Waste Management Trends in the Paint Manufacturing Industry

Paint Makers Have Come a Long Way in Reducing Hazardous Residuals

Editor's Note: This is the first installment of a two-part report on waste management trends in the paint industry. While this part focuses on paint manufacturers, the second installment will focus on the major paint-using industries.

by Alan J. Duff

The paint industry makes a variety of products that preserve, protect and enhance the objects to which they are applied. Although the post-consumer residuals of these products are usually labeled non-hazardous, they have often been termed "environmentally unfriendly" — as has the industry responsible for creating them.

With 1,400 manufacturing plants and an output of more than 1.1 billion gallons per year, the U.S. paint industry is a significant customer group for waste service vendors. In a recent study involving three paint factories, non-wastewater generation rates ranged from about 300 to 450 pounds per 1,000 gallons of paint. In recent years, however, paint makers have reduced the toxicity and ignitability of many types of paint by curtailing the use of metallic pigments and organic solvents, and a growing trend toward recycling paint wastes has meant volume reductions as well.

The paint manufacturing industry in the United States has done much to change this image in recent years. Paint makers have reduced the toxicity and ignitability of many types of paint. In addition, the industry has taken steps toward further reducing the amount of manufacturing waste it generates by recycling pre-consumer materials that have traditionally been discarded.

This report introduces readers to the current state of paint manufacturing. A brief overview of the industry is followed by an examination of recent changes that have been incorporated into paint-making processes to make them more environmentally friendly. The final section reviews waste re-

Paint Production in the U.S., 1986-1993

![Paint Production Chart]

Source: U.S. Department of Commerce, 1994

Figure 1
duction activities currently being implemented at paint plants.

The Paint-Making Industry

A total of 1,421 paint manufacturing plants in the U.S. were tallied by the Department of Commerce in 1992. The fact that these 1,421 plants are owned by 1,133 companies suggests that the industry is dominated by small manufacturers; in fact, most paint manufacturing plants have fewer than 20 employees, and only about one plant in 10 has a payroll of 100 or more.

Both the number of plants and the number of companies that manufacture paint have decreased nominally over the past 15 years, a trend that is generally attributed to consolidation of the industry. Many of the larger paint manufacturers have recently purchased smaller competitors that have been unable to keep up with the industry’s increasing R&D demands for product improvement and environmental compliance.

Although paint manufacturers are found near major cities across the U.S., a few states host a disproportionate number of paint manufacturing facilities. California is home to nearly 15 percent of U.S. paint plants, while the top-five paint-producing states (California, Illinois, New Jersey, Texas and Ohio) comprise 42 percent of the total. And two of every three paint plants in the U.S. is located in one of the top-10 paint-manufacturing states, which also include Florida, New York, Michigan, Missouri and Pennsylvania.

If all U.S. paint makers were to consolidate into one corporation, the conglomerate would rank 36th among Fortune 500 companies. And the industry is still growing; since 1986, production levels have grown by about 2 percent per year, on average (see Figure 1).

The domestic paint market accounts for the vast majority of sales by U.S. producers; over the past decade, only 2 to 3 percent of domestically-made paint has been exported. Nevertheless, recent trends indicate that paint exports are increasing. In 1992 and 1993, paint exports ran at around 4 to 5 percent of domestic production levels, while imports represented only about 1 percent of total U.S. sales, according to data compiled by the U.S. Department of Commerce. Most of the foreign trade involves paints used in residential applications.

Table 1 Primary Raw Materials in Paint

<table>
<thead>
<tr>
<th>Pigments</th>
<th>Solvents</th>
<th>Additives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium dioxide</td>
<td>Hydrocarbon compounds</td>
<td>Talc</td>
</tr>
<tr>
<td>Iron oxides</td>
<td>Ketone compounds</td>
<td>Clay</td>
</tr>
<tr>
<td>Many others, depending on color desired</td>
<td>Water</td>
<td>Silicates</td>
</tr>
</tbody>
</table>

Water-based paints feature an aqueous solvent base augmented by an organic co-solvent in concentrations of 5 to 40 percent. Waterborne coatings include aqueous emulsions (latex paint), colloidal dispersions, and water-reducible coatings. Latex paint is used primarily for architectural purposes. As residuals, these paints are less likely to be hazardous due to their reduced organic content.

