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WMRC is a division of the Illinois Department of Natural Resources
Paint Waste Reduction
and
Disposal Options

Volume II — Site Visits

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ABSTRACT

This report presents case studies which document site visits conducted to characterize paint related waste activities of Illinois paint manufacturers, users, and waste processing facilities. Case studies are presented for eight paint users, four paint manufacturers, and one paint related waste processing facility within Illinois. In addition, two case studies document visits to waste processing facilities outside Illinois which process significant quantities of Illinois paint related waste.

The report includes an overview of paint manufacturing and application technology which introduces the processes which result in the generation of paint related waste. An overview of the case studies then describes methods currently used by manufacturers and users to reduce paint related waste through modifications of procedures and applications of new technologies. The complete case studies which follow the overview provide a concise description of the findings at each site.

The report concludes that greater emphasis should be placed on reducing wastes by Illinois paint users than by Illinois paint manufacturers. The study also found a lack of formal waste reduction plans at most of the facilities surveyed, even though significant waste reduction efforts had been undertaken. The results of the case studies suggest that existing environmental regulations and the New Clean Air Act, are already sufficient to provide powerful legal and economic incentives for both users and manufacturers of paint to implement VOC waste reduction measures. The case studies also indicate that cooperation between paint users and paint manufacturers is leading to the emergence of technologies to reduce paint related liquid wastes by capturing and reusing overspray generated in the application of liquid paints. Based on the site visits, it would appear that most paint related liquid wastes do not reach the environment untreated.

The case studies suggest that opportunities for improvement exist in the area of solid waste handling for both manufacturers and users of paint. In particular, while larger users and manufacturers tended to indicate they disposed paint related solid waste in a special waste landfill, smaller facilities, such as auto body shops and small paint manufacturers, tend to rely on general purpose landfills. Data on quantities of solid wastes generated were also often lacking at many of the sites. The case studies suggest that both paint users and manufacturers would benefit from additional guidance on proper handling of paint related solid wastes.
CHAPTER 1
INTRODUCTION

1.1 Background

The manufacture and use of paints and coatings is an important part of the economy of Illinois. Illinois is among the top five states in the production of paints and coatings. In addition, most manufacturing industries, and many small businesses, such as automobile body shops and residential/commercial painting contractors, use paint in their operations. Large quantities of paint are also used by households.

Both the manufacture and use of paint result in significant quantities of waste. The wastes generated occur in solid, liquid, and gaseous form, and due to the nature of paint, some may be hazardous.

Many manufacturers and larger users of paint have programs in place to reduce the amount of paint related waste. They utilize recycling where possible and dispose of their paint related wastes according to regulations. In combination, smaller businesses, industries, and households may produce quantities of these wastes similar in magnitude to larger industries, but may not have the resources to manage their paint related wastes as effectively.

Recognizing the potential impact of paint related waste on the State’s environment, the Illinois General Assembly amended the Solid Waste Management Act in 1989. The amendment directed the Illinois Department of Energy and Natural resources to conduct a study of paint waste reduction and disposal options for Illinois paint manufacturers and users, with special emphasis on small businesses and households.

This study consisted of three major efforts:

- a literature search and data review,
- a mail survey of Illinois paint manufacturers and users, and,
- case studies of Illinois paint manufacturers and users, conducted through site visits.

The results of these efforts, and overall conclusions and recommendations are discussed in the HWRIC report RR-060. The case studies are detailed in the report presented here.

Throughout this report, the term "waste" is used to refer to all non-product outputs from manufacturing or using paint. This definition of waste includes releases to the air, water, and land. It also refers to waste generation before any treatment or recovery activities. In this report, the wastes associated with paint manufacture and use will be broadly referred to as "paint related waste".
1.2 Objective

The objective of the effort described in this report is to characterize paint related waste generation, waste reduction, and waste disposal by Illinois manufacturers and users of paints and coatings. A further objective is to identify particularly successful methods of paint related waste reduction and disposal currently in use by, or applicable to, Illinois small businesses and industries.

1.3 Approach

Case studies were performed to characterize the paint related waste activities of Illinois paint manufacturers, users, and waste processing facilities. The case studies document visits to 13 facilities within Illinois. Two additional case studies were performed at paint waste processing facilities located outside of the state. These sites were included because they either currently or potentially may handle significant quantities of Illinois paint related wastes. Each of the case studies was guided by a detailed questionnaire. The questionnaire was developed through discussions with HWRIC, and pre-tested through site visits to three facilities. Summaries of the case study and pre-test site visits are included in this report. A copy of the case study questionnaire is included as Appendix B.

Candidates for site visits were identified through the Illinois Manufacturers Directory (1990). Selection of the sites visited was not random in that access to the site was controlled by the site operator. It is recognized that the observations gathered at these sites may be biased to the extent that those sites with good waste management practices were more likely to allow site access. An effort was made to achieve a reasonable geographic distribution of sites, but many sites were located in northeastern Illinois due to the concentration of both paint manufacturers and paint users in this area.

The procedure for gaining site access was through telephone contacts with the plant managers or environmental staff at the candidate facilities. In cases where the site was interested in participating in the study a copy of the survey questionnaire was provided, along with a cover letter describing the overall project objectives, sponsor, and project team. About one in three sites which expressed initial interest eventually allowed a site visit.

All of the site visits consisted of three phases. In the first phase an entry interview was conducted to discuss the objectives of the project, the overall information goals of the visit, and the nature of the site being visited. During this meeting the paint manufacturing or paint use process occurring at the site was discussed in detail to insure a complete understanding prior to beginning the actual inspection of the process. The majority of the site visit questionnaire was generally completed during the entrance interview. Those items of information requiring lead time to acquire were identified and efforts initiated to insure their availability during the third phase exit meeting.

The second phase of each visit consisted of the actual inspection of the paint use or manufacturing process. In the case of paint manufacturers, the inspection followed the process from the receipt of raw materials through production activities, to the completion and final packaging of the finished product. In the case of industrial paint users, the inspection began
at the portion of the manufacturing process where surface preparation began and followed the item to be painted to the point where the paint had been cured (dried). The inspection concentrated on identifying points of waste generation, quantities and types of waste generated, and methods of disposal, reuse, or recycling.

The third and final phase of each site visit consisted of an exit meeting. At this meeting the results of the inspection were discussed and any remaining items of the site visit questionnaire completed.

Following each site visit, a case study summary was developed. A copy of the summary was provided to each participating site for review and correction. Analysis of the site visit case studies provides a basis for characterizing the paint related waste management practices of these, and similar, Illinois paint users and manufacturers.
CHAPTER 2

PAINT TECHNOLOGY OVERVIEW

Site visits were conducted at five paint manufacturing facilities and nine paint user facilities within Illinois. During these visits a broad spectrum of paint types, paint application techniques, and paint manufacturing methods were surveyed. In order for the reader to better understand some of the observations from the site visits, this section provides a brief overview of paint types, paint manufacturing methods, and paint application techniques.

2.1 Paint Types

Paint can be defined as a fluid material that when spread over a surface in a thin layer will form a solid, cohesive, and adherent film (Morgans, 1990). Paint is generally considered to consist of a mixture of the following components:

- pigment,
- binder,
- solvent, and
- additives.

In paint, the combination of binder and solvent is referred to as the paint "vehicle". Pigment and additives are dispersed within the vehicle. The type and proportion of each of the components determine the properties of a particular paint. The various components of paint also determine the characteristics of the waste generated in its manufacture and use, including the potential environmental hazard and the available waste management options.

Paint classification can be approached in many different ways. From the standpoint of waste reduction and disposal, a convenient method is to classify paints based on the primary solvent they contain. Using this approach, paints can be classified as follows:

- waterborne
- organic solvent-borne, or
- powder (dry, without solvent).

2.1.1 Waterborne Coatings

The term waterborne refers to coating systems which use water to some degree as the solvent. These types of coatings include aqueous emulsions (latex), colloidal dispersions, and water-reducible coatings. Emulsion or latex coatings are made from polymers that are synthesized in water and contain a surfactant. Emulsion paints are formed by emulsion polymerization, i.e., by introducing a liquid monomer into water and causing polymerization of that monomer within small droplets. These coatings consist of discrete particles of high molecular weight polymer dispersed in an aqueous media. Emulsion paints are manufactured using a variety of polymeric resins. Resins used in emulsion paint vehicles include styrene-butadiene copolymers, polyvinyl acetate, acrylics, alkyls, and polystyrene. The term "latex" has become synonymous with emulsion paints, but strictly speaking, latex refers to an
emulsion of rubber particles. Latex coatings are used primarily for architectural purposes. They have been found to be generally unacceptable for use in industrial finishing due to problems associated with application (Gardon, 1973).

Water-reducible coatings are coatings that use water in part as a solvent and that can be reduced (thinned) using water. These coatings can be applied effectively using a wide range of application techniques. Water-reducible coatings are more complex than latex coatings. In water reducible coatings chemical structures (polar groups) are incorporated into the polymer to allow it to be soluble in water. The polymers used in water-reducible coatings are copolymers (polymers made with more than one kind of monomer) which are synthesized in water-miscible organic solvents such as alcohols and esters. Incorporated in these polymers are a small percentage of monomers containing carboxylic acid. These acid groups are then neutralized by bases such as ammonia or other amines to produce a product soluble in water. Water-reducible coatings contain organic solvents to varying degrees, depending on their formulation. A high-boiling point water miscible organic solvent is required to aid coalescence of the polymer after the water leaves the paint film. The coalescing solvent enables the deposited paint film to have fluidity for smooth curing after the water has evaporated. During curing of the water-reducible coating, the water, organic solvent, and bases (ammonia or amines) evaporate, leaving a material which is no longer soluble in water. Chemicals to induce cross-linking of the polymer as the coating cures can be added to improve coating durability.

