparing Regulations To Control Volatile Organic Compounds from Ten Stationary Source Categories (EPA)[2]

In addition to these specific sources, we contacted air pollution control agencies for each state where coaters or paneling plants are located.

From these sources, we compiled a list of 501 paneling plants. We contacted each plant by phone to identify those that coat paneling.

Statistical data on the industry were obtained from the 1977 Census of Manufactures, published by the Bureau of Census (U.S. Department of Commerce), for SIC's 2435 (Hardwood Veneer and Plywood), 2492 (Particle board), and 2499 (Hardboard). Other sources of statistical data were journal articles and the CTG; some data were also obtained from trade associations, coating plants, and coating suppliers.

Process description information was obtained from the CTG, from literature, and from the six plant visits that we conducted during the study.

Emissions data were obtained from coating suppliers, trade associations, and coating plants. We also asked representatives at these sources to comment on the compliance schedule, on the RACT options, and on their implementation.

SECTION 3

INDUSTRY CHARACTERIZATION

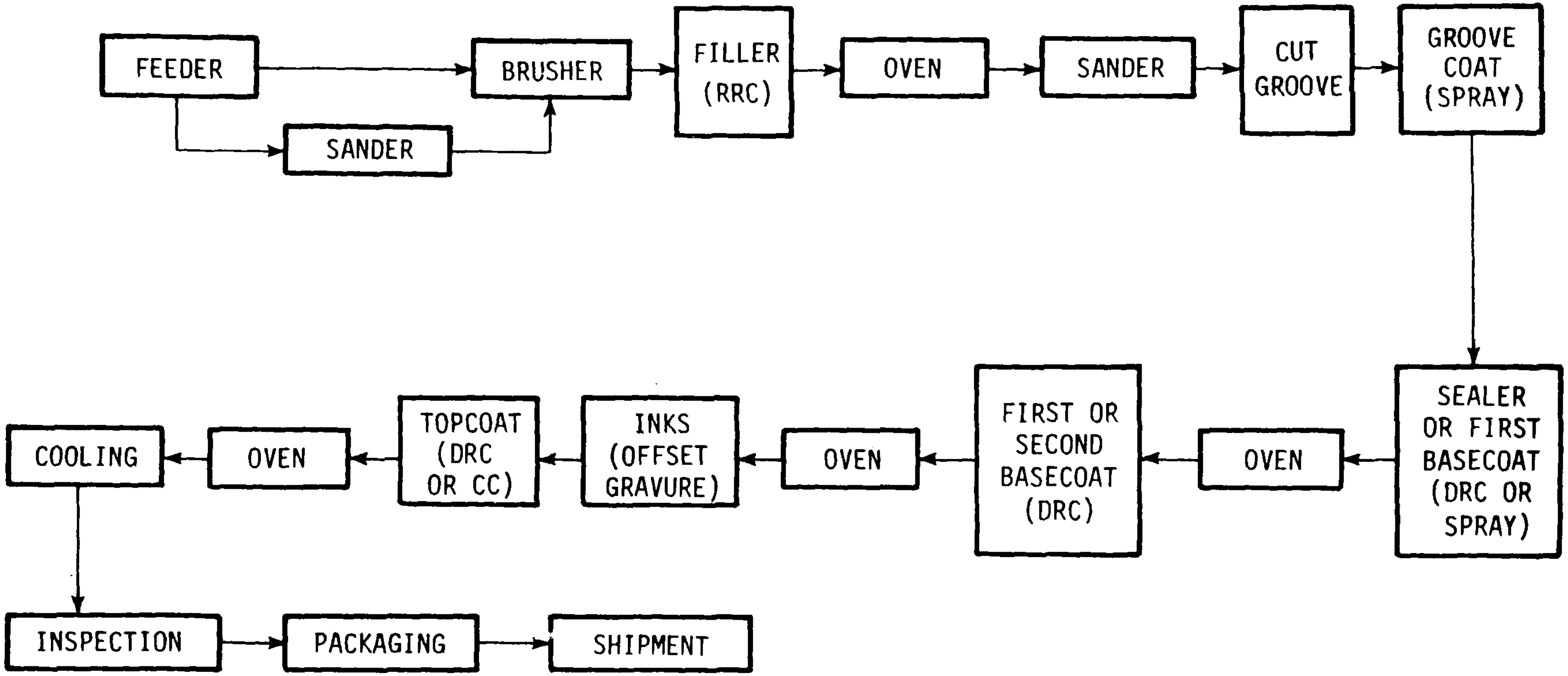
3.1 PROCESS DESCRIPTION

Printed interior paneling products are made by applying a decorative finish to the surface of lauan (an imported tropical hardwood), hardboard, or particle board. The components and procedures of the coating production lines vary from plant to plant. The basic series of coatings is filler, base coat, inks, and topcoat. Most lines also include a groove coat.

The following general process descriptions and flow diagram (Figure 1) show typical production line variations. Product categories include printed interior paneling and natural hardwood plywood interior paneling.

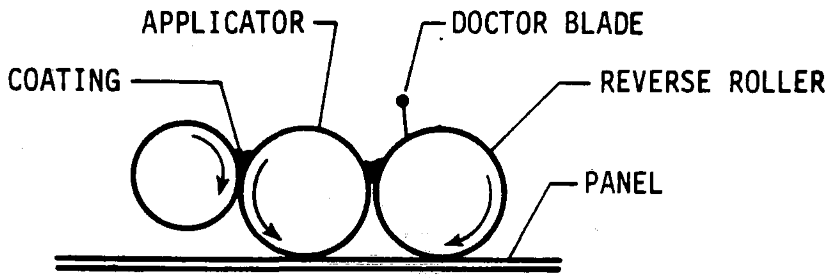
The first step in finishing the board is sanding or brush dusting to provide a smooth, dust-free surface. Hardboard may need to be tempered with oil and resin for added strength and stability before brushing.

The next step is application of filler. Filler is normally applied by reverse-roll coating. Roll coating is a process in which coating is applied to the wood by cylindrical rollers. The reverse-roll coater (Figure 2A) consists of a coating applicator roll that rotates in the direction of panel movement, followed by a wiper roll that rotates against the direction of the panel movement. The reverse roller forces the filler into the depressions, voids, and cracks in the panels and removes excess coating material. Filler provides a smooth, even surface for further coating applications.

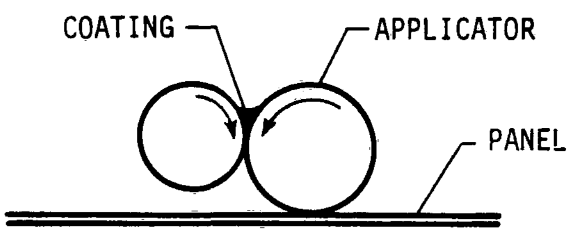


RRC = REVERSE ROLL COATING
DRC = DIRECT ROLL COATING
CC = CURTAIN COATING

Figure 1. Printed interior paneling line (lauan, hardboard, and particle board).



A. REVERSE ROLL COATER



B. DIRECT ROLL COATER

Figure 2. Simplified schematic of roll coaters.

Fillers must dry fast, sand easily, seal the board (especially if no separate sealer is applied), and not shrink with age. Several different fillers, each with various advantages and disadvantages, are available: (1) polyester filler, which is ultraviolet cured, (2) water-based filler, (3) lacquer-based filler, (4) polyurethane filler, and (5) alkyd-urea-based filler. Water-based fillers are in common use on printed paneling lines. Filler is not applied to prefilled particle board or to boards that can remain nonfilled. It is sometimes applied more than once to assure complete coverage of particularly porous substrates, and can be followed by application of a separate sealing compound. The sealer may be water- or solvent-based, and is usually applied to seal off pores and substances in the wood that could affect subsequent finishes. Filling and sealing operations are both followed by ovens (steam heated, convection, infrared, or ultraviolet) and by sanders.

The next step in many coating lines is groove cutting, followed by groove coating. Groove cutting can, however, be performed at other points in the coating process--before filling, for example. Groove color can be applied in different ways, but commonly by air sprays. Groove coats are usually pigmented, low-resin solids that are reduced with water before use. Even in coating operations that are entirely solvent based, the groove coat may be water based.

The next step for printed paneling is application of the base coat, which provides a smooth surface of the appropriate color on which to print the wood grain or other pattern (the original grain is completely obscured). Base coats must be fast drying and provide good coverage. In printed paneling, they fall into the following categories: lacquer, synthetic, vinyl, modified alkyd urea, catalyzed vinyl, and water based (used primarily on lauan paneling at this time.

Basecoats are usually applied by direct-roll coaters (Figure 2B). This coater is an applicator cylinder that rotates in the same direction as the panel movement.