Although powder-coating technology has been around since the early 1950s, it wasn’t commercialized until the early 1980s. During that decade, powder coatings enjoyed tremendous success; annual production grew by as much as 15 percent in some years. While early growth in the powder-coating market was achieved by displacing oil- and water-based paints in established applications, about half the current growth in powder-coating markets consists of newly emerging applications.
Raw Material Usage by U.S. Paint Manufacturers, 1982-1992

1982 Usage*
(millions of pounds)

- Pigments (1,062)
- Solvents (3,774)
- Additives (1,162)

1992 Usage**
(millions of pounds)

- Pigments (1,296)
- Solvents (1,661)
- Additives (3,485)


Applications, according to paint industry representatives, are expected to be reduced as a result of the changing nature of materials used in paint formulations.

The Changing Components of Paint

Paint is comprised of four main components: pigments, resins, solvents and additives (see Table 1). Pigments are tiny particles of organic or inorganic material that provide color and impart glossiness, opacity and durability to the finish. The most common pigment is titanium dioxide, a synthetic, inorganic chemical that provides a white pigment base. Resins, or binders, provide the paint with film continuity and adhesiveness. Solvents dissolve or disperse the binder component to modify the viscosity of coatings, while additives are used to improve coating performance and coverage, enhance durability and reduce material costs.

Traditionally, the residuals of most paints have been considered nonhazardous; paint residuals bearing the “hazardous” label have generally exceeded certain toxicity or ignitability thresholds. Nevertheless, in response to consumer concerns, manufacturers of many of these paints have altered their batch compositions in recent years.

- Mercury

Paint formulas in the past often included such toxic metals as mercury, lead, chromium and cadmium. Mercury was added to water-based paints and ship coatings to retard fungal growth in the paint. During the 1970s, when mercury use in paint reached its peak, concentrations of the metal in paint were limited to 200 parts per million, but its use continued; as of 1989, about 30 percent of water-based paints contained mercury. However, during the late 1980s, the paint industry struck an agreement with the U.S. Environmental Protection Agency to completely eliminate the use of mercury by August of 1990. Nevertheless, mercury can still be found in some water-based paints because some pre-1991 paints are still in circulation.

- Lead

While leaded solvents have been used in certain types of paint, lead-containing pigments are the primary source of lead in paint. Lead pigments are relatively inexpensive and offer good protection against sunlight and corrosion. However, due to concern over the poison risks for children, the Consumer Products Safety Commission in 1972 limited lead content in residential paints to 500 parts per million. Today, lead pigments are used primarily for industrial maintenance purposes and in roadway markings, where the metal can account for as much as 30 percent of the paint’s mass.

Efforts are underway to eliminate the use of lead in all paint. An initiative forwarded by the Coalition of Northeast Governors (CONEG) and adopted by 13 states will phase out lead, cadmium, mercury and hexavalent chromium in paint production by July 1 of this year. In addition to the 13 states under the regulation, several other states have followed suit by enacting similar or identical laws of their own.

However, the changeout will have its drawbacks. “Organic substitutes for lead cause higher paint prices and lower quality,” explains Jay Willner, president of San Francisco-based WEH Corp., which recently published a report entitled “Residential Lead-Based Paint Remediation.” Alternative materials are about 20 times more expensive than lead, and they offer less opacity and corrosion resistance.”
Wastes Produced During Paint Manufacture

**Inputs**

- **Water-Based Paints:** Water, Ammonia, Dispersant, Pigments, Extenders
- **Organic Solvent-Based Paints:** Resins, Pigments, Extenders, Solvents, Plasticizers

**Process**

- Raw Material Inventory
- Grinding
- Mixing
- Filtering
- Packaging
- Final Product Inventory