Waterborne paints have advantages over some types of organic solvent-borne coatings because they generally decrease volatile organic chemical (VOC) emissions, eliminate organic solvents for thinning, and reduce the use of organic solvents during clean-up. When waste water is generated in waterborne painting, (such as in water-wall paint booths), the waste water contains fewer toxic organics because of the limited amounts of organic solvents in the paint. There are, however, two key disadvantages to waterborne paints. First, the surface to be painted must be completely free of oil film or the paint will not adhere well. Secondly, waterborne coatings require longer drying times or oven drying.

2.1.2 Solvent-borne Coatings

The term solvent-borne refers to coating systems that use organic solvents as their primary solvent. Nearly every type of binder material can be used in formulating organic solvent-borne paints. Included among organic solvent-borne paint are "oil-based" paint, most industrial and special coatings, primers, and wood finishes.

By their nature, organic solvent-borne coatings contain significant amounts of VOCs. High-solids coatings are being formulated to reduce VOCs. The solids content required in order for a coating to be considered a high-solids coating is not clearly established; Rauch (1990) defines high-solids coatings as having over 60 percent solids. The higher solids content produces a coating using less solvent, but modifications to spraying equipment are required due to the greater viscosity of high-solids coatings. Also, the reduced solids content makes high-solids coatings less tolerant to contaminants on the surface being coated (Higgins, 1989).
Wastes from solvent-borne paints are generally hazardous due to toxicity, flammability or both. However, the relative ease of solvent recycling and the high BTU content of solvent-borne wastes provides several possible avenues for waste recycling, reuse, or disposal.

2.1.3 Powder Coatings

Powder coatings entirely eliminate the use of a solvent and consist of resin, pigment, curing agents, catalysts, reinforcing filler, flow control agents, and other minor ingredients. The use of powder coatings continues to expand; in 1990 they were 8 percent of the industrial finishing market (Bocchi, 1991). Powder coatings are applied dry using electrostatic spray, fluidized bed, and flame spray application techniques. In all cases, the powder which adheres to the object being painted is melted using heat to provide a continuous film.

Thermosetting and thermoplastic resins are used in making powder coatings. With both types, the powder melts, flows, and forms a continuous film when heat is applied. Thermoplastic resins used in powder coatings are nylon, polyvinyl chloride, fluoropolymers, and polyolefins. These resins are used mostly in applications requiring a thick film. The majority of powder coating resins are thermosetting. These include epoxy, polyester, polyurethane, and acrylic resins for thin film applications.

Because powder coatings do not begin to cure until they are heated, it is possible to design spray booths to capture and recycle powder overspray. The result is potentially very high overall transfer efficiencies, in the range of 90 to 97 percent. (Section 2.3.2 provides further information on transfer efficiency.)

Powder coatings offer significant environmental benefits. VOCs are nearly eliminated because no organic solvent is used in powder coatings. In addition, little overspray waste (either solid or liquid) is generated because of the high transfer efficiency. After using a powder coating system for one year, one appliance manufacturer stated, "To date we have generated a total of 30 lbs of waste. We had a budget for waste disposal with our wet (paint) system in excess of $60,000 a year. We've dropped that to nearly nothing" (Stevens 1990).

Most of the disadvantages of powder coating systems are related to application. As for waterborne coatings, the substrate being coated must be completely clean for good adhesion of the powder. Organic solvent-borne paint systems are more tolerant of contaminants because the solvent can dissolve them in small quantities. Another disadvantage related to powder coatings application is the need to heat the parts being coated for most application methods. This can present difficulties in the case of large or very heavy objects. A third difficulty associated with application can occur in electrostatic powder spray systems for objects with certain surface geometries. For some geometries, electric fields can become established which prevent uniform deposition of the paint powder.

Powder coating technology is rapidly developing, increasing the number of products that can be coated using powder. Small-scale powder coating equipment is becoming available for use by smaller manufacturing operations. Powder coatings present a very viable option for reducing environmental impacts of painting operations.

2.2 Paint Manufacturing
2.2 Paint Manufacturing

The production of paint is a complex process involving dispersion of pigments and additives into a solution of resin and solvent, followed by relatively simple mixing operations. Figure 2.1, (EPA, 1990) provides a general overview of the paint manufacturing process.

Figure 2.1 Paint Manufacturing Process and Waste Generation  Source: USEPA 1990, p.7
The most important step in the paint manufacturing process is the initial pigment dispersion operation sometimes termed "grinding". A number of types of machines are used in the grinding operations; among the most common are ball mills, disc mills, and sand mills.

The ball mill consists of a cylindrical drum containing small balls which can be metal, pebbles, or steatite. In use, the pigment, vehicle, and other additives are introduced into the drum and the whole unit rotates continuously. As the mill rotates, the pigment is dispersed by the rubbing action of pigment caught between balls and between balls and the drum surface.

A disc mill is made up of a circular saw-toothed metal blade attached to a shaft, which rotates at high speed. The blade is immersed in the tank of material being dispersed. As the blade rotates, shear and mixing forces are generated in the media. While primarily mixing occurs, some particle size reduction may occur through impact with the mixing blade. Disc mills provide fast dispersion and are excellent for many types of latex paints.

A sand mill consists of a water cooled cylinder containing sand and agitator blades. The agitator blades generate rapid movement of the sand particles. The violent agitation of the sand produces shearing of the pigment particles. The dispersed mixture leaves the mill through a screen which retains the sand particles.

After dispersion, additional vehicle, solvent, and other additives are added to the ground mixture through simple mixing operations. When the paint is found to meet specifications it is filtered and packaged.

Different types of paint are manufactured by changing the raw materials used and their relative quantities. Organic solvent-borne paint manufacturing begins by mixing and grinding resins, dry pigments, extenders, organic solvents, and plasticizers. Tints and thinners (consisting of organic solvents) are then added and mixed into the batch. Waterborne paints are made by mixing water, ammonia, and a dispersant. Dry pigments and extenders are then added and the mixture is ground. Finally, resins, plasticizers, antifoaming agents, polyvinyl acetate (PVA) emulsion, and more water are added and mixed.

Many paint manufacturers 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 all manufacturing equipment is generally cleaned between batches of different types or colors to prevent contamination. Generally, an organic solvent is required to clean equipment after manufacturing an organic solvent-borne paint, while water can be used to clean equipment after manufacturing waterborne paints. In some instances, caustic cleaning solutions must be used to remove dried paint from equipment.
2.2.1 Wastes Generated in Paint Manufacture

Wastes generated in manufacturing paint (EPA, 1990) include:

- equipment cleaning waste, such as;
  - waste rinse water,
  - waste solvent,
  - paint sludge from cleaning operations,
- off-specification paint,
- obsolete paints and returned paint,
- empty raw material packages and containers,
- pigment dusts from air pollution control equipment,
- air emissions (VOCs),
- paint filter bags and cartridges,
- accidental spills and discharges.

Equipment cleaning wastes make up 80 percent of the waste generated in paint manufacture (EPA, 1990). The paint characteristics that affect the volume of clean-up wastes are drying time, curing mechanism, and solvent type (water or organic). For example, drying time determines if the mix tank must be cleaned soon after use or some hours later. A slightly longer drying time in the mix tank would allow the manufacturer more flexibility in scheduling tank cleaning. Similarly, the curing mechanism affects the drying time and also determines to some extent the difficulty of removing the dried film. Depending on the curing mechanism, the dried paint may or may not be soluble in its original solvent. Thus, the type of cleaning solution (and its potential environmental hazard) are affected by the paint curing mechanism.

The solvent type also affects the drying time and the ease of removal of the cured paint. In addition, the solvent type determines the degree to which the rinse wastes can be recycled into the next paint product. Under ideal conditions, rinse waste can be stored and incorporated into the next batch of paint. The applicability of this method varies for different circumstances. Paints incorporating organic solvents may be more sensitive to the mix of solvent, requiring tighter control of the type and quantity of solvent used in rinsing operations, and making it more difficult to incorporate rinse solvents in the next batch of paint. Reuse of rinse water in latex paint manufacturing operations may be difficult if the rinse water must be stored for more than a day. In such cases, the potential for bacterial contamination of the water may preclude its use in the next paint batch.
The use of organic solvents in paint formulations or to clean equipment generates waste in the form of VOC vapors. The evaporation characteristics of each solvent will affect the volume and environmental hazard of the VOC waste. For paint manufacturers, VOCs can be reduced by covering mixing tanks. VOC emissions from vents on solvent storage tanks can be reduced by changes in the vent design and by using equipment to recondense solvent vapors.

2.3 Paint Application

Paint is applied by various methods to provide a protective and decorative coating. In most instances the type of paint used and the application method are critical to the satisfactory performance of the coating. The process of painting an object includes:

- surface preparation,
- paint application,
- paint curing (drying).

2.3.1 Surface Preparation

Surface preparation is essential to obtaining a satisfactory coating which meets the requirements of surface protection and decoration. The types of surface preparation used vary depending on the material to be painted, the paint to be used, and the desired properties of the resulting finish.