After passing through an oven (gas fired, infrared, etc.), the panel is printed. Inks are applied by an offset gravure printing operation similar to direct-roll coating. Several colors may be used to reproduce the appearance of wood, marble, leather, textured cloth, and so on. The final effect depends on surface smoothness, color of the base coat and inks, strength and transfer properties of the inks, and other variables. Most lauan printing inks are pigments dispersed in alkyd resin, with some nitrocellulose added for better wipe and printability. Water-based inks may have a good future for cost and ecological reasons, but they are not currently used in any significant amounts.

After printing (or after base coat application, if no printing is done), a clear, protective topcoat is applied to the board by one or two direct-roll coaters or curtain coaters. These are wet-on-wet applications. Most topcoats are organic-solvent-based coatings, some are synthetic, being prepared from solvent-soluble alkyd or polyester resins, urea formaldehyde cross-linkings, or other resins. Some water-based topcoats are used; these often contain an alkyd-urea catalyst. The synthetic topcoats are catalyzed and sent through a hot-air oven for curing; other topcoats are cured in infrared or ultraviolet ovens. The panels are cooled prior to stacking, inspection, and shipping.

A curtain coater applies a free-falling film of coating to the panel. In a pressure-head curtain coater (Figure 3), coating material is metered into a pressure head, then forced through a calibrated slit between two knives. The rate of panel movement and the controlled uniform flow of the film determines the coating thickness. The important variables are physical properties of the material, temperature, slit width, coating flow rate, and panel speed. Excess coating is caught in a trough and recirculated.

Natural-finish hardwood plywood interior paneling undergoes a more involved coating process. This paneling is produced in very few plants (probably only six plants in the entire United

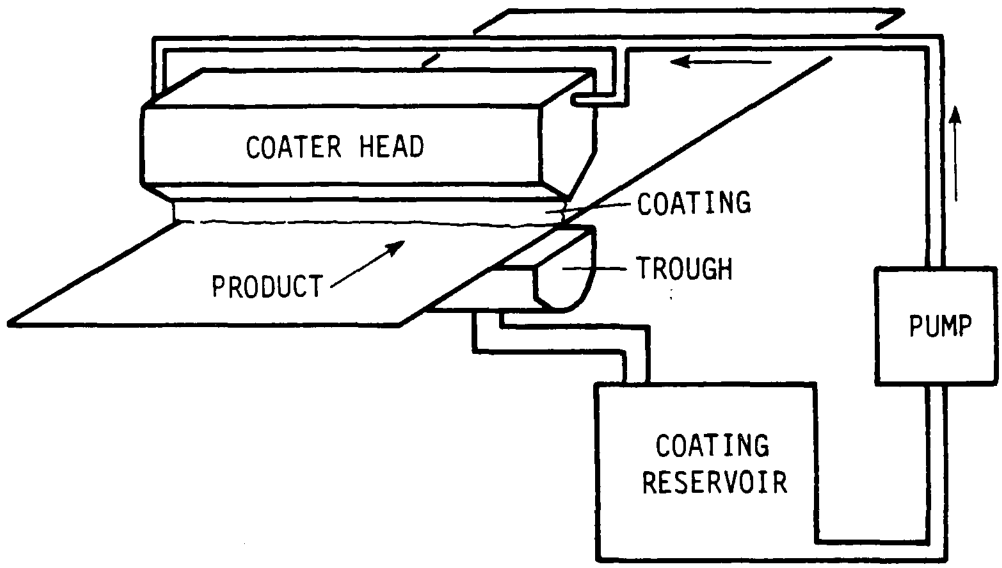


Figure 3. Pressure-head curtain coater.

States, according to an industry representative). Only a brief, general description of the process will be presented here; some variations occur among plants.

The first step in finishing a natural-finish hardwood panel is to fill the open knots with a putty material. The second step is to cut a groove and paint it with an opaque finish. The panel is then sanded prior to application of a stain, which gives the surface a uniform color without raising the grain of the wood fiber. The stain is normally applied by a direct-roll coater. The panel is then dried in a high-velocity or infrared oven.

A thin wash coat, known as a toner if it is colored with dyes or transparent pigments, may then be directly rolled on to seal the stain and to improve the clarity and lightness of the finish. Next, the plywood is filled, usually by a reverse-roll coater, and then dried and polished in a brush unit.

The primer sealer is the next coating applied, normally by direct-roll coating. The sealer, which floods the complete panel, protects the wood from moisture, provides a smooth base for the topcoat, and gives gloss to the grooves. The sealed board is then dried, sanded, and buffed.

At this point, the surface of the panel is embossed and valley printed to give a distressed or antique appearance. One or more print steps may then be added. The panel is then dried, and it is sealed with a direct-roll coater to smooth the surface in preparation for topcoating.

One or more topcoats are applied to provide durability, protection, and gloss. Direct-roll coating is the usual application method, but curtain coating may also be utilized. The final topcoat is cured and the panels are cooled, buffed, and stacked for shipment.

3.2 DEMOGRAPHY

One of the first requirements of this study was an accurate inventory of flat wood paneling coating plants. The first reference consulted was the Census of Manufactures.[7] According to this source, about 670 flat wood plants were in operation in 1977. This total, however, includes many plants to which the regulations do not apply, either because the plants make or coat products other than paneling or because they coat softwood products. Table 3 provides information on the plants that actually produce prefinished interior paneling. This information does not indicate the total number of plants with coating operations, because some plants produce more than one kind of prefinished product.

Other sources were thus investigated to reduce this number to include only those plants covered by the proposed flat wood paneling regulations. Listings from the 1979 Directory of Panel Plants-U.S.A.[3] and from wood products associations,[5,8] together with direct phone contacts, were used to compile total plant numbers for all flat wood plants with surface coating operations. The results of this survey are presented in Table 4. From this information, we can see that the total number of interior paneling coating plants is small when compared with the total flat wood industry (see Appendix A, Table A-3, for further data): only 57 plants were identified in this survey. Further, the 13 largest plants (20% of coating plants) account for about 60 percent of the production.

Although coating plants are found throughout the United States, most are located in the South and on the West Coast. (Table 4 shows the distribution of plants by EPA region.) Region IV (the southeastern states) and Regions IX and X (the Pacific coast states) contain more than half the plants and most of the biggest producers. Appendix A presents a state-by-state tally of coating plants. California, Virginia, and Oregon are the three states with the largest production of prefinished interior paneling (about 50% of total production). Table 5 summarizes the attainment status of flat wood paneling coating operations. Of the 57 flat wood coating plants, 35 plants (61%) are located in attainment areas for oxidants; and 43 plants (75%) are located in attainment areas for particulates.

TABLE 3. 1977 CENSUS OF MANUFACTURES INFORMATION ON PANELING COATING PLANTS WITH SHIPMENTS OF $100,000 OR MORE[7]

Product (SIC code)	Number of companies	Product shipments[a]	
		Quantity (million ft^2)	Value (million dollars)
Prefinished hardwood plywood (24352 00)	26	2565.1	390.2
Hardwood veneer panels[b] (24353 31)	9	107.1	12.8
Prefinished hardboard panelings from self-produced hardboard (24996 11)	12	4864.8	353.9
From purchased hardboard (24998 03)	19	419.1	90.1
Coated or prefinished medium-density fiberboard[c] (24997 11)	11	230.1	28.9
Prefinished particle board[c] (24999 65)	21	NA	66.5

[a] Includes all producers, not just shipments over $100,000.

[b] Includes noncoated production.

[c] Includes products used for purposes other than paneling.

NA = Not available.

TABLE 4. SUMMARY OF FLAT WOOD PANELING PLANTS WITH SURFACE COATING OPERATIONS

EPA region	Total plants	Hardwood plywood	Particle board	Hardboard panelboard, fiberboard	Production	
					≥200 million ft^2/yr	<200 million ft^2/yr
I	1	1				1
II	2	2				2
III	7	3	2	2	2	5
IV	13	6	2	5	2	11
V	9	3		6	2	7
VI	6	3	2	1		6
VII	0					
VIII	1		1			1
IX	8	6	1	1	5	3
X	10	3	2	5	2	8
Total	57	27	10	20	13	44

TABLE 5. ATTAINMENT STATUS OF FLAT WOOD PANELING PLANTS WITH SURFACE COATING OPERATIONS

EPA region	Number of plants	Oxidants		Particulates	
		Attainment	Nonattainment	Attainment	Nonattainment
I	1	0	1	1	0
II	2	0	2	1	1
III	7	4	3	7	0
IV	13	9	4	9	4
V	9	7	2	6	3
VI	6	1	5	4	2
VII	0	0	0	0	0
VIII	1	1	0	0	1
IX	8	4	4	6	2
X	10	9	1	9	1
Total	57	35	22	43	14
Percentage	100	61	39	75	25

3.3 EMISSIONS

The predominant emissions from flat wood surface coating operations are volatile organic compounds, which are emitted by the evaporation of the volatile organic solvents contained in conventional coatings. Other emissions include small quantities of particulates from sanding and groove-cutting operations and combustion emissions from gas-fired ovens.