**Wastes**

- VOCs, Spills, Raw Material Containers, Baghouse Pigment Dust, Equipment Cleaning Waste
- VOCs, Spills, Raw Material Containers, Equipment Cleaning Waste
- VOCs, Filter Cartridges, Paint Sludge, Equipment Cleaning Waste
- VOCs, Spills, Equipment Cleaning Waste, Off-Spec Paint
- Returned Paints, Obsolete Paints

*Figure 3*
- Chromium

For years, chromium has been added to paint to produce a conversion coating, or "primer," for aluminum, galvanized steel and other substrates that resist adherence. Chromium is especially useful in this application because it is the only pigment reactive enough to convert aluminum surfaces. "Alternative products are available," says Phil Strom of Minneapolis-based Ti-Kromatic Paints, "but they are having only limited success in producing the properties that chromium accomplishes."

- Cadmium

Cadmium pigments, which are similar to lead and zinc chromate pigments, are used primarily in red and orange paints for automobiles, outdoor equipment and other applications that demand strong resistance to sunlight. Inexpensive cadmium pigments also offer good colorfastness and excellent heat resistance. And, due to cadmium's high color component, very little of the pigment is needed.

The use of cadmium pigments has been curtailed due to concerns over the safety of raw-material handlers. However, in January of this year, the Occupational Safety & Health Administration (OSHA) acknowledged the importance of this material and announced that the current TCLP standard of 1,000 parts per million would not be further reduced. An affordable replacement for cadmium pigments has eluded the industry; however, Rhone-Poulenc, a European chemical manufacturer, recently completed a multi-year study of a possible substitute. Dubbed "cerium sulfide," the inorganic material contains no heavy metals and is reportedly comparable in price and quality to cadmium pigments.

- Volatile Organic Compounds

The movement toward water-based paints has helped to reduce the VOC content of paints in general. Although oil-based paints are still burdened with VOC and ignitability problems, recent efforts to increase water-reducible co-solvents in oil-based paints have partially alleviated these concerns as well.

As a result of paint composition changes, raw material ratios have changed dramatically over the past decade; significant reductions in the use of solvent have meant corresponding increases in the use of resins, pigments and additives (see Figure 2). This trend is the direct result of the paint industry's efforts to reduce VOCs, according to Joe Maty, editor of American Paint & Coatings Journal, who adds that the trend could accelerate as more states impose stricter air regulations.

- Recycled Paint

A final development in paint formulation is the cautious movement toward using recycled paint. Major Paint Co., based in Torrance, California and the largest paint manufacturer on the West Coast, now produces a recycled paint — which includes about 50 percent virgin materials — that accounts for about 10 percent of its sales. About 90 percent of the recycled half comes from pre-consumer, in-house streams and the other 10 percent from household hazardous waste programs. Major Paint has a blanket agreement to supply the federal General Services Administration with the recycled paint for distribution to offices worldwide.

Paint industry innovators are now working to increase the ratio of recycled material and to utilize more post-consumer paint waste. Minneapolis-based Hirschfield Paints manufactured recycled paint as part of a cooperative pilot project with several counties in the Twin Cities metropolitan area. The recycled product, which was batch-processed and returned to the original owner of the paint, contained more than 90 percent post-consumer latex; titanium paste was added to improve the paint's appearance. "This closed-loop recycling project is still in the early stages of analysis," says Mark Uglem, a vice president for Hirschfield Paints. "But early results are promising for manufacturing recycled paints in this type of program."

Table 2

<table>
<thead>
<tr>
<th>Year of UCSC Assessment</th>
<th>Plant A</th>
<th>Plant B</th>
<th>Plant C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Mix</td>
<td>Oil-based paints (2/3 of total output); water-based paints; lacquers</td>
<td>Oil-based paints (2/3 of total output); water-based paints; stains; varnishes</td>
<td>Architectural paints; metal surface coatings</td>
</tr>
<tr>
<td>Annual Production (gallons)</td>
<td>1.5 million</td>
<td>2.7 million</td>
<td>6.0 million</td>
</tr>
<tr>
<td>Annual Production Time (hours)</td>
<td>4,000</td>
<td>2,000</td>
<td>4,125</td>
</tr>
</tbody>
</table>