Wood

Surface preparation of wood depends in part on the type of wood and its intended use. Preparation methods include sanding and application of fillers, sealers, preservatives, and primers.

Metal

Methods for surface preparation of metals are extensive. The first step can be a cleaning operation to remove any mill scale and/or rust which may be on the metal surface. This is accomplished using blast cleaning with abrasives, flame cleaning, or acid pickling. Metals that have oil or grease on their surface can be cleaned by solvent wiping or vapor degreasing. Solvents used include trichloroethylene, perchloroethylene, and 1,1,1 trichloroethane. Oils and grease can also be removed using alkaline degreasing solutions such as sodium hydroxide, sodium carbonate, sodium phosphate, sodium metasilicate, and borax. Alkali degreasing must be followed by efficient rinsing and several rinses are often used.

Following cleaning, a conversion coating may be applied to metal surfaces using a phosphating process. In the phosphating process the metal surface is treated with a dilute solution of phosphoric acid. The phosphate process results in a microcrystalline layer that improves the surface for paint application, providing better adhesion and some corrosion protection.
Plastic

Plastics to be painted may be roughened with mildly abrasive media, in some cases plastic shot. Vapor degreasing may also be used to prepare plastic surfaces for painting. For some plastics the surface may be oxidized using ultraviolet light activated chemicals, corona discharge, or acid pre-soaks (Roobol, 1990).

2.3.2 Application Methods

Paint application methods vary considerably depending on the material being painted, the paint used, and the desired finish. Most household painting is done using brushes and rollers, with a small amount of spray application. Auto body shop painting is almost exclusively done using spray equipment, either conventional pressure spray or newer, high-volume, low-pressure spray equipment. For paints used as product coatings, the importance of a high quality, durable finish demands tailoring of both the paint and the application technology.

The transfer efficiency is an important aspect of paint application technology from the standpoint of waste generation. Transfer efficiency is the amount of paint applied to the object being painted, divided by the amount of paint used. Transfer efficiencies for a given type of paint formulation vary with the type of equipment used, the skill of the operator, and the object being painted. Transfer efficiencies can range from 15 to 99 percent. Table 2.1 gives typical transfer efficiencies for industrial paint application processes. Efficiencies of brushes and rollers used in residential painting are estimated to be 95 percent.

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</table>
2.3.3 Curing Mechanisms

Once the paint is applied to the surface, a curing process takes place that converts the fluid paint into a hard, tough, adherent film. What occurs when a paint dries or cures depends on whether it contains a convertible or nonconvertible binder. If the binder is convertible, some form of chemical reaction occurs during curing which converts the paint to a solid film which is no longer soluble in its original solvent component. Paints which are made with nonconvertible binders do not undergo chemical reaction upon curing. As they dry, only the loss of solvent takes place through evaporation. The resulting films remain soluble in the original solvent component.

For paints with convertible binders, curing can take place through oxidation reactions at ambient temperature, through chemical reactions with another component (as in two-pack systems such as epoxy and polyurethanes), and by baking. Additional curing mechanisms include infrared radiation, ultraviolet radiation, and electron beams. Infrared curing is used for automobile finishes, industrial vehicles, and electric motors. Ultraviolet curing is frequently used for wood and metal finishing. Ultraviolet curing offers advantages from the waste reduction standpoint since few VOCs are used in paints made for ultraviolet curing. However, ultraviolet curing equipment is costly and requires certain additional precautions for worker safety.

Coatings that cure by a mechanism whose initiation can be controlled, such as radiation or baking, offer an advantage in terms of waste reduction because any overspray does not cure and thus is more readily recycled. Powder coatings in particular make use of this advantage; because they cure by baking, almost all powder overspray can be captured and reused.

2.3.4 Waste Generation in Paint Application

Wastes generated from industrial paint application processes may be hazardous due to the presence of toxic metals and organic solvents. Wastes generated in industrial paint application include the following:

- scrubber water, paint sludge, and filters from air pollution control equipment,
- equipment cleaning wastes,
- aqueous waste and spent solvents from surface preparation,
- VOC emissions during paint application and curing,
- empty raw material containers, and,
- obsolete or left-over paint.

Household paint use generates waste from equipment cleaning, VOC emissions, empty containers, and left-over paint. Figure 2.2 summarizes the waste generation processes occurring during paint application.
Figure 2.2 Paint Application Waste Generation
Paint transfer inefficiency can be the largest source of waste from paint application processes. Paint used but not applied to the surface being coated, (e.g., paint overspray), generally becomes waste. Paint-laden air from overspray is often filtered using dry filters or a water scrubber that removes the paint from the air. Dry filters containing overspray are usually disposed in a landfill. Scrubber water is recycled, and paint sludge is disposed either in a landfill, or through fuel blending or incineration, depending on the characteristics of the sludge.

Surface preparation can also be a large source of waste in paint application processes. Some metal surfaces may require surface cleaning, degreasing, and phosphate treatment. These processes result in wastewaters and alkaline and phosphate sludges.

Evaporation of organic solvents is another important source of waste. The entire solvent component of organic solvent-borne paints eventually evaporates after the paint is applied. In addition, organic solvents used to thin paint, to clean equipment, and to prepare surfaces for painting are sources of VOC air pollution.

Equipment cleaning is also a major source of waste generation. Generally, paint application equipment must be cleaned after use to avoid contaminating the next paint job. Brushes and rollers used in household painting need to be cleaned after each use to remain pliable. Wastes generated in equipment cleaning include spent organic solvents, alkaline solutions, wastewaters, and paint sludge.
CHAPTER 3

CASE STUDY OVERVIEW

The discussion presented here provides an overview of the data gathered during the site visits. Complete case study summaries are presented in Chapter 4. While there are many areas of similarity among the various sites, each is to some extent unique. It is difficult to completely summarize the site visit data due to the number of topics covered and the diversity of responses. The reader is encouraged to review the case study summaries to gain further insight into the waste management activities at each site.

The case study methodology is not intended to develop conclusions of a statistical nature. The sample size, and the non-random method used to select the sample, preclude such use of the data. Numerical data presented here are accurate to the greatest extent possible, but are representative of specific sites only. Use of the data in making industry or state-wide projections should be approached with caution. Based on data presented here, such estimates should be regarded as order of magnitude only. The objective of the case study methodology is to provide specific knowledge regarding the workings and characteristics of the individual sites, recognizing that many similar sites exist within Illinois.

3.1 Paint Manufacturing

Five paint manufacturing facilities were visited. Table 3.1 below provides the designation used to identify the facilities in this study. Of these facilities, one is a small manufacturer of product coatings, two are large manufacturers of product coatings, and two are large manufacturers of architectural coatings primarily sold to households. Annual production volume ranged from 7 million gallons per year for the largest architectural coatings plant, to 240,000 gallons per year for the smallest product coatings plant. The number of employees at these facilities ranged from 19 to 150.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architectural Coatings</td>
<td>2</td>
<td>B, N</td>
</tr>
<tr>
<td>Product Coatings</td>
<td>3</td>
<td>A, C, P2</td>
</tr>
</tbody>
</table>

The types of paints manufactured at the five facilities included both organic solvent-borne and waterborne paints. Paints being manufactured at these plants include epoxies, silicone polyesters, alkyds, acrylics, phenolics, epoxy phenolics, vinyl and acrylic emulsions (latex), water reducible alkyds, and high-solid polyesters. Industries served by the manufacturers of product coatings in this study include coil coating, steel container manufacturing, manufacturing of automobile parts, agricultural and industrial equipment manufacturing, office equipment and furniture manufacturing, and manufacturing of metal buildings. The architectural coatings plants in this study serve retail customers and building construction contractors.
The manufacturing processes employed at all the facilities was similar and is illustrated in Figure 2.1. Equipment used for grinding and dispersion included horizontal and vertical sand mills, ball mills, and disc mills. In this study, both facilities that use horizontal sand mills expressed a belief that this piece of equipment reduces VOC emissions during grinding. Filters in use at the facilities included both cartridge and bag types; with the architectural coating plants using bag types only, while the product coatings plants used both filter types.

All of the plants use a batch type manufacturing process. The plants making product coatings tended to serve niche markets and manufacture paint somewhat on an as-needed basis. These plants also manufacture a wide variety of different paint types in smaller batches, often custom blended for specific clients. The plants making architectural coatings, primarily for retail sale to households, tended to operate in a more continuous, fixed-volume fashion, with more latitude for long term production scheduling.