3.3.1 Sources and Quantity of VOC Emissions

The VOC emissions from flat wood coating plants occur primarily at the coating lines. Figure 4 presents a schematic diagram of emission sources in the coating line. Oven exhausts are discrete point sources. Printing operations may be enclosed in a room with controlled airflow. In this case, the printer represents a point source, with emissions vented to the roof along with oven exhausts. All other coaters and rollers are considered fugitive emission sources. Another source of fugitive VOC emissions is the vaporization of organics at paint mixing and storage areas.

The solvents in organic-based coatings are usually multicomponent mixtures, including methyl ethyl ketone, methyl isobutyl ketone, toluene, xylene, butyl acetates, propanol, ethanol, butanol, VM and P naphtha,* methanol, amyl acetate, mineral spirits, SoCal I and II, glycols, and glycol ethers. Organic solvents most often used in water-based coatings are glycol, glycol ethers (such as butyl cellosolve), propanol, and butanol. Table 6 shows the amounts of volatile organics in the different conventional coatings supplied to the flat wood coating industry, as well as the estimated emission factors (solvent density). The composition of the solvent determines the type of VOC emitted. Water-based coatings are discussed in Section 4.

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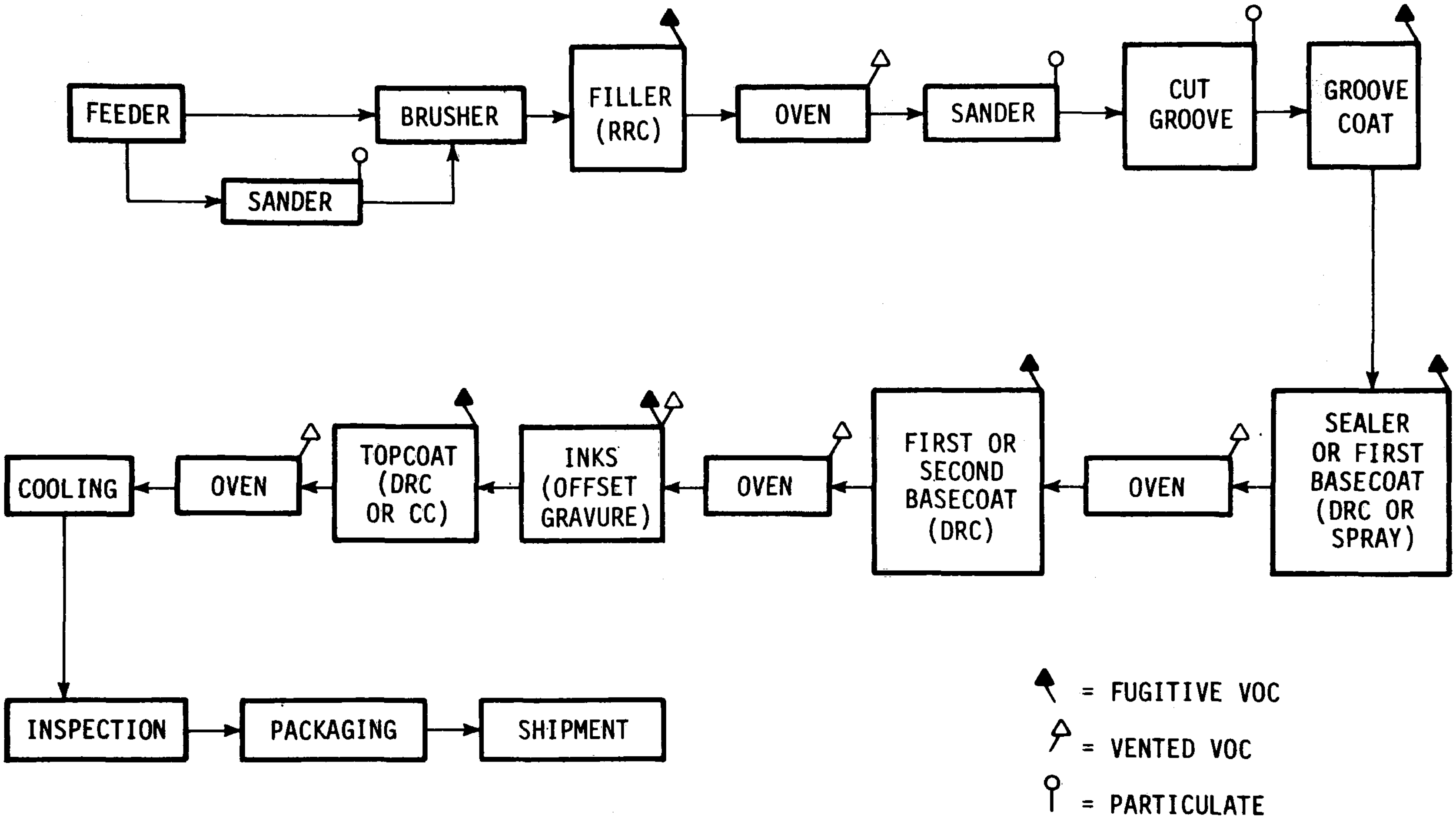
* VM and P: Varnish maker's and painter's; a refined solvent naphtha.



RRC = REVERSE-ROLL COATING
DRC = DIRECT-ROLL COATING
CC = CURTAIN COATING

Figure 4. Emission sources in the coating line.

TABLE 6. VOLATILE ORGANIC CONTENT OF CONVENTIONAL FLAT WOOD COATINGS

Paint type	Density kg/liter	Density (lb/gal)	Volatile organics, weight percent
Filler	1.7	(14.5)	15 to 30
Sealer	1.1	(9)	15 to 50
Base coat	1.4	(11.5)	40 to 75
Grain ink	1.2	(10)	30 to 70
Topcoat	1.1	(8.8)	50 to 75

Source: Reference 9.

Particulate emissions from sanders and groove cutters are collected with fabric filters and cyclones. If particulates from precoating sanders can be collected separately from other particulates, the collected material can be sold or recycled. Other particulates must be disposed of in landfills.

Natural gas is the primary fuel used in the drying and curing ovens; liquefied petroleum gas is the primary backup fuel when natural gas supplies are curtailed or where natural gas is not available. Some coating plants use infrared or ultraviolet cure ovens, which are electrically heated. These ovens can eliminate onsite combustion emissions, such as carbon monoxide, unburned fuel, and nitrogen oxides. Ultraviolet ovens produce a small amount of ozone, which is usually not a problem.

3.3.2 Factors Influencing VOC Emissions

Organics vaporize at ambient temperature and pressure. Emissions from ovens are at ambient pressure and at temperatures determined by the substrate and the coatings used. Table 7 lists the common organic solvents used in conventional coatings and their vapor pressures and relative evaporation rates. The evaporation rate indicates the rate of VOC emissions relative to each compound. For example, ethanol evaporates three times faster

TABLE 7. VAPOR PRESSURE AND EVAPORATION RATE OF SOLVENTS USED IN COATINGS

Compound	Vapor pressure, at 20°C, mmHg	Evaporation rate[a]
Butanol, iso	8.8	0.63
Butanol, n	4.4	0.46
Butanol, sec	12.7	0.90
Ethanol, anhydrous	44.0	1.9
Propanol, anhydrous	31.2	1.7
Methanol	96.0	3.5
Methyl ethyl ketone	70.6	4.6
Methyl isobutyl ketone	16.0	1.6
Toluene	38.0	1.5
Xylene	9.5	0.75
Butyl acetate, sec	4.0	1.9
Butyl acetate, iso	12.5	1.45
Butyl acetate, n	7.8	1.0
VM and P naphtha	2.0	0.45
Amyl acetate (primary)	4.0	0.4
Glycols	<0.01	
Glycol ethers	<1.0	<0.01

[a] Relative to that of butyl acetate, 1.0.

Source: Reference 9.

than isobutanol at a given temperature, pressure, and humidity. Coating mixtures contain a number of these solvents, and the particular composition varies with each operation (filling, sealing, base coating, topcoating) and at each plant. Consequently, VOC emissions vary widely in mass rate per unit production, in mass rate per unit weight of coating used, and in concentration.