Table 2 Overview of Paint Manufacturing Plants in UCSC Study
Table 3  Waste Generation Rates and Disposal Costs for Plants in UCSC Study*

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Plant A</th>
<th>Plant B</th>
<th>Plant C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material bags with containers</td>
<td>40.7</td>
<td>19.6</td>
<td>123.0</td>
</tr>
<tr>
<td>Pigment dust</td>
<td>$0.50¹</td>
<td>$19.64²</td>
<td>$21.33</td>
</tr>
<tr>
<td>Off-spec paint product</td>
<td>1.5²</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Spills and leaks</td>
<td>$2.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contaminated solvents</td>
<td>234.1⁴</td>
<td>172.4³</td>
<td>208.8³</td>
</tr>
<tr>
<td>Paint sludge</td>
<td>150.6⁵</td>
<td>49.1³</td>
<td>45.3¹</td>
</tr>
<tr>
<td>Filter cartridges</td>
<td>12.0²</td>
<td>14.4²</td>
<td>n/a</td>
</tr>
<tr>
<td>Totals</td>
<td>443.1</td>
<td>306.5</td>
<td>453.3</td>
</tr>
</tbody>
</table>

* Figures along top of each row represent pound per 1,000 gallons of paint produced; figures along bottom row represent disposal costs per 1,000 gallons of paint produced. ¹ Material is re-used or reconditioned. ² Material is landfilled. ³ Material is incinerated. ⁴ Material is sent off-site for disposal, method unspecified.

Sources: U.S. Environmental Protection Agency, University City Science Center (1994)

Paint Manufacturing Waste: A Three-Facility Case Study

Making paint is a relatively simple operation; pigments and additives are dispersed into a solution of resin and solvent and then mixed. Most manufacturers use the same set of equipment to produce many different types and colors of paint, including both organic solvent-borne and waterborne paints. Each type and color of paint is manufactured in a separate batch, and manufacturing equipment is thoroughly cleaned between batches to prevent contamination. Caustic or alkaline cleaning solutions are generally used to remove dried paint from equipment.

A historical review of paint manufacturing waste shows that, while a fair amount of innovative reuse techniques have been implemented since 1960, most of the implementation has been limited to the largest of facilities. However, as disposal costs have risen over the past decade, smaller manufacturers have signed on to more progressive waste prevention measures.

The EPA has contracted with the University City Science Center, a research group based in Philadelphia, to help small and mid-sized paint manufacturers minimize their generation of hazardous waste. Four paint manufacturing plants were selected to take part in a pilot assessment program. While one of the case studies was too limited in scope to be included here, the studies conducted at the other three plants provide useful insights into the waste management concerns of the industry as a whole.

Due to variations among the three studies — they were performed by different universities using different waste categories — it is difficult to compare the plants in a strict "apples-to-apples" sense. Nevertheless, the major manufacturing steps used at each plant — the grinding, mixing and filtering processes — are relatively universal.

Production levels at the three plants, which make a wide variety of paints and coatings, ranged from 1.5 million to 6.0 million gallons during the year of the study (see Table 2). The paint-waste generation rates of the three plants ranged from about 300 to 450 pounds per 1,000 gallons of paint (see Table 3). Although great variance exists among paint makers in terms of waste generation, these figures provide a good picture of the industry's typical plant, according to several paint manufacturers.

At each of the plants studied, contaminated solvents made up about 50 percent of the total waste stream. Due to in-house minimization efforts