Some of the differences in operation between the product and architectural coatings manufacturers in this study are reflected in the variation in batch sizes at these facilities. While the maximum batch size is approximately the same for all the larger facilities, the minimum batch size is much smaller for the product coatings plants. For the larger product coatings plants, the minimum batch size is 5 gallons, while the smaller product coatings plant will manufacture a batch as small as 1 quart. The table below illustrates these batch size differences.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Batch Size Range</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant A</td>
<td>5 to 4,000 gallons</td>
<td>Product coatings</td>
</tr>
<tr>
<td>Plant B</td>
<td>500 to 4,000 gallons</td>
<td>Architectural coatings</td>
</tr>
<tr>
<td>Plant C</td>
<td>5 to 4,000 gallons</td>
<td>Product coatings</td>
</tr>
<tr>
<td>Plant N</td>
<td>750 to 6,000 gallons</td>
<td>Architectural coatings</td>
</tr>
<tr>
<td>Plant P2</td>
<td>.25 to 1,200 gallons</td>
<td>Product coatings</td>
</tr>
</tbody>
</table>

3.1.1 Waste Generation

Sources of waste generation at all of the paint manufacturing facilities were found to be similar and include; equipment cleaning waste, waste paint, air emissions, accidental spills, empty raw material containers, spent filters, and pigment dusts from air pollution control equipment. While the sources of waste at each of the plants were similar, the quantities and compositions varied among the facilities. Direct comparison of many of the waste types is difficult because of different units used to record the data at each plant. Some plants used gallons, others used pounds, and others used cubic yards. The solids content and chemical composition of many of the liquid wastes was not well documented or varied on a daily basis.
In general, each paint manufacturer indicated that equipment clean-up was the greatest source of waste. The clean-up waste typically consists of newly manufactured paint and clean-up solvent. At plants manufacturing solvent-borne paints organic clean-up solvents are used. At plants manufacturing waterborne paints the clean-up solvent used is water. Some plants manufactured both waterborne and solvent-borne paints and had both a water and an organic solvent waste stream. One plant manufacturing solvent-borne paints indicated that in some circumstances it is necessary to use a caustic solution in tank cleaning. Usually, it was not possible to identify the specific quantity of clean-up wastes being generated at a facility, because often the facility kept data only on its total liquid waste stream. In some plants, clean-up solvent, waste paint, aqueous waste, and even baghouse dust were blended into one liquid waste stream.

Spills and waste paint are another source of waste for the paint manufacturing facilities. Waste paint may be generated by manufacturing too much paint and also as customer returns and obsolete stock. Only one plant reported disposing of waste paint. All of the other plants indicated that they "worked-off" waste paint by reformulating it into other products or finding alternative customers for the material. Spills at the paint manufacturing plants included in this survey were reported to be rare, but when they do occur causes include overflowing of batch tanks and can upsets during can filling operations. All of the plants indicated that spills and waste paint make up only a small portion of the waste generated.

Air emissions from the plants in the survey occur mainly in the form of VOCs. All of the plants use a baghouse to capture airborne dusts generated in the manufacturing process. Of the five plants visited, only three had VOC data available during the site visit. The data from one plant manufacturing solvent-borne paint indicated VOC emissions equivalent to .015 pounds of VOC per gallon of paint manufactured. These emissions were not measured, but were estimated by the paint manufacturer using EPA guidelines. The VOC emissions from the plants manufacturing waterborne paints were extremely low, except for one plant which also packaged solvent-borne paints (manufactured elsewhere) into aerosol cans. This plant reported a large VOC emission from this activity. The VOC emissions from aerosol can filling operations at this plant were on the order of .029 pounds per gallon.

Solid wastes in the form of bag and cartridge filters, baghouse dust, and empty raw material containers are also generated at the facilities surveyed. Data for filter wastes were reported in pounds per year, cubic yards per year, bags per year, and gallons per year. Overall quantities of filter wastes reported by the facilities are small relative to the quantities of paint manufactured. For one product coatings manufacturer making solvent-borne paints, the volume of spent cartridge filters reported was 120 cubic yards per year. This amounts to about .00007 cubic yards of filter waste per gallon of paint produced. Similarly, one manufacturer of architectural latex paints reported using 900 bag filters per year, or one filter for every 2,780 gallons of paint manufactured. Data for solid wastes in the form of material containers were not well documented. Drums were generally disposed through a drum recycler or returned to the material supplier. Information on wastes from empty packaging such as fiber bags for pigment and other dry powder additives was generally unavailable during the site visits. At the small products coating plant, this material was being disposed with other non-paint related wastes. During the site visit to this facility, personnel responsible for waste management were informed of the requirement to dispose of paint related wastes at a licensed...
special waste landfill. It has since been determined that this facility has begun to segregate its paint and non-paint related solid wastes.

3.1.2 Waste Reduction

Waste reduction methods for the paint manufacturing industry are well documented in the EPA report "Guides to Pollution Prevention - The Paint Manufacturing Industry" (EPA, 1990). Two of the five paint manufacturers surveyed had this document on hand. All of the facilities have implemented one or more of the waste reduction methods outlined in the EPA report. At each plant, certain waste reduction efforts were considered to be the most effective; these are summarized below.

Reduction of Equipment Clean-up Waste

All of the facilities reported reusing clean-up solvent as a waste reduction measure. Two of the five plants surveyed reported using an in-house organic solvent recovery still to recover and reuse organic solvent used for equipment clean-up. One plant reported that the payback for a $35,000 still was six months. At both plants using solvent stills, the amount of solvent which could be reclaimed was limited by the minimum required BTU content of the plant’s overall liquid waste stream. Two other plants reported using a solvent recycling service and purchased recycled solvent for use in equipment clean-up. Several of the facilities also incorporated clean-up solvents as ingredients in subsequent paint batches. It was found in this study that manufacturers of solvent-borne product coatings and manufacturers of waterborne architectural paints each face different obstacles in implementing this practice.

As indicated previously, the product coatings manufacturers tend to manufacture a variety of paints. Incorporation of clean-up solvent in a subsequent batch of paint is more difficult in this case because the contents of the clean-up solution may not be compatible with the next paint batch. Two of the three solvent-borne coating manufacturers in this study have solved this problem by saving clean-up solution in drums and logging the drums into their computerized inventory system as raw material. Data for each drum indicate the contents of the clean-up solution. The computer flags this material for use when a compatible paint batch is made. Neither facility has quantified the savings resulting from this practice.

The manufacturers of architectural latex paints in this study also reuse clean-up solutions, but at latex plants this material can be kept only for a short time. This is due to the potential for bacterial contamination of the clean-up solution. Ideally, a compatible paint batch should occur within twenty-four hours. At one plant, if the clean-up solution has to be retained over the week-end, a bactericide is added to the solution. If a compatible batch of paint is not manufactured in at most two days, the clean-up solution must be processed for disposal. Both manufacturers of architectural latex paints in this study report reusing wastewater generated in equipment clean-up as raw material in subsequent paint batches. One manufacturer made changes in the paint formulation specifically to improve the ability to reuse wastewater in this fashion. One plant reports a 60 percent reduction in sludge sent to landfills, while the other reports an 86 percent reduction in the quantity of this material.
Demand-Side (User) Waste Reduction

One of the product coatings manufacturers reports development of a wet and dry overspray recycling system to be implemented by its paint customers. Customers using this system collect overspray and return this material to the paint manufacturer. The material is remanufactured into paints which are purchased by the customer at reduced cost. A similar system, developed independently by a paint user, is described later in this report.

Other Waste Reduction Efforts

Two of the five paint manufacturers report recently implementing formal, goal-driven, waste reduction programs. Employee incentives for waste reduction are included in both of these programs. Results of these programs have not been assessed since they have only recently been initiated. These same two facilities have also initiated total quality management programs which should also impact waste generation. However, neither plant has formally integrated its total quality management program with its waste reduction program.

3.2 Paint Users

Ten site visits were made to users of paint within Illinois. Table 3.3 below provides a breakdown of the various industries included in the site visits.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Case Study</th>
</tr>
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<tbody>
<tr>
<td>Automobile Body Repair</td>
<td>3</td>
<td>I, J, P1</td>
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<tr>
<td>Wood Finishing</td>
<td>2</td>
<td>E, K</td>
</tr>
<tr>
<td>Metal Containers</td>
<td>1</td>
<td>D, O</td>
</tr>
<tr>
<td>Lawn &amp; Garden Equipment</td>
<td>1</td>
<td>L</td>
</tr>
<tr>
<td>Construction Equipment</td>
<td>1</td>
<td>P3</td>
</tr>
<tr>
<td>Product Finishing Contractor</td>
<td>1</td>
<td>F</td>
</tr>
<tr>
<td>(Misc. metal products)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The paint users surveyed ranged in size from the product finishing contractor that employs 9 people, to the construction equipment manufacturer that employs more than 3,000. Paint application processes in use at these facilities ranged from primarily manual methods to complete automation.

While a variety of industries were included in the site visits, many similarities were found in the painting activities at each site. In all cases, painting operations consisted of surface preparation, followed by paint application (including priming), followed by paint curing (drying). Surface preparation methods in use at the sites ranged from dry sanding, to a five stage phosphate rinse process. The sites surveyed included both metal and wood painting operations. A variety of waterborne and solvent-borne paints were in use. Application
techniques in use at the sites included conventional spray, high-volume low-pressure spray (HVLP), electrostatic spray, spinning disc electrostatic spray, curtain coating, dip coating, electrocoating, and electrostatic powder spray. Overspray collection systems included dry filter paint booths, and horizontal and downflow water-wall paint booths. Paint curing methods included air drying and oven curing.

3.2.1 Waste Generation

Sources of paint related waste generation were similar among the user sites. Waste generation occurred in the form of VOCs from paint curing and equipment clean-up, as liquid and solid surface preparation waste, as overspray from spray painting operations, as left-over paint, as liquid waste from equipment clean-up, and as empty paint containers and other solid wastes. The quantities and composition of these wastes varied significantly among the paint users. Also, as in the case of paint manufacturers, waste quantities were reported in a variety of units.

With the exception of the facility using powder paint, the greatest amount of paint related waste for all of the sites were VOCs from paint curing and equipment clean-up. The relative amounts of other types of waste varied among the sites.