In addition, the distribution of solvent emissions from solvent handling, mixing, and application (workroom emissions exhausted through roof vents and windows), and from drying ovens (point sources) can vary widely. A plant that uses highly volatile solvents, such as methanol, ethanol, and methyl ethyl ketone will emit much greater amounts of VOC from handling, mixing, and application (say 70%) than through drying oven exhaust (say 30%). In contrast, a plant that uses relatively low-volatility solvents, such as amyl acetate, butanol, and VM and P naphtha, will emit much less VOC from handling, mixing, and application (say 20%) than from drying oven exhaust (say 80%). The first example is probably more typical.

3.3.3 Nationwide Emissions

Based on contacts with various coating manufacturers, we estimate that 11,000 tons of VOC were emitted from flat wood coating plants in 1978. This estimate is based on the production of 3.0 billion square feet of paneling and on emission rates of 6.5 $lb/1000\ ft^2$ for printed interior paneling (90% of production) and 12.0 $lb/1000\ ft^2$ for natural-finish interior paneling (10% of production). The figures can be compared with those for 1970 to show the reduction of VOC emissions over the time period. The total for 1970 was 34,000 tons of VOC emissions, based on the production of 3.5 billion square feet of paneling and emission rates of 18.1 $lb/1000\ ft^2$ for printed panels (75% of production) and 24.2 $lb/1000\ ft^2$ for natural-finish panels (25% of production). Emissions were reduced about 70 percent while production was reduced 15 percent. (The decline in production is partly due to replacement by paper and vinyl laminating products, which are not covered by this regulation.)

From these figures, we can calculate the quantity of emissions from a typical paneling coating plant (thus allowing order-of-magnitude comparisons to be made with other industries). A large paneling coating plant coats about 12 million ft^2/mo, or 144 million ft^2/yr. At an emission rate of 6.5 lb VOC/1000 ft^2 for printed interior panels, 470 tons/yr or slightly less than 2 tons/day are emitted. Natural-finish paneling coating, with an emission rate of 12 lb VOC/1000 ft^2, emits 865 tons/yr or a maximum of 3.3 tons/day (based on 260 days per year). Small paneling plants coat about 5 million ft^2/mo, or 60 million ft^2/yr. Using the same emission rates of 6.5 lb VOC/1000 ft^2 and 12 lb VOC/1000 ft^2 for printed interior panels and for natural-finish panels, VOC emissions are estimated to be 195 tons/yr (0.5 to 1 ton/day) and 360 tons/yr (1-1.5 tons/day). These order-of-magnitude figures are summarized in Table 8.

TABLE 8. ESTIMATE OF VOC EMISSIONS FROM TYPICAL LARGE AND SMALL PANELING COATING PLANTS

	Large plant	Small plant
Coated production	144 million ft^2/yr	60 million ft^2/yr
Printed panel emission factor	6.5 lb VOC/1000 ft^2	6.5 lb VOC/1000 ft^2
Printed panel emissions	470 tons/yr or 1.5 to 2 tons/day	195 tons/yr or 0.5 to 1 ton/day
Natural finish panel emission factor	12 lb VOC/1000 ft^2	12 lb VOC/1000 ft^2
Natural finish panel emissions	865 tons/yr or 3 to 3.5 tons/day	360 tons/yr or 1 to 1.5 tons/day

Some of the major coating manufacturers have also supplied information on the percentages of solvent-based vs. water-based coatings produced and sold. One major supplier reported that the coating materials for all flat wood operations (including furniture, exterior siding, etc.) were 76 percent solvent based vs. 24 percent water based in 1976, and 69 percent vs. 29 percent in 1977.

For paneling only in 1977, this manufacturer estimated the sale of 36 percent solvent-based coatings vs. 64 percent water-based coatings. Another coating manufacturer estimated that coatings sold to paneling operations were 20 percent solvent based vs. 80 percent water based. Other coating manufacturers are selling 45 to 50 percent water-based coatings.

Although we can determine the total gallons of coatings sold by individual coating manufacturers, amounts of VOC emissions per gallon cannot be readily calculated. The volatile content of a coating is highly variable, depending on its type and the coating manufacturer. Table 9 presents estimates of potential VOC emissions from each kind of operation using conventional coatings. At plants that apply filler, sealer, base coat, grain ink, and topcoat, the estimated VOC emission factor may range from 88 to 174 g/m^2 (11 to 21 $lb/1000\ ft^2$) of flat wood coated.

Because the volatile fraction of the coatings contributes essentially all of the VOC emissions, the total emissions from a plant are the product of the weight fraction of volatile organics in the coatings and of coating usage. Composition of the VOC emissions depends upon the types of solvents used. The ovens release practically all of the incoming volatile compounds, and the fraction of total plant emissions that comes from the dryer ovens depends on the types of solvents used, or (more specifically) their relative volatility or evaporation rate.

3.4 GROWTH PROJECTIONS

In the past few years, the number of flat wood plants in operation (coating and noncoating) has steadily declined (see Table 10). The industry has, however, experienced increased production over the same time period (see Table 11). This trend is true for the surface coating industry as well (including paper and vinyl laminating). Industry literature predicts that the factory surface coating of flat wood products will increase as more prefinished wood is used in the building trade. The market

TABLE 9. POTENTIAL VOC EMISSIONS FROM FLAT WOOD OPERATIONS USING CONVENTIONAL COATINGS

	Range of VOC emissions		Coverage		Range of VOC emissions	
Operation coating	kg/liter coating	(lb/gal coating)	liters/ 10^3 m^2	(gal/10^3 ft)	g/m^3 coated	(lb/10^3 ft^2)
Filler	0.26 to 0.53	(2.2 to 4.4)	119	(1.7)	31 to 62	(3.7 to 7.5)
Sealer	0.17 to 0.54	(1.4 to 4.5)	21	(0.3)	3.6 to 11.3	(0.4 to 1.4)
Base coat	0.44 to 1.0	(3.7 to 8.6)	56	(0.8)	25 to 56	(3.0 to 6.9)
Grain ink	0.36 to 0.84	(3.0 to 7.0)	7	(0.1)	2.5 to 5.9	(0.3 to 0.7)
Topcoat	0.53 to 0.79	(4.4 to 6.6)	49	(0.7)	26 to 38.7	(3.0 to 4.6)
			Total		88 to 174	(11 to 21)

Source: Reference 9.

TABLE 10. NUMBER OF PLANTS IN FLAT WOOD INDUSTRY FROM 1976 TO 1979

Year	Hardwood plywood	Particle board	Hardboard panelboard[a]	Total
1976[b]	247[c]	86	67	400
1977[d]	288[c]	84	NA	NA
1978[e]	151	71	26	266
1979[f]	135	61	28	242

[a] Medium density fiberboard.

[b] Reference 9.

[c] This number may be inflated due to inclusion of hardwood veneer plants.

[d] Reference 7.

[e] Reference 10.

[f] Reference 11.

NA = Not available.

includes recreational vehicles, home improvement/do-it-yourself, nonresidential, and industrial construction.[11]

TABLE 11. FLAT WOOD INDUSTRY PRODUCTION
(Square feet)

Year	Hardwood plywood, surface measure	Particle board, 3/4-in. basis	Hardboard, 3/4-in. basis	MDF,[a] 3/4-in. basis
1976	1,463,135,000	3,202,200,000	7,066,022,000	280,036,000
1977	1,478,000,000	3,592,210,000	7,200,000,000	441,354,000
1978[b]	1,675,000,000	3,610,000,000	7,800,000,000	480,000,000

[a] Medium density fiberboard.
[b] Estimated data.

Source: Reference 11.

During this survey, officials at several of the plants contacted reported that they had recently shut down either their coating operations or their entire plant. Many small plants are being bought by major flat wood producers, and many low-production coating lines are being shut down. The result is a smaller number of plants operating at higher production levels.

Some surface coating operations are also being replaced by paper laminating operations. These products, which require only top coatings, are not included in the proposed regulations. Vinyl laminates are also replacing some printed interior paneling operations. These are not generally topcoated.

These trends will produce a smaller number of larger surface coating operations, which will reduce the number of emission sources. Total emissions may also be reduced, because larger operations can better afford to buy and develop emission control equipment, processes, and materials.

SECTION 4

CONTROL TECHNOLOGIES

Control technologies addressed in the Control Technique Guideline can be classified into three groups: add-on devices, materials changes, and process changes. Add-on devices include incineration and adsorption. Adsorption methods such as carbon adsorption are not generally used in the flat wood finishing industry.