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<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Opportunity</th>
<th>Anticipated Reduction</th>
<th>Capital Investment Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spent Filter Cartridges</td>
<td>Replace disposable cartridges with stainless steel</td>
<td>90-100%</td>
<td>1 month</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Filtration effectiveness can diminish unless other parts of the process are reconfigured to aid the filtration process.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spent Wash Solvent</td>
<td>Store spent solvent and reuse</td>
<td>75-90%</td>
<td>1 month</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Great minimization opportunity; widespread acceptance already exists.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solvent Vapors</td>
<td>Cover portable tanks</td>
<td>60-80%</td>
<td>18-24 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Is already a common practice in many plants to meet air regulations (especially in EPA-designated non-attainment areas).</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modify process tanks for submerged filling</td>
<td>40-50%</td>
<td>3-4 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Reduces leakages in paint flow process.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sludge</td>
<td>Extend settling and decanting time</td>
<td>30-60%</td>
<td>18-24 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: May require additional storage space.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computerize batch scheduling and inventory</td>
<td>25-50%</td>
<td>12-24 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Improves the long-range mixture forecasting.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Bags and Dust</td>
<td>Modify feed-in process</td>
<td>20-50%</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Simply move delivery area closer to tanks.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Install bulk storage silos</td>
<td>20-25%</td>
<td>24-36 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Only practical for producers of large quantities of specific paints. This also greatly reduces the amount of bags and pigment dust generated.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint Waste</td>
<td>Coat let-down tanks prior to cleaning</td>
<td>20-25%</td>
<td>18-24 months</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Reduces clinkage on tank walls.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Squeegee let-down tanks prior to cleaning</td>
<td>15-25%</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td><em>Comment: Allows greater re-use of paint.</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Comments provided by Mark Levine, manufacturing committee chair for the National Paints & Coating Association.

*Sources: U.S. Environmental Protection Agency, University City Science Center (1994)*
(reclaiming solvents and using no caustic cleaners), plants B and C generated 100 pounds less paint sludge per 1,000 gallons of paint than Plant A.

Total costs for waste treatment and disposal ranged from $105 to $157 per 1,000 gallons of paint manufactured. Plant A had the highest per-unit disposal costs, possibly because the larger plants were better able to negotiate favorable prices. Note that Table 3 does not include wastewater or wash-water disposal costs, which may add $25 to $100 for every 1,000 gallons of paint produced, depending on a plant's product mix and local wastewater regulations.

Table 4 shows a summary of the waste reduction methods implemented or considered by at least one of the three plants. Note that, when applied to other plants, waste reduction amounts and payback periods can vary greatly. Prior to assessing a paint manufacturing waste stream, a review of these minimization efforts is prudent as most plants will eventually incorporate many of these activities due to the relatively short payback periods.

**Current Options Limited**

While many regulations impinge on the production of paint, wastes generated by the paint manufacturing industry have not been specifically targeted by the EPA for reduction efforts. Because of this, the industry has traditionally been more concerned with producing paints that meet exacting customer specifications than paints that have minimal impacts on the environment.

"Paint manufacturers are generally complacent with existing waste-handling options," says Phil Farina, marketing director for Environmental Purification Industries (EPI), a paint-waste recycling company based in Toledo, Ohio. The environmental staff person at most paint plants has several other duties in addition to waste management, Farina explains; because of this, waste treatment and disposal options are seldom given comprehensive consideration.

During EI's discussions with paint manufacturers, three main criteria for choosing waste-management options emerged: cost (with long-term liability factored in), convenience (i.e., options that don't require extensive pretreatment), and transportation requirements.

As for disposal options, the industry's stated preference is clearly with solvent recovery and fuel blending; however, landfill disposal is still the most common choice for many paint waste streams because of cost and convenience. Most paint producers use hazardous waste landfills for some portion of their waste, although many plants segregate nonhazardous waste streams for disposal in Subtitle D landfills. Smaller plants are much more likely to use incinerators and fuel blenders, while larger facilities tend to rely more on landfills and solvent recyclers.

**Conclusion**

Over the past decade, the paint manufacturing industry has become responsive to environmental issues and consumer demands. Paints in general have become less toxic, and ignitability concerns have been addressed. Many paint manufacturers have implemented significant in-house waste reduction measures, reusing and recycling many materials that were previously discarded. It also appears that the paint-making industry is meeting most consumer demands — in particular, the demand for more water-based paints.

Although paint manufacturers generate significant quantities of waste, substantially greater waste streams are generated by end users. The second installment of this report will focus on the major paint users — including building contractors, equipment manufacturers, building contractors and specialty paint users — and their associated paint waste streams. △