Automobile Body Shops

At automobile body repair shops, overspray and left-over paint were the largest sources of waste after VOCs. At two of the shops surveyed, left-over paint was estimated to be as much as 20 percent of paint usage. Transfer efficiencies reported for auto body painting ranged from 25 to 80 percent depending on the equipment used. These transfer efficiencies were not measured, but represent the estimates of paint equipment operators. For a facility whose left-over paint accounts for 20 percent of paint usage, overspray and left-over paint quantities are equal at 75 percent transfer efficiency. At values of transfer efficiency less than 75 percent, overspray waste is greater than left-over paint. At the auto body shops surveyed, the next largest source of waste after overspray and left-over paint is organic solvent used in equipment clean-up. Solid wastes in the form of paint dust and other dust from surface preparation sanding represented the smallest volume of waste.

All of the shops included in the study use enclosed down-flow paint booths. One shop uses a down-flow booth having a water-wall overspray capture mechanism. This type of paint booth generates a liquid sludge from the captured overspray. At this shop, which repairs approximately 3,000 vehicles annually, the combined volume of paint sludge from overspray and organic solvent from clean-up is 2,700 gallons per year.

Solid waste in the form of spray booth filters was generated at each of the shops surveyed. For those shops using the dry filter paint booths, these filters contained the majority of overspray. Accurate data on the number and volume of filters generated annually were not available at any of the auto body repair shops included in this study.
Wood Finishing

Two wood finishing companies were included in the site visits. Both of the facilities are manufacturers of wood kitchen cabinets. Paint used at both facilities included solvent-borne stains and nitrocellulose lacquers. After VOCs, the greatest sources of waste at these facilities are overspray and clean-up solvent. One of the kitchen cabinet manufacturers uses spray application techniques exclusively, while the other uses both spray and curtain coating application techniques. At both facilities, spray painting is performed in dry filter paint booths. At one facility, spot measurements of transfer efficiency by the plant’s spray equipment supplier indicated spray painting transfer efficiencies of approximately 40 percent. Transfer efficiency of the curtain coating operation at this plant was not measured, but is estimated at better than 90 percent.

Clean-up waste at the wood finishing facilities includes organic solvent used to clean equipment and also organic solvent used to wipe overspray from finished products. At one point in the painting operation at one of the plants, cabinet edges are spray painted. This results in overspray accumulating on previously painted surfaces of the cabinet. This overspray is removed through manual wiping with organic solvent. This use of organic solvent represented a significant source of VOC generation for this plant. In fact, at this plant, VOCs generated by the evaporation of clean-up solvent are estimated to exceed those produced in paint curing. At both wood finishing plants, no liquid organic solvent waste stream was reported, and neither plant utilizes a solvent waste hauler. Both plants reported that all organic solvent used is allowed to evaporate, and one plant indicated that some is burned as a means of disposal. Neither plant reported a left-over paint waste stream. The paint colors used at the plants are constant enough so that all paint is eventually applied. Paint left-over in paint lines due to color changes is back-flushed into the original paint container using organic solvent. Surface preparation waste generated at the two plants consists of wood dust from sanding operations. By their nature, both plants generate large quantities of sawdust. Wood dust generated in paint preparation sanding is not separately recorded.

Metal Finishing

The manufacturer of containers, the manufacturer of lawn and garden equipment, and the product finishing contractor can be grouped as metal painting operations. With the exception of the product finishing contractor, the greatest source of paint related waste at the sites is VOC. The product finishing contractor visited in this study utilizes an electrostatic powder spray application technique and generates no VOCs. Sources of paint related waste other than VOCs for the metal painting operations included surface preparation wastes, paint overspray, and equipment clean-up.

For the product finishing contractor using powder paints, the greatest source of waste is from surface preparation. At this plant, surface preparation consists of an iron phosphate rinse followed by a clear water rinse. This process generates approximately 1,000 gallons of effluent per year which is discharged to the sanitary sewer system. Surface preparation is also the greatest source of waste for the lawn and garden equipment manufacturer and in this case, the quantities are significant. This plant uses a five step surface preparation process consisting of an alkaline rinse, a clear water rinse, an iron phosphate rinse, a second clear water rinse, and a final deionized water rinse. This process results in 19,200 gallons of alkaline rinse.
sludge and 12,000 gallons phosphate rinse sludge per year. On the other hand, the container manufacturer had no surface preparation wastes. All sheet metal used in this operation is purchased "clean and dry". A type of oil known as "vanishing oil" is used to lubricate the production machinery. The oil evaporates completely from the work piece before painting occurs.

At the container manufacturing plant, after VOCs, overspray is the greatest source of paint related waste. This plant generates 11,000 gallons of paint sludge per year from water-wall paint booths. At the lawn and garden equipment manufacturing plant, overspray is the third largest source of paint related waste, following VOCs and surface preparation. The industrial paint contractor using powder coating reported no overspray waste, since his powder coating system is designed to recover overspray.

Organic solvents for equipment cleaning or color changes result in a significant waste stream at the container manufacturing and lawn and garden equipment manufacturing plants. The lawn and garden equipment manufacturer also has a waste stream from a caustic dip paint stripping operation. The product finishing contractor reported no organic solvent usage for clean-up. However, some waste powder paint is generated in paint spills.

3.2.2 Waste Reduction

All of the paint users included in the site visits had implemented some form of paint related waste reduction measure. These efforts are summarized below.

Reduction of Overspray

Two of the three auto body shops included in the survey either had switched to, or were experimenting with, using High Volume Low Pressure (HVLP) spray technology. One shop reported paint savings of 33 percent during the period that HVLP paint technology was under evaluation. The third auto body shop reported paint transfer efficiency improvements through changing the brand of paint used. This shop estimated transfer efficiency improvements to be on the order of 15 to 20 percent due to improvements in the application characteristics of the new paint.

Both of the wood finishing plants included in the site survey reported improvements in transfer efficiency by switching from high to low pressure spray systems. In addition, one of these plants also purchased a curtain coating system with transfer efficiency on the order of 90 percent. The use of the curtain coating technology is estimated to have reduced paint consumption by as much as 50 percent at this facility.

At the facility manufacturing lawn and garden equipment, an in-house modification has been made to water-wall paint booths to capture and recycle overspray. The paints used at this plant are solvent-borne high-solids polyester that do not cure rapidly until baked. The plant has installed a set of baffles in each of their water wall paint booths to capture paint for recycling. Recycled paint is returned to the plant’s paint supplier for remanufacture and is then purchased by the plant at a substantial discount. This arrangement is similar to that discussed under waste reduction by paint manufacturers.
At the container manufacturing plant, transfer efficiency has been improved from an estimated 35 percent to an estimated 75 percent by converting from a high pressure to a low pressure spray system. Overspray sludge from paint booths was reduced from 23,500 gallons per year to 11,000 gallons per year. Containers painted per gallon improved from 125 to 180 containers per gallon. Estimated payback period for the $40,000 investment was three months based on paint savings alone. Additional savings in clean-up and waste disposal are estimated at between $15,000 and $20,000 per year.

Also at the container manufacturing plant, data is maintained regarding "mileage" or cans coated per gallon of paint. This information has been useful in evaluating overall paint process effectiveness, as well as the effectiveness of changes in operations, such as the change in spraying systems described above.

The powder coating system in use at the product finishing contractor’s facility has resulted in nearly complete elimination of overspray waste due to capture and recycling of powder overspray.

**Reduction of VOCs**

All of the efforts to reduce overspray described above also result in reduction in generation of VOCs. The use of powder paint by the product finishing contractor has completely eliminated VOC waste at this plant. In addition, the container manufacturing plant is experimenting with waterborne paints having reduced VOCs, and one of the wood finishing plants is also considering this option.

**Reduction of Left-over Paint**

One auto body shop reports using a paint manufacturers system which has greatly reduced left-over paint by allowing the mixing of only as much paint as is needed. A second auto body shop reports plans to begin using a similar system and digital scales along with assigning an individual to act as a specialist and perform all paint mixing duties. This shop is also considering purchasing computer software to aid in estimating required paint quantities and paint formulations.

**Reduction of Clean-up Waste**

The container manufacturer reports the purchase of a solvent still to recover clean-up solvent for reuse. Projected savings for this technology are $17,000 in costs for clean-up solvent and waste disposal. This facility has also purchased a burn-off oven to remove paint from work piece hangers. The oven replaces a hot acid bath used for the same purpose. Savings from the burn-off oven are small, on the order of $1,000 per year. However, the plant reports that the oven has resulted in improved ease of operation and worker safety.
3.3 Waste Disposal

Methods of paint related waste disposal were found to be similar regardless of whether the waste is generated during paint manufacture or paint use. All waste streams are either incinerated, fuel blended, or landfilled. In general, none of the sites visited were applying any type of VOC capture or destruction process. At all of the sites, organic solvent liquid wastes not recycled were found to be disposed through fuel blending or incineration. Aqueous wastes and sludge were found to be either dewatered and landfilled, or mixed with solvent wastes and disposed of through fuel blending or incineration. Certain solid wastes, such as baghouse dust or paint dust removed in sanding operations, were found to be disposed of by being landfilled or by being mixed with solvent waste and fuel blended or incinerated. Other solid wastes such as empty paint containers, pigment bags, masking materials etc., were disposed in landfills. Accurate data on paint related solid waste quantities disposed in landfills were lacking at all facilities surveyed. None of the auto body shops or wood finishing plants in the survey segregated paint related solid waste from ordinary solid waste. One small paint manufacturer also was not segregating paint related solid waste at the time of the survey.