Materials changes include use of water-based coatings and of high-solids coatings. High-solids coatings have not generally been used in the paneling industry, but coating suppliers could develop acceptable products in the future. The wood finishing industry is using more high-solids coatings, which are defined as those with 70 percent or more solids. The industry used 25 percent high-solids coatings in 1972, 35 to 40 percent in 1977,[12] and 40 to 45 percent (by volume) in 1978.[13] Much of this increase, however, has been in coatings for wood products other than paneling, such as furniture. The higher viscosity has led to several application problems. The coating must often be heated to reduce viscosity before application. Instead of resembling natural wood the finish tends to look painted, which is unacceptable. Powder coatings, another high-solids product, require a higher temperature for curing than is suitable for wood products. This problem may be solved as coating suppliers expand their technologies.

Process changes include ultraviolet curing and electron-beam curing. Both are used to a limited degree in the industry.

4.1 PROPOSED REGULATIONS

The EPA guidance document gives emission limits for coating application systems.[2] The VOC standards are as follows:

(a) No owner or operator of a flat wood manufacturing facility subject to this regulation shall emit volatile organic compounds from a coating application system in excess of:

(1) 2.9 kg per 100 square meters of coated finished product (6.0 lb/1000 sq ft) from printed interior panels, regardless of the number of coats applied;

(2) 5.8 kg per 100 square meters of coated finished product (12.0 lb/100 sq ft) from natural-finish hardwood plywood panels, regardless of the number of coats applied; and,

(3) 4.8 kg per 100 square meters of coated finished product (10.0 lb/100 sq ft) from Class II finishes on hardboard panels, regardless of the number of coats applied.

(b) The emission limits in paragraph (a) of this section shall be achieved by:

(1) The application of low solvent content coating technology; or,

(2) An incineration system that oxidizes at least 90.0 percent of the nonmethane volatile organic compounds entering the incinerator (VOC measured as total combustible carbon) to carbon dioxide and water; or,

(3) An equivalent means of VOC removal. The equivalent means must be certified by the owner or operator and approved by the Director.

(c) A capture system must be used in conjunction with the emission control systems in parts (b)(2) and (b)(3). The design and operation of a capture system must be consistent with good engineering practice and shall be required to provide for an overall emission reduction sufficient to meet the emission limitations in paragraph (a) of this section.

Emission limits are stated in terms of the amount of VOC per area of coated surface. This limit is flexible because it allows coaters to make sufficient adjustments anywhere in the line to meet the requirement; i.e., an operator could reduce the thickness of a coat, use different coatings, or apply different numbers of coats to meet the limit. The limits do not apply to a particular coating, such as filler or topcoat. For printed interior panels, emission limits are based on the use of both water-based and solvent-based coatings. For natural-finish paneling, the limits are based on the use of solvent-based coatings containing less solvent than conventional coatings.

The guidance document applies only to flat wood manufacturing and surface-finishing facilities that manufacture the following products:

(1) Printed interior panels made of hardwood, plywood, and thin particle board;

(2) Natural finish hardwood plywood panels; or,

(3) Hardboard paneling with Class II finishes (as defined in Voluntary Product Standard PS-59-73 of the American National Standards Institute).

The regulation does not apply to the manufacture of exterior siding, tile board, or particle board that is used as a furniture component.

Emissions from the inks used to print simulated grain or decorative patterns on printed interior panels are covered in this CTG category, and should not be considered a Graphic Arts activity.

4.2 DESCRIPTION AND HISTORY OF CONTROLS

This section discusses the control technologies that can be used in flat wood paneling: incineration, water-based coatings, ultraviolet curing, and electron-beam curing. Continuing problems with these technologies are discussed in Section 6.1.

Incineration was used by two plants in Southern California. In a new plant in Ohio that uses conventional solvent coatings, ovens are equipped with afterburners to reduce VOC emissions.

Most representatives of the coating industry who were contacted said that incineration or afterburners were too expensive to install and to operate because of the extra fuel required.

Water-based coatings have steadily increased in use since the first water-based fillers were developed in the late 1960's. Use of water-based fillers, base coats, and groove coats is widespread in the industry, resulting in significantly less solvent use and fewer VOC emissions from coating plants. The technology of water-based inks and topcoats, however, particularly clear topcoats, is still being developed. Some suppliers and coaters estimated that full development of these products is still 1 to 3 years away (as of January 1980).

People in the industry commented that conversion to water-based products is desirable for several reasons:

Water-based coatings emit fewer fumes, thus making the plant environment more pleasant. Workers experience much less discomfort from eye, nose, and throat irritations when low-solvent products are used.

The presence of fewer solvents and fumes in the plant significantly reduces fire hazards. Fire insurance costs and equipment replacement costs decrease as a result. Fires had occurred monthly at one plant, but they became infrequent when water-based coatings were adopted.

Emissions are fewer. Plants converting to water-based coatings are more likely to meet local or state emission standards.

Cleanup, when done promptly, is easier when water-based coatings are used. When wet, the equipment can be hosed down or washed with water.

Some of the problems that arose when plants first tried water-based fillers, sealers, and other coatings have since been corrected. These problems included blocking, mudcracking, roping, and defects in appearance. Some early water-based coatings were thermoplastic, meaning that they would soften and fuse when heated and would harden again when cooled. Panels and doors coated with thermoplastic coatings would be cured in an oven and then stacked. The warm coatings on each wood product would then fuse and a banded stack would become a fused block. Early temporary solutions consisted of spreading all the panels or doors out to dry and cure completely for 24 hours before stacking. Since then, new coatings and more complete drying and curing in the process line have reduced the probability of blocking.

Other problems were roping and mudcracking. Roping, an uneven finish caused by the absence of tail solvents to smooth the application, has been avoided by new coating formulations and sometimes by the application of two thin coats rather than one thick coat. Improvements are still being made in this area. Mudcracking, or fine cracks in the finish, has been alleviated by altering the drying process; conventional ovens are commonly followed by high-intensity infrared ovens.

Many finishers commented, particularly about earlier coatings, that the appearance was not as clear or smooth as solvent coatings. This problem continues with topcoats and inks, for which satisfactory water-based coatings are not yet developed. The inks tend to block the pyramids in the metal gravure printing rollers, creating a less distinct pattern. The topcoats have not been clear enough, and some discoloration or cloudiness has been experienced. Solvent coatings are reported to have better adhesion and more gloss. Water-based topcoats are reportedly difficult to cure.

Ultraviolet and electron-beam curing, both of which use radiation-cured finishes, are process changes that can be used in flat wood finishing. Ultraviolet curing is gaining acceptance as an option for finishing lines, especially to coat particle board, where water-based coatings are less successful. Ultraviolet-curable coatings are a combination of resin, prepolymers, monomers, and a photosensitizer that serves as a catalyst, with no solvents. The coatings are applied as a liquid; the material hardens and cross-links upon exposure to ultraviolet light, forming a tough, solid coating within seconds. Less than 1 percent of the coating is emitted as VOC; the ultraviolet-cured coatings are thus considered nearly 100 percent solids. Small amounts of ozone are emitted. Ultraviolet-cured coatings are generally more expensive per gallon ($8 to $15/gallon) than conventional coatings, but usage costs are competitive because greater mileage is possible. Ultraviolet ovens used to cure the coatings are usually smaller than conventional ovens because these coatings cure very quickly; as a result, less floor space is needed. The ovens run on electricity rather than natural gas, and energy consumption is reportedly 5 to 80 times less than with conventional coatings.[12]

Radiation-cured coatings are most suitable for flat wood panels because the radiation must reach all coated areas uniformly without benefit of heat or reflection.

A plant visited in Oregon used ultraviolet-cured fillers and topcoats on particle board and fiberboard for furniture and cabinet parts. Most of these coatings are clear to semitransparent fillers and topcoats; opaque ultraviolet-cured coatings have not yet been developed. The Oregon plant used conventional solvent based coats between the ultraviolet-cured filler and topcoat because topcoats do not adhere well to ultraviolet-cured base coats. This adhesion problem limits the number of finishes that can be applied over ultraviolet-cured coatings. Usage is expected to increase, however, as the technology progresses.

Electron-beam curing is a new technology for flat wood finishing.[14,15] Particle board, fiberboard, or hardboard are coated with an opaque, acrylic coating and passed under a beam of accelerated electrons in a low-oxygen, high-vacuum atmosphere. Nitrogen is pumped across the panel to maintain an inert environment. The coating cures rapidly to a very durable, smooth finish comparable in some respects to plastic laminates. Electron-beam-cured products are currently used for furniture and cabinet components, although the technology can be applied to paneling products as well.

The electron-beam curing system has several advantages. Emissions of VOC are virtually eliminated because the liquid coatings are almost entirely converted to solids upon curing. Because expensive heating is not required, less electricity or other energy is used. A third advantage is the wider range of colors available in comparison with plastic laminate products.