As part of the site visits, three facilities processing liquid and solid paint related wastes from Illinois were visited. Two of these plants are fuel blending and recycling operations. Any material which these plants receive and do not fuel blend or recycle is disposed by the plant through incineration. A third plant processes aqueous paint related liquid wastes into a dry powder that is being recycled. Site visits to these facilities are described in case studies G, H, and M. The figure below indicates the relative proportion of material which is fuel blended and recycled at one of the fuel blending and recycling facilities.

![Figure 3.1 Disposition of Wastes By a Solvent Waste Processing Facility](image-url)
CHAPTER 4

CASE STUDIES

Documentation of fifteen site visits follows. All of the participating sites did so with the understanding that their identity would not be disclosed. Each of the sites is identified alphabetically. Table 4.1 below provides a summary of the industries which participated in the site visits. These sites were chosen based on a literature search and data review, as representative of the major paint-related small businesses and industries in Illinois. Visits to three additional sites, conducted during the questionnaire pre-test phase of the work effort, are described in Appendix A.

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<thead>
<tr>
<th>Site ID</th>
<th>Type of Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Manufacturer of product coatings</td>
</tr>
<tr>
<td>B</td>
<td>Manufacturer of architectural (household) coatings</td>
</tr>
<tr>
<td>C</td>
<td>Manufacturer of product coatings</td>
</tr>
<tr>
<td>D</td>
<td>Container manufacturer</td>
</tr>
<tr>
<td>E</td>
<td>Wood products manufacturer</td>
</tr>
<tr>
<td>F</td>
<td>Product finishing contractor</td>
</tr>
<tr>
<td>G</td>
<td>Organic solvent recycling facility</td>
</tr>
<tr>
<td>H</td>
<td>Organic solvent recycling facility</td>
</tr>
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<td>I</td>
<td>Automobile body repair shop</td>
</tr>
<tr>
<td>J</td>
<td>Automobile body repair shop</td>
</tr>
<tr>
<td>K</td>
<td>Wood products manufacturer</td>
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<tr>
<td>L</td>
<td>Lawn and garden equipment manufacturer</td>
</tr>
<tr>
<td>M</td>
<td>Paint waste recycling facility</td>
</tr>
<tr>
<td>N</td>
<td>Manufacturer of architectural (household) coatings</td>
</tr>
<tr>
<td>O</td>
<td>Specialty metal containers and cabinets</td>
</tr>
</tbody>
</table>
4.1 Plant A

4.1.1 General

Paint manufacturing plant A was visited in May 1991. Meetings were held with the plant manager and the plant engineer. Coincidentally, a member of the corporate staff responsible for materials accounting was at the plant to give a presentation to employees on waste management and this presentation was attended by the site visit team as well.

Plant A is a medium to large producer of product coatings with an annual output in 1990 of 1,655,000 gallons. A significant portion of the plant's output is shipped out-of-state to Iowa, Indiana, and Tennessee. Of the paints produced at the plant, 90 percent are organic solvent-borne coatings and the remaining 10 percent are waterborne. Paints manufactured at this facility are primarily used in coating metal. Major industries that are served by the plant include coil coating, steel container manufacturing, manufacturers of automobile radiators, and manufacturers of metal buildings. The paints are formulated for dip, roll, and spray application techniques.

A manufacturing process diagram for plant A is shown in Figure 4.1. The paint is manufactured in a batch process. In the beginning of the process or "pre-batch" stage, materials are assembled based on a formula sheet and placed on a pallet. The materials from the pallet are placed in a mixing tank and solvent and resin are added. Depending on the formula, the ensuing step may be one of several possible grinding/dispersion operations. Following this operation, the batch is "let-down" into mixing tanks for further blending with other components. At this point quality control operations take place to determine if the paint meets customer specifications and adjustments are made as necessary. When the paint passes quality control it is filtered and metered into containers for shipment to the customer.

Batch sizes range from 5 to 4,000 gallons. Paints are packaged in 50 to 55 gallon drums, 275 to 300 gallon totes, 3,000 gallon tank wagons, and occasionally in 5 gallon cans. Many different kinds of paint are manufactured at the plant including epoxies, silicone polyesters, alkyds, acrylics, phenolics, epoxy phenolics, and high solid polyesters. Many of these paints are high-solids paints formulated for low VOCs. All the paints manufactured generally have a VOC content of about 3 pounds per gallon. About 650 different raw materials are used at the plant. Some heavy metal chromate pigments such as lead, zinc, and strontium chromate are used to make primers for the coil coating industry. Organic solvents used include toluene, xylene, methyl isobutyl ketone, ethyl benzene, butyl alcohol, methyl ethyl ketone, and cellusolve blends (cellusolve is a name used for various glycol ether compounds).

Because the plant custom manufactures paints for each customer, several hundred different formulations are manufactured. Because the manufacture of many different formulations in separate batches can contribute to waste generation from frequent equipment cleaning, the plant manager was asked why it wasn't possible to reduce the number of formulations through standardization. The plant manager indicated that there were several reasons and used the following case as an illustration. In an actual situation, the plant was supplying two different manufacturers of the same product. Although the products being manufactured were the same, there were variations in the manufacturing technique. The variations in manufacturing...
technique resulted in differences in paint application method, speed of application, and curing method so that both product manufacturers required slightly different paint formulations to achieve the same final result.

![Paint Manufacturing Process at Plant A](image)

**Figure 4.1 Paint Manufacturing Process at Plant A**

A variety of equipment is used in the paint manufacturing process at this plant. Equipment varies in age from new to 50 years old. The plant uses 12 ball mills, mostly very old, 8 vertical sand mills, and 2 horizontal sand mills. It was stated by the plant manager that the new horizontal sand mills release fewer VOCs than the vertical mills because they utilize closed pressurized vessels. In addition to the milling equipment, the plant uses numerous large
and small mixers/dispersers. Various fixed and moveable scales and meters are used to measure each component of the paint formulation. Steps are being taken toward automating certain aspects of the plant operations. Some smaller scale production operations may soon be controlled using a personal computer. Overall production of each batch of paint is tracked manually using a wall mounted tag system in a central office. The position of the tags is periodically entered into the plant central computer system so that various plant activities can access information on the status of a batch of paint.

Twenty-five people are directly employed in manufacturing paint at the plant. There currently is no formal program for training employees in manufacturing methods (although there are formal safety training programs). At present, when a new employee is hired, they are assigned to work with the most knowledgeable worker available and learn on-the-job. It was admitted by the plant manager that there are variations in the way each job is performed. For example, each mill operator operates their mill a little differently from the next. There is a mix of good and bad work habits. This situation is changing, however. As part of a new corporate quality improvement program, each step of the paint manufacturing process is being documented, including identification of the best methods to employ. As part of this effort, at each stage of the manufacturing process the process output and in-plant customer for the output are identified. Criteria are determined which define the quality of the product required by each in-plant customer. Clear definition of input and output quality requirements at each step, as well as approved operating methods, will result in an overall improvement in product quality and manufacturing efficiency.

4.1.2 Waste Generation

Wastes are generated at each stage of the manufacturing process. Some loss of material occurs in raw material inventory due to spills, spoilage, and obsolescence. Some raw materials are lost as air-borne dust, solvent evaporation, and clingage to bags and containers. It was noted that in cold weather it becomes more difficult to completely empty drums of certain materials. Wastes are also generated in the form of off-specification paint due to errors which occur in the manufacturing process.

Equipment clean-up is another source of waste generation. Equipment must be cleaned following the manufacture of each batch of paint unless the next batch follows very shortly and is of the same formulation. At this plant, recycled organic solvent is primarily used for equipment clean-up, although some virgin organic solvent may be used in a final flushing operation. It is estimated that about 40 gallons of organic solvent are used to clean a 1000 gallon mixing tank. The plant manager provided estimates of annual quantities of waste generated for the following waste streams:
Table 4.2 Waste Quantity Estimates for Plant A

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic solvents</td>
<td>30,000 gallons/year</td>
</tr>
<tr>
<td>Aqueous waste</td>
<td>6,000 gallons/year</td>
</tr>
<tr>
<td>Waste paint</td>
<td>14,000 gallons/year</td>
</tr>
<tr>
<td>Spent filters</td>
<td>120 cubic-yards/year</td>
</tr>
<tr>
<td>Baghouse dust</td>
<td>220 gallons/year</td>
</tr>
</tbody>
</table>

The majority of the waste generated at the plant is disposed through fuel blending. Organic solvents, aqueous waste, waste paint, baghouse dust, and other paint waste solids are blended for this purpose. An old ball mill is used to blend the solid materials with the liquid wastes. The aqueous waste stream from the plant is small, so that it can be blended with the other liquid wastes to produce a material which still has sufficient BTU content to be acceptable for fuel blending. Most of the filters used to filter paint prior to shipment are the cartridge type. The plant manager indicated that this type of filter was required to provide the fine filtration necessary for many of the paints produced at the plant. After use, these filters are drained and allowed to air dry prior to disposal in a special waste landfill.