Disadvantages of electron-beam-curable coatings are cost and safety precautions required. Because electron-beam curing emits radiation while it is operating, the vaults must be heavily shielded to protect workers from radiation exposure. The Oregon plant has a 2-ft-thick concrete wall around the accelerator and a 1-ft-thick wall around the entries and exits to the vault. The electron-beam line at this plant cost $500,000 to install.[15] The acrylic coatings used in the system are also expensive, ranging from about $25 to $30/gallon.

Although radiation curing is expensive, its use, especially of ultraviolet cures, is expected to increase in the future.[13]

SECTION 5

COMPLIANCE SCHEDULE

5.1 SCHEDULE

The EPA guidance document has separate compliance schedules depending on the VOC control method used.[2] Those plants using water-based (low-solvent) coatings must comply with the regulations by July 1, 1982. Plants using incineration with heat recovery must also comply by that date. If incineration without heat recovery is used, the plant must comply by July 1, 1981. Alternative compliance schedules can be submitted to the EPA Director, subject to approval. The details of the compliance schedule from the guidance document are included here for reference.

> The owner or operator of a source of volatile organic compounds subject to this regulation shall meet the applicable increments of progress in the following schedules:
>
> (1) Sources utilizing low solvent content coatings to comply with the emission limitations in §XX.9330 shall:
>
> (i) Submit final plans for the application of low solvent technology before October 15, 1980;
>
> (ii) Complete evaluation of product quality and commercial acceptance before April 1, 1981;
>
> (iii) Issue purchase orders or contracts for low solvent content coatings before June 1, 1981;
>
> (iv) Initiate process modifications before July 1, 1981; and,
>
> (v) Complete process modifications and begin use of low solvent content coatings before July 1, 1982.

(2) Sources utilizing process equipment changes or add-on control devices, including incineration with heat recovery, to comply with the emisson limitations in §XX.9330 shall:

(i) Submit final plans for the emission control system, or process equipment, or both, before October 15, 1980;

(ii) Award contracts or purchase orders for the emission control systems, or process equipment, or both, before December 15, 1980;

(iii) Initiate onsite construction or installation of the emission control system, or process equipment, or both, before June 1, 1981;

(iv) Complete onsite construction or installation of the emission control system or process equipment, or both, before June 1, 1982; and,

(v) Achieve final compliance, determined in accordance with §XX.9350, before July 1, 1982.

(3) Sources utilizing incineration without heat recovery or process modifications not requiring purchase orders, to comply with the emission limitations in §XX.9330, shall:

(i) Submit final plans for the emission control system or process modification, or both, before September 15, 1980;

(ii) Award contracts or purchase orders for the emission control system or process modification, or both, before November 1, 1980;

(iii) Initiate onsite construction or installation of the emission control system or process modification, or both, before January 15, 1981;

(iv) Complete onsite construction or installation of the emission control system or process modification, or both, before May 15, 1981; and,

(v) Achieve final compliance, determined in accordance with §XX.9350, before July 1, 1981.

The owner or operator of a source of volatile organic compounds subject to this regulation may submit to the Director, and the Director may approve, a proposed alternative compliance schedule provided:

(1) The proposed alternative compliance schedule is submitted before September 15, 1980;

(2) The owner or operator provides information showing the need for an alternative schedule;

(3) The alternative compliance schedule contains increments of progress;

(4) Sufficient documentation and certification from appropriate suppliers, contractors, manufacturers, or fabricators is submitted by the owner or operator of the volatile organic compound source to justify the dates proposed for the increments of progress; and,

(5) Final compliance is achieved as expeditiously as possible and before the photochemical oxidant attainment date.

The owner or operator of a volatile organic compound source subject to a compliance schedule of this section shall certify to the Director within 5 days after the deadline for each increment of progress, whether the required increment of progress has been met.

5.2 INDUSTRY REACTION AND COMMENTS ON COMPLIANCE SCHEDULE

The flat wood finishing industry has participated in the review of proposed VOC regulations within the last several years, and has thus had the opportunity to review and comment on the emission limits as they were being developed. Coatings suppliers have also participated in the process. The result of the industry participation is that, with some exceptions, the industry accepts the proposed compliance schedule for the emission limits stated.

PEDCo contacted representatives at all the paneling coating plants in the survey. About half of the plant representatives contacted said that the compliance schedule as written is realistic. Some of these added that costs for compliance might be high for some plants, however, mainly because of the need to purchase and install new ovens.

About one-third of the plant representatives who commented on the compliance schedule said that they thought it was realistic, but with some qualifications. Some stipulated that it would depend on whether the coatings suppliers could meet the demand, particularly for low-solvent, water-based coatings. Several finishers commented that the schedule is easier to meet in some plants than others. They emphasized that each plant is different and that coating suppliers must develop products for each line because of differences in wood substrate, equipment type and age, and amounts of coatings to be applied in various coating lines. Some plants apply more coatings than other plants; decreasing coating thickness may adversely affect product quality. Some finishers thought that the schedule was realistic for printed lauan, but that it might take more time for hardboard and particle board.

About 17 percent of the plant representatives who commented on the compliance schedule said that 2 years was too short a time for conversion to water-based coatings. Some plants have taken 3 to 4 years (sometimes longer) to convert to a water-based system, because many trials and adjustments are necessary before acceptable products are found for a particular plant. The time should decrease, however, as suppliers expand the water-based coating technology.

The most common response about the compliance schedule was that most plants could meet it if they spent enough money and effort. The plant would also have to be committed to making the changes within the allowable time frame.

SECTION 6

ENFORCEMENT OF PROPOSED REGULATIONS

6.1 PROBLEMS IN MATCHING RACT AND PROCESSES: INDUSTRY COMMENT

Conversion to low-solvent, water-based coatings is the most commonly chosen RACT option in the flat wood paneling industry. Ultraviolet- and electron-beam-curable coating are increasing in use at a slower rate. Incinerators are quite limited in use at this time. Most of the industry comments about experiences with RACT options, therefore, concern water-based coatings. Table 12 summarizes the comments about the control options.

Like most materials changes in an industry, conversion to water-based coatings involves a period of experimentation during which suitable coatings must be developed. Although many of the earlier problems (see Section 4.3) have been solved, problems still arise whenever a new coating is tried in a plant. Coatings suppliers and coating plants must experiment until a satisfactory finish is obtained for a particular line. A water-based filler that works on one line may not work on another because of differences in wood substrate, equipment, and other coatings used. The time and money required to develop coatings for a particular line is a substantial problem in the use of water-based coatings.

Flat wood finishers most frequently commented that water-based coatings are more difficult to dry, requiring more heat, longer drying times, or different types of ovens. New ovens, a considerable capital expense, might be required in some plants. Another option is to slow down the line that decreases productivity.

The second most frequent comment about water-based coatings concerned their tendency to raise the grain in the wood, due to

TABLE 12. PANELING INDUSTRY PROBLEMS WITH VOC CONTROL METHODS

Control method	Problem
Water-based coatings	Experimentation period required for conversion
	Increased oven capacity required for drying and curing
	Grain raising; more buffing required
	Metal equipment parts must be modified to minimize corrosion
	Changes in rolls may be necessary
	Costs
	Coatings must be protected from freezing
Ultraviolet- and electron-beam-curable coatings	Lack of adhesion to other coatings
	Cost
Incineration	Cost

the water swelling the fibers. Grain raising is particularly troublesome on fiberboard and particle board. The finish is not as smooth and may need sanding or buffing. The water-based coating on particle board and fiberboard may have to be thicker; more coating must be used, resulting in more emissions.

Besides the new ovens, conversion to water-based coatings requires several lesser modifications. Plates, trays, and other metal parts that come into contact with the water-based coating must be covered with a metal that will resist corrosion. Stainless steel and cadmium have been used. The rolls (on the roll-coaters) may need to be changed more often. Changes may also be necessary in pump and bearing materials.

Several finishers commented that the profit margin in panel finishing is small, and that small finishers cannot afford large capital outlays for new ovens and other equipment changes.

Water-based and solvent-based coatings have different handling and storage requirements. Water-based coatings are far more susceptible to freezing, and they must be stored in a heated area in cold climates. Solvent-based coatings are more of a fire hazard, and must be stored away from plant operations. Explosion-proof equipment is also needed for solvent materials, but not for water-based coatings.

One finisher commented that the flame spread rating on his panels was less desirable when using water-based coatings. Other finishers reported no change in flame spread rating.

Mixed comments were made about the cost, mileage, and durability of the different coatings. Some users stated that price per gallon was greater for water-based coatings, while others said that the prices were comparable. Some finishers expected solvent coatings to become more expensive as petroleum prices increase. Mileage derived from water-based coatings was greater for some users and less for others. Some finishers reported that water-based coatings are harder and more durable than solvent-based coatings, as long as they are cured completely. Other finishers disagreed.