4.1.3 Waste Reduction

Waste streams at the plant are assessed monthly. A corporate level waste minimization program is being implemented using much of the guidance provided in the EPA document "Guides to Pollution Prevention - The Paint Manufacturing Industry" (EPA, 1990). The program has a 1991 goal of a 15 percent reduction in hazardous waste generation and an overall goal of 97.5 percent material efficiency. Present material efficiency is 93 percent. Management involved in waste minimization include the plant manager, the plant engineer/environmental scientist, and the production supervisor. The new quality improvement program is not formally integrated with the new waste minimization effort, but it is not unreasonable to expect additional waste reduction due to its implementation.

While the program in waste minimization is new, there has been an on-going program in managing material efficiency as evidenced by the seminar on this subject which the site visit personnel attended while at the plant. Material efficiency is part of the plant manager’s performance evaluation. An incentive program exists in which staff scientists who develop a saleable product from a waste material receive a portion of the profits from the sale of the product. The distinction between the waste reduction program and the material efficiency program lies to some extent in the units of measurement used.

The material efficiency program is administered by the corporate accounting staff and the units of measurement are dollars. Material efficiency is determined by the ratio of the dollars of product produced divided by the dollars of raw material purchased. In certain cases, this efficiency can be quite different from an efficiency based on mass flows. Consider an extreme case where ten dollars are spent on ten pounds of raw materials. Suppose that two raw materials are purchased. One pound of expensive material is purchased for nine dollars, while nine pounds of inexpensive material are purchased for one dollar. If none of the expensive
material is wasted, and half of the inexpensive material is wasted, the material efficiency based on dollar accounting would be:

$$\frac{9.50}{10.0} = .95$$

On the other hand, if a mass balance technique were used, the material efficiency would be:

$$\frac{5.5}{10.0} = .55$$

It was also learned that in the dollar accounting method, the cost of waste disposal is not included in the material cost. If these costs were included it might be found that the costs of the low and high cost materials are nearly the same when costs for disposal of the wasted "low cost" material are included.

A number of waste reduction methods have already been implemented at plant A. Those currently being applied are listed in the Table 4.3. This table was developed based on completion of a checklist which was part of the site visit questionnaire. Not all elements of the checklist were discussed in detail during the site visit.

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Waste Minimization Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Equipment cleaning waste</td>
<td>Reuse equipment cleaning wastes</td>
</tr>
<tr>
<td></td>
<td>Schedule production to minimize cleaning</td>
</tr>
<tr>
<td></td>
<td>Clean equipment immediately</td>
</tr>
<tr>
<td></td>
<td>Increase spent rinse settling time</td>
</tr>
<tr>
<td></td>
<td>Use recycled solvent for equipment cleaning</td>
</tr>
<tr>
<td>b. Spills and off-spec. paint</td>
<td>Increase use of automation</td>
</tr>
<tr>
<td></td>
<td>Use appropriate clean-up methods</td>
</tr>
<tr>
<td></td>
<td>Recycle back into process</td>
</tr>
<tr>
<td></td>
<td>Implement better operating procedures</td>
</tr>
<tr>
<td>c. Air emissions including pigment dust</td>
<td>Modify bulk storage tanks</td>
</tr>
<tr>
<td></td>
<td>Use paste pigments</td>
</tr>
<tr>
<td></td>
<td>Install dedicated baghouse systems</td>
</tr>
<tr>
<td>d. Filter cartridges</td>
<td>Improve pigment dispersion</td>
</tr>
<tr>
<td></td>
<td>Use of bag or metal mesh filters (20 percent)</td>
</tr>
<tr>
<td>e. Obsolete products and customer returns</td>
<td>Blend into new products</td>
</tr>
<tr>
<td></td>
<td>(Used to coat backing of steel roof decks)</td>
</tr>
</tbody>
</table>
Two of the waste reduction methods listed above were considered particularly successful; the use of an organic solvent reclamation still, and the development of a useable paint product from waste paint. The solvent still is used to reclaim 60 percent of the solvent used in cleaning operations. The percentage which can be reclaimed is controlled to some extent by the minimum acceptable BTU content of the combination of organic solvent still bottoms, waste organic solvent, and other materials which may be mixed for fuel blending. Solvent used in cleaning mixing tanks is also reduced by using some of the solvent required in the paint formulation itself as clean-up solvent. In this process, material in the mixing tank is allowed to flow into the let-down tanks prior to adding all of the solvent required by the formulation. The remaining solvent is added to the mixing tank where it partially cleans the tank walls as it flows into the let-down tank.

The amount of waste paint which is sent to fuel blending has been reduced by development of a paint product which is used to paint the steel backing portion of flat roof decks. This product provides a method for reuse of much of the plant's waste paint from sources such as obsolete materials and customer returns.

There have been some unsuccessful experiences in the plant's waste handling. One incident occurred in which some unused solid raw materials were mixed with waste organic solvents for fuel blending. The solid material was incompatible with the organic solvent and as a result the mixture became semi-solid within the waste hauler's tank truck. The plant had to pay for removal of the material from the truck at considerable expense. Now, prior to attempting such an action, a plant chemist evaluates the potential for such unexpected reactions.

Overall, the majority of paint related wastes from the plant are either reused, recycled, incinerated, or fuel blended. The exceptions are paint filters and baghouse dust, which are landfilled.

4.2 Plant B

4.2.1 General

At plant B the inspection team met with the manager of manufacturing operations. The plant manufactures interior and exterior latex paints used as architectural coatings. It also manufacturers ready mix paints which are sold under a retail store brand in addition to "colorants" which are used for in-store blending of custom colors. The plant is beginning to manufacture paint on a contract basis for an outside customer. In 1990 the output of the plant was 2.5 million gallons. This figure is expected to increase to 3.2 million gallons in 1992 due to the new outside customer. All of the paint manufactured at the plant is waterborne. In a separate portion of the plant floor cleaners and floor finishes are manufactured. Some of these products are made with organic solvents, however, this portion of the facility was not included within the scope of this study.

Data on paint formulations were considered sensitive and were not provided. A variety of raw materials are used at the plant including; titanium dioxide, acrylic resin, polyvinyl acetate (PVA), ethylene and propylene glycol, "texanol" coalescing solvent, alkyd blends, surfactants, lecithin, methyl cellulose, colloidal clay, and biocides such as
2(hydroxymethyl)[amino]ethanol. Material safety data sheets (MSDS) were gathered for a sample of the paints manufactured at the plant. The only hazardous material listed for these paints was ethylene glycol. However, barium sulfate pigment is used at the plant and is sometimes listed as a hazardous material on material safety data sheets. Efforts are underway to reduce the use of barium sulfate and ethylene glycol, primarily through modifications in the formulation of the paint produced.

All of the paints manufactured at the plant are for retail sale. Most of the paints are packaged in 1 gallon metal or plastic cans with some paint packaged in quarts and occasionally in 5 gallon pails. The VOC content of the paint manufactured varies but is in the range of .7 pounds per gallon. The paints are manufactured to be applied with brushes or rollers, but with thinning can be applied using spray equipment.

Paints and colorants are manufactured as shown in Figures 4.2 and 4.3. Unlike a products coating plant, there is little variation in the manufacturing process used from one paint to the next. However, paint is still manufactured in a batch process; batch sizes range from 500 to 4,000 gallons, with the average around 3,600 gallons. Dispersion of raw materials is accomplished using high speed disc mills. Many of the titanium dioxide pigments used at the plant are purchased in slurry form and require minimal grinding. The plant uses two 100-horsepower Hockmeyer disc mills, one 10-horsepower Cowles mill, and 3 sand mills (horsepower data not provided). Most of the equipment at the plant was purchased in 1974. Eight bulk storage tanks (3 of which are compartmented) are used to store titanium dioxide slurry, acrylic resin, PVA, ethylene and propylene glycol, "texanol" coalescing solvent, alkyd modifier, and "tamol" surfactant. The acrylic resin and PVA tanks are closed systems, the remaining storage tanks are vented.

Twenty people are directly employed in the paint manufacturing process. Special training is provided for mill and disperser operators, filling machine operators, and tinters. This training is provided on-the-job by experienced plant personnel.
Figure 4.2 Paint Manufacturing Process at Plant B
Figure 4.3 Colorant Manufacturing Process at Plant B
4.2.2 Waste Generation

Wastes are generated in the manufacturing process due to spoilage of material in inventory, spills of solid and liquid raw material, spills of finished material, and equipment cleaning. Of these, the primary cause of waste in the operation of the plant was identified as equipment cleaning. Occasionally, spills occur due to can upsets in can filling operations, and in very rare instances, hose breakage. Spills are washed into floor drains which connect to the in-plant waste water treatment system. Estimates for the waste stream quantities from all sources were provided by the plant manager and are listed in Table 4.4.

| Table 4.4 Waste Quantity Estimates for Plant B |
|-----------------|-----------------|
| VOC (ethylene glycol) | 326 pounds/year^1 |
| Organic Solvent | none |
| Aqueous Waste (sludge) | 70,000 gallons/year^2 |
| Waste Paint | 0^3 |
| Spent Filters | 900 bag filters/year |
| Baghouse Dust | 4,000 pounds/year |
| Paint Cans | 5,200 cans/year |
| (1 gallon) | |

^1 This quantity of VOCs was estimated by the plant manager based on an EPA estimating guide (EPA, 1987)
^2 Clear effluent decanted from the plant waste treatment system and discharged to the municipal sewer is not included in this quantity. Data for this quantity were not available. The volume of this effluent is estimated to be approximately twice the volume of the aqueous sludge.
^3 No paint leaves the plant as waste paint, all waste paint which cannot otherwise be recovered leaves the plant as aqueous sludge.