Although use of ultraviolet- and electron-beam-curable coatings is expected to increase in the future,[13] there are impediments to their widespread use at this time. First are the technical problems of adhesion to radiation-cured coatings. This situation will improve as coating suppliers advance the technology in this area. The second impediment is price. Both the coatings and the equipment used to cure them are expensive. The finishers at the plant visited are pleased with the results of their radiation-cured coatings, and they plan to expand their operations. Speed of curing was cited as one advantage.

Most finishers who commented on incineration said that it was not a desired option. Incinerators are expensive, and the finishers prefer to work with water-based coatings. The one plant that had an afterburner used conventional solvent coatings. Incineration is not expected to gain acceptance as a means of reducing VOC emissions.

6.2 FACTORS AFFECTING ENFORCEMENT

Most of the finishers visited stated that they have been converting to water-based coatings wherever possible; as a result, many plants have reduced VOC emissions significantly over the last decade. The reduction in fumes--bringing greater worker comfort and lessening the fire hazard--is a compelling reason for the conversion. It is reasonable, therefore, to expect the trend to continue. Most finishers stated that they could meet or nearly meet the emission limits within the 2 years allowed for compliance. Particle board finishers may have trouble meeting the limits because this product requires heavier coatings. The industry as a whole, however, should be able and willing to meet the standards for VOC.

Enforcement efforts should be minimal. The number of finishers is small (57), and few plants are located in nonattainment areas. The advantages of conversion to water-based coatings will aid the enforcement effort.

Plants in California are generally ahead of other plants with respect to VOC emission reduction. California has had VOC regulations for several years, and the current regulations (for 1981) are more strict than those in the EPA guideline document. Enforcement in that State should be easier than elsewhere.

The guidance document states (page 56) that plants are to show compliance with emission limits by following specified VOC emission test procedures, or by submitting a "composition of the coating, if supported by actual batch formulation records."[2] It is a straightforward task to compute VOC emissions, given the percentages of solids and volatiles and the amount of solvent used. Use of plant records to determine compliance or noncompliance may create a legal problem in some states, such as California. This problem should be evaluated by DSSE.

Few add-on controls will be encountered in the paneling finishing industry. The guidance document specifies that monitoring is required for add-on control equipment (page 56).[2] Incinerators must have continuous monitors for exhaust gas temperature, and catalytic incinerators must have continuous monitors measuring temperature rise. (Carbon adsorption beds are not currently used by the industry.) The guidance document also says (page 58) that recorders should be used at "larger installations," or those emitting 100 tons or more of VOC per day. If this provision is adopted into state laws, continuous monitors will only be installed on larger plants. Enforcement effort will be minimal in this area.

Particulate emissions are generated from the sanders used in the finishing operations. In all the plants visited, the particulates were ducted in an enclosed system to cyclones and/or baghouses. Collection efficiencies were more than 90 percent. The particulates tend to be large particles that are easy to collect and that settle out of the air quickly. Because of these controls, the plants visited were relatively dust-free. Further, 75 percent of the coating plants are located in attainment areas for particulates. Enforcement efforts for particulate emissions will be largely confined to those plants having adequate collection systems.

The applicability section of the guidance document lists (page 49) the products covered by the regulations.[2] They are:

Printed interior panels made of hardwood, plywood, and thin particle board

Natural-finish hardwood plywood panels

Hardboard paneling with Class II finishes

Products not covered are exterior siding, tile board, or particle board that is used as a furniture component.

Paper and vinyl laminated products are not covered, and the survey of paneling coaters did not include these products. A few of the wood paneling finishing plants visited were also making vinyl and paper overlay panels. These panels closely resemble the printed panels, and may be made in the same plants on the same lines. Paper-laminated panels may have a groove coat and a topcoat application similar to the wood panels. An adhesive is also used to laminate the paper to the board. Vinyl-laminated panels do not usually have a topcoat.

It would be reasonable to include these operations in the regulations because they are so similar to wood panel finishing. Emissions are expected to be lower because no fill coats, base coats, or printing inks are used. The adhesives, groove coats, and topcoats that are used would be sources of VOC emissions. A water-based topcoat, with few emissions, was used at one plant that was visited.

6.3 RECOMMENDATIONS

Emissions of VOC from factory surface coating of flat wood paneling are being reduced by the gradual conversion to water-based coatings. The 57 plants located in our survey emitted a total of about 11,000 tons/year from coating operations. The DSSE should rank the magnitude of these emissions, and thus determine their relative importance, in relation to the other industries for which VOC emission guidelines have been written.

A small enforcement effort is expected, for the following reasons:

The small number of plants in nonattainment areas

The relatively small amounts of VOC and TSP emissions from the industry

The reduction of VOC emissions due to conversion to water-based coatings

The slow growth of the industry

Vinyl and paper laminated panels are not included among the applicable products covered in the EPA guidance document. It is reasonable to include the paper and vinyl laminated panels under the same regulations as the printed interior panels because they are often made in the same plants and with similar coatings. The list of coaters in the appendix does not include those who responded only as paper or vinyl laminators. If these plants are later included in the regulations for wood paneling coating, the survey would have to be expanded to include them.

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APPENDIX A

TABULAR DATA ABOUT FLAT WOOD PANELING PLANTS

TABLE A-1. DIRECTORY OF FLAT WOOD PANELING PLANTS WITH SURFACE COATING OPERATIONS

Plant name and address	County	Located in attainment area[16] for VOC (O_3)	for TSP
Region I			
Weyerhaeuser Co. Wood Products Division Hancock, VT 05748	Addison	No	Yes
Region II			
Predco Precision Panels 3900 River Road Pennsauken, NJ 08110	Camden	No	Yes
U.S. Veneer Co., Inc. 888 Longfellow Avenue Bronx, NY 10474	Bronx	No	No
Region III			
Masonite Corporation Box 311 Towanda, PA 18848	Bradford	No	Yes
Champion Building Products Highway 304, Drawer 250 South Boston, VA 24592	Halifax	Yes	Yes
Lane Co., Inc., The E. Franklin Street Altavista, VA 24517	Campbell	Yes	Yes
Masonite Corporation Box 378 Waverly, VA 23890	Sussex	Yes	Yes
Plywood Panels, Inc. 3747 Village Avenue Norfolk, VA 23502	-	No	Yes
U.S. Gypsum Co. Box 3327 Danville, VA 24541	-	Yes	Yes
Weyerhaeuser Co. Box 1188, 201 Dexter St. W Chesapeake, VA 23324	-	No	Yes

TABLE A-1 (continued)

Plant name and address	County	Located in attainment area[16] for VOC (O_3)	for TSP
Region IV			
Champion Home Builds Co. Box 248 Plains, GA 31780	Sumter	Yes	Yes
Georgia-Pacific Corp. Box 386 Monticello, GA 31064	Jasper	Yes	Yes
Georgia-Pacific Corp. Box 367 Savannah, GA 31402	Chatham	Yes	No
Jasper-American Mfg. Co. Box 378, Priesh Rd. Henderson, KY 42420	Henderson	No	No
Masonite Corp. Box 488 Laurel, MS 39440	Jones	Yes	No
Abitibi Corp. Box 98 Roaring River, NC 28669	Wilkes	Yes	Yes
Broyhill Industries Pacemaker Division Lenoir, NC 28645	Caldwell	Yes	Yes
Georgia-Pacific Corp. Southern Division Box 950 Whiteville, NC 28472	Columbus	Yes	Yes
Masonite Corp. Fiberboard Div. Box 369 Spring Hope, NC 27882	Nash	Yes	Yes
Vanply, Inc. Prefinished Prod. Div. Box 8289 900 N. Hoskins Rd. Charlotte, NC 28208	Mecklenburg	No	Yes

TABLE A-1 (continued)

Plant name and address	County	Located in attainment area[16] for VOC (O_3)	for TSP
Region IV (continued)			
Champion Bldg. Products Div. of Champion Int'l. 238 E. Bay Street Charleston, SC 29403	Charleston	No	No
Champion Bldg. Products Div. of Champion Int'l. Box 1087, 5 Chop Road Orangeburg, SC 29115	Orangeburg	Yes	Yes
International Paneling Prod., Inc. Box 7031, North Station 705 Corrine Avenue Memphis, TN 38107	Shelby	No	Yes
Region V			
Abitibi Corporation 416 Ford Avenue Alpena, MI 49707	Alpena	Yes	Yes
Iron Wood Products Yale Avenue Bessemer, MI 49911	Gogebic	Yes	Yes
Superwood Corporation Box 6267 Duluth, MN 55806	St. Louis	Yes	No
Abitibi Corporation Building Prod. Div. 2900 Hill Avenue Toledo, OH 43607	Lucas	No	Yes
Eggars Plywood Co. 1819 E. River St. Two Rivers, WI 54241	Manitowoc	Yes	Yes
Pluswood, Inc. 11450 Oshkosh Avenue Oshkosh, WI 54903	Winnebago	Yes	No
Superior Fiber Products Box 365 Superior, WI 54880	Douglas	No	No