4.2.3 Waste Reduction

The plant has an in-house wastewater treatment facility. The facility contains a collection tank, a treatment (settling) tank, a sludge tank, and an effluent tank. The collection tank is connected to the floor drains in the plant and a drain located in the parking lot under the liquid raw material transfer station. There are two waste streams from the water treatment facility, a clear effluent discharged to the municipal sewer, and a sludge which is hauled away for de-watering and eventual landfill disposal. The effluent discharge is monitored regularly for organic solvent content by the local sanitary district. The sludge waste stream is checked annually using a toxic chemical leaching procedure (TCLP) test performed by an outside contractor.

Other than assessing the aqueous waste stream, there appears to be little formal evaluation of in-plant waste streams or a formal waste reduction program. Waste, however, is a concern
of the plant manager and although no formal written waste reduction program exists, the plant manager tracks waste generation and looks for methods of waste reduction. Waste reduction activities are not formally integrated with quality control, although connections between waste reduction and product quality are recognized. For example, some changes in formulation, made to enhance the ability to reuse water from tank cleaning, are limited by their effects on paint quality.

The plant has a county air permit, an IEPA air permit, and a local sanitary district discharge permit. The plant manager is aware of the new Clean Air Act amendments and stated that he intends to rely on the National Paint and Coatings Association, (NPCA) for information regarding the Act’s impact on the paint manufacturing industry. Cost impacts of waste generation and disposal are lumped as a cost of sales. Sludge handling costs were estimated at $.38/gallon. Total costs for all pollution control activities in 1990 were estimated at $72,500.

While the plant does not have a formal waste reduction plan, a number of waste reduction methods have been implemented at the facility. The plant manager has available a copy of the EPA document "Guides to Pollution Prevention - The Paint Manufacturing Industry" (EPA, 1990) and has utilized several of the recommended techniques. Table 4.5 provides a summary of the waste reduction methods being employed at the plant. This table was developed based on completion of a checklist which was part of the site visit questionnaire. Not all elements of the checklist were discussed in detail during the site visit.

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Waste Minimization Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Equipment cleaning waste</td>
<td>Use high pressure wash systems</td>
</tr>
<tr>
<td></td>
<td>Reuse equipment cleaning wastes</td>
</tr>
<tr>
<td></td>
<td>Schedule production to minimize cleaning</td>
</tr>
<tr>
<td></td>
<td>Clean equipment immediately</td>
</tr>
<tr>
<td>b. Spills and off-spec. paint</td>
<td>Increase use of automation</td>
</tr>
<tr>
<td></td>
<td>Recycle back into process</td>
</tr>
<tr>
<td></td>
<td>Implement better operating procedures</td>
</tr>
<tr>
<td>c. Air emissions including</td>
<td>Use paste pigments</td>
</tr>
<tr>
<td></td>
<td>Install dedicated baghouse systems</td>
</tr>
<tr>
<td>d. Filter cartridges</td>
<td>Improve pigment dispersion</td>
</tr>
<tr>
<td></td>
<td>Use bag or metal mesh filters</td>
</tr>
<tr>
<td>e. Obsolete products and</td>
<td>Blend into new products</td>
</tr>
<tr>
<td>customer returns</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5 Waste Reduction Methods at Plant B

38
Perhaps the most successful waste reduction technique applied at the plant is the incorporation of wastewater from equipment cleaning into subsequent batches of paint. This has become the standard operating procedure at the plant and some minor reformulations of the paint products were made specifically to facilitate this practice. Wastewater from equipment cleaning is used immediately after it is generated, or at most, within twenty-four hours. Storage time for the wastewater is limited due to concern for growth of bacteria. Certain bacteria can thrive on the raw materials used in the manufacture of latex paint and if bacterial contamination occurs, the entire batch of paint is ruined. In addition, extensive decontamination of the manufacturing equipment is required. The plant maintains a laboratory staff whose major duties include inspecting all raw materials entering the plant for signs of bacterial contamination. Other than time, the other determinant of the useability of the wastewater is color. Water used to clean equipment for making colorants is not reused because the pigment concentration in the water is too high to allow it to be added to the primarily light colored paints being manufactured. Back-to-back manufacture of colorant does not occur frequently enough to allow reuse of the water as a colorant raw material. Since reuse of equipment cleaning water began in 1989, the plant has reduced its output of sludge from its waste treatment facility by 60 percent. There are concerns, however, that the practice of reusing cleaning water may not be applicable to the paints being manufactured under contract. At present the formulation of these paints apparently either will not tolerate the use of the wastewater or the customer is not confident that his quality control specifications can be met using wastewater as a raw material.

The plant has also had unsuccessful experiences in waste reduction. At one point, an automated high pressure spray system was tried in place of the manual high pressure system. It was found that the automated system used more water and did not do as thorough a cleaning job. In another case, a polymer additive was added to the wastewater settling tank to increase the density of sludge produced in order to decrease the solids content of the effluent discharged to the municipal sewer system. The resulting settled material was too difficult to pump with the plant’s existing equipment.

As indicated previously, waste management is an informal part of the overall review of manufacturing operations at the facility. There are presently no employee incentives for waste reduction. The plant manager felt that they did have a fairly good accounting of waste quantities and that the responsibility for waste management was clearly defined as part of his job. The plant manager indicated that his primary sources for information on waste management were seminars sponsored by NPCA and articles in trade magazines.

Presently, all of the waste streams from the plant are ultimately disposed in a special waste landfill. At one point, sludge was being incorporated into concrete but the waste hauler used by the plant has discontinued this practice. The sludge is now de-watered and landfilled.
4.3 Plant C

4.3.1 General

Paint manufacturing Plant C was visited in May 1991. Meetings were held with the plant manager and the environmental compliance officer. Plant C is a producer of industrial finishes. The plant’s paint output in 1990 was 1,750,000 gallons. This output was made up of 90 percent organic solvent-borne coatings and 10 percent waterborne coatings. The plant’s parent company also operates another smaller paint manufacturing plant outside Illinois.

Paints manufactured at this facility are primarily used in coating metal. The formulations of all the paints manufactured at the plant are considered proprietary. Agricultural and industrial equipment manufactures and metal office furniture manufacturers are the major consumers of paints manufactured at this plant. Seventy percent of the paint produced at this plant is sold under the company’s own label with the remaining 30 percent, primarily touch-up paints, packaged under a customers brand name. Most of the paints made at the plant are formulated for spray application. However, paints are manufactured for a variety of other application techniques including; flow coating, dip coating, and in-mold coating. Much of the plants production is custom blended for specific customers. One agricultural equipment manufacturer requires 22 different formulations of the same basic paint type (and color) depending on the part to be coated and the application method to be used.

The bulk of the plant’s customers are in Illinois, and much of the paint produced at the plant is used within the State. However, Plant C also supplies coatings to customers in all 50 States, Canada and Europe. Some of the plant’s customers redistribute touch-up paints worldwide.

A manufacturing process diagram is shown in Figure 4.4. Paint is manufactured in a batch process. Once a paint order is received, the raw materials are allocated for that batch. The first step is a mixing and milling process to accomplish the required pigment dispersion and grind. Ball mills are commonly used for this step although horizontal sand mills are also used especially when making concentrated pigment paste. The milled product is then "let-down" into mixing tanks and the remaining resins, solvent and additives are added. Quality control operations are performed on the blended batch to determine if it meets specifications including color match. Adjustments are made as necessary. When the paint passes quality control, it is filtered, packaged into containers, and shipped to the customer.

The average batch size at the plant is approximately 400 gallons; however, a large number of small batches, 5 gallons or less, are produced. Paints are packaged in quarts, 1-gallon cans, 5-gallon pails, 55-gallon drums, 300-gallon totes and occasionally, 4,000-gallon tanker wagons.
Figure 4.4 Paint Manufacturing Process at Plant C
Most of the organic solvent-borne paints manufactured by Plant C are enamels and primers based on alkyd binders. Of the waterborne coatings, approximately 80 percent are acrylic emulsions and 20 percent are water reducibles. All of the product coatings made at the plant are formulated to reduce VOCs. Years ago, a 6.0 pounds per gallon VOC content was typical. The VOC content of product coatings now manufactured by Plant C is typically in the range of 2.3 to 3.5 pounds per gallon.

Toluene, xylene, mineral spirits, most ketones (e.g., acetone, methyl ethyl ketone, methyl isobutyl ketone), butyl cellusolve, butyl alcohol and aromatic blends are the most commonly used organic solvents at Plant C. The plant uses yellow and red iron oxides, chrome containing yellows, lead pigments and other miscellaneous inorganic pigments. The plant has 200 active pigments in-house. Pigments containing lead are used when increased corrosion resistance and durability are required. The paints could be made lead-free, but at present, customer specifications for properties such as gloss retention require the use of lead.

At Plant C, ball mills and vertical and horizontal sand mills are used for grinding operations; high-speed disc mills are used for premixing, mixing, and blending. Equipment ranges in age from new to 50 years old. The plant has 12 ball mills of various sizes. Water jacketed ball mills, which can control heat build-up, are used in manufacturing heat sensitive paint formulations. At this plant, horizontal sand mills are considered to have advantages over the vertical sand mills in terms of reducing VOC emissions.

Computers are used to keep track of manufacturing operations and materials handling. Bar-coding is used at the plant to assist in