TABLE A-1 (continued)

Plant name and address	County	Located in attainment area[16] for VOC (O_3)	for TSP
Region V (continued)			
Superwood Corporation P.O. Box 138 Phillips, WI 54555	Price	Yes	Yes
Warvel Products, Inc. Box 266, 160 Park Street Gillett, WI 54124	Oconto	Yes	Yes
Region VI			
Singer Co., The Main Street Trumann, AR 72472	Poinsett	No	Yes
Superwood Corporation Box 3151, Hwy. 130 N. Little Rock, AR 72117	Pulaski	No	Yes
AFCO Industries Box 5085, 3400 Roy Avenue Alexandria, LA 71301	Rapides	Yes	Yes
Plywood Paneling Co. 100 Napolean Avenue New Orleans, LA 70130	Orleans	No	Yes
Ponderosa Products Box 25506 1701 Bellamah Avenue N.W. Albuquerque, NM 87125	Bernalillo	No	No
Champion Building Prod. Div. Champion International Box 186, 3902 Port Industrial Rd. Galveston, TX 77551	Galveston	No	No
Region VII			
Region VIII			
Louisiana-Pacific Intermountain Div. Box 407, 3300 Raser Dr. Missoula, MT 59806	Missoula	Yes	No

TABLE A-1 (continued)

Plant name and address	County	Located in attainment area[16] for VOC (O_3)	for TSP
Region IX			
Collins Pine Co. Box 796 Chester, CA 96020	Plumas	Yes	Yes
Davidson Panel Co. 1551 E. Babbit Avenue Anaheim, CA 92805	Orange	Yes	Yes
Forest Products 4315 Dominguez Rd. Rocklin, CA 95677	Nevada	Yes	Yes
Masonite Corporation Hardboard Div. 300 Ford Rd. Ukiah, CA 95482	Mendocino	Yes	No
National Plywood, Inc. Box 9340 2870 El. Presidio Street Long Beach, CA 90810	Los Angeles	No	Yes
Pacific Finishing Co. Box 474, 16200 Illinois Avenue Paramount, CA 90723	Los Angeles	No	Yes
Western States Plywood 12848 E. Firestone Blvd. Santa Fe Springs, CA 90670	Los Angeles	No	Yes
Weyerhaeuser Co. 11355 Arrow Hwy. Rancho Cucamonga, CA 91730	San Bernadino	No	No
Region X			
Champion Home Builders Co. Weiser Prod. Div. Box 551 Weiser, ID 83672	Washington	Yes	Yes
Champion Building Prod. Div. Champion Int'l. Box 1166 Hood River, OR 97031	Hood River	Yes	Yes

TABLE A-1 (continued)

Plant name and address	County	Located in attainment area[16]	
		for VOC (O_3)	for TSP
Region X (continued)			
Champion Building Prod. Div. Champion Int'l. Box 547 Lebanon, OR 97355	Linn	Yes	Yes
Evans Products Co. Fiber Products Group Box E, 1115 S.W. Crystal Lake Dr. Corvallis, OR 97330	Benton	Yes	Yes
Georgia-Pacific Corp. Box 869 Coos Bay, OR 97420	Coos	Yes	Yes
Roseburg Lumber Plants #1 and #2 Dillard, OR 97432 (Mailing address: Box 1088 Roseburg, OR 97470	Douglas	Yes	Yes
States Veneer Co. Box 7037, 95 Foch St. Eugene, OR 97401	Lane	No	No
Weyerhaeuser Co. Box 9 Klamath Fall, OR 97601	Klamath	Yes	Yes
Willamette Industries Duraflake Div. Box 428 Albany, OR 97321	Linn	Yes	Yes
Vanport Industries Box 1089, 8th St., Terminal #2 Vancouver, WA 98666	Clark	Yes	Yes

TABLE A-2. FLAT WOOD PANELING PLANTS WITH SURFACE COATING OPERATIONS

	Hardwood plywood	Particle board	Hardboard, panelboard[a]	Production (No. of companies) ≥200 million ft²/yr	<200 million ft²/yr
Region I					
Vermont	1				1
Region II					
New Jersey	1				1
New York	1				1
Region III					
Pennsylvania			1	1	
Virginia	3	2	1	1	5
Region IV					
Georgia	2		1	1	2
Kentucky		1			1
Mississippi			1		1
North Carolina	1	1	3		5
South Carolina	2			1	1
Tennessee	1				1
Region V					
Michigan	1		1	1	1
Minnesota			1		1
Ohio			1	1	
Wisconsin	2		3		5
Region VI					
Arkansas		1	1		2
Louisiana	2				2
New Mexico		1			1
Texas	1				1
Region VII					
Region VIII					
Montana		1			1
Region IX					
California	6	1	1	5	3
Region X					
Idaho	1				1
Oregon	1	2	5	2	6
Washington	1				1
Total	27	10	20	13	44

[a] Medium density fiberboard.

TABLE A-3. SUMMARY OF PANEL PLANT INFORMATION SUPPLIED IN FOREST INDUSTRIES MAGAZINE (APRIL 1979)

	Hardwood plywood		Particle board		Hardboard, fiberboard		Production (No. of companies)		
	Coat	No coat	Coat	No coat	Coat	No coat	>200 million ft²/yr	<200 million ft²/yr	Not known
Region I									
Maine		1						1	
New Hampshire		1						1	
Vermont	1	2						3	
Region II									
New Jersey		1						1	
New York	1	1				1		2	1
Region III									
Pennsylvania		1		1	1		1	2	
Virginia	2	7	2	1	1	1		9	5
West Virginia		1						1	
Region IV									
Alabama		4		4		1		7	2
Florida		1						1	
Georgia	1	5		3	1		1	9	
Kentucky		2	1					1	2
Mississippi		2		4	1	1		6	2
North Carolina		21	1	1	3	2	1	19	8
South Carolina	2	12		1		2	1	11	5
Tennessee		5		1		1		6	1
Region V									
Indiana		4						3	1
Michigan	1	2		1	1		1	4	
Minnesota		3		1	1	2	2	3	2
Wisconsin	2	12		1	2	1		15	3
Region VI									
Arkansas		3	1		1	1		4	2
Louisiana	1	1		3				5	
New Mexico			1	1				2	
Oklahoma				1					1
Texas	1	2		3		1	1	4	2
Region VII									
Region VIII									
Montana			1			1		2	
Region IX									
California		7	1	6	1	2	1	14	2
Region X									
Idaho		2		1				3	
Oregon	1	3	2	8	5	4	2	18	3
Washington		3		1		1		5	
Total	12	110	10	43	18	22	11	162	42

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Enforceability Aspects of RACT for Factory Surface Coating of Flat Wood Paneling		5. REPORT DATE April 1980 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Catherine E. Jarvis, Cathie L. Gardinier, and Thomas C. Ponder, Jr.		8. PERFORMING ORGANIZATION REPORT NO. P/N 3570-3-L
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo Environmental, Inc. 11499 Chester Road Cincinnati, Ohio 45246		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-01-4747, Task No. 129
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15. SUPPLEMENTARY NOTES

DSSE Project Officer: John R. Busik, EN-341, (202) 755-2560

16. ABSTRACT

Revised State Implementation Plans must include controls for emissions of volatile organic compounds (VOC's) from factory surface coating of flat wood paneling. This report identifies 57 coaters to which the VOC regulations apply. Sixty-one percent of these plants are located in attainment areas for oxidants; 75 percent are in attainment areas for particulates. According to information from coating suppliers, factory surface costing of flat wood paneling emitted a total of 11,000 tons VOC's in 1978. Emissions in 1970 were estimated at 34,000 tons VOC's. These figures show an emission reduction of approximately 70 percent with a production decrease of 15 percent.

Methods currently used to control VOC emissions are: use of water-based coatings, use of ultraviolet-curable and electron-beam curable coatings, and incineration. Use of water-based coatings, the most widely applied method, is significantly reducing VOC emissions.

Enforcement of standards for coating plants in the paneling industry is not expected to require a major effort due to the small number of plants, the relatively small amounts of VOC and TSP emissions, the increasing use of water-based coatings, and the slow growth of the industry.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Control	Volatile Organic Compounds (VOC's)	13B
Organic Compounds	Oxidants	07C
Coatings	Surface Coatings	11C
Wood Products	Flat Wood Paneling	11L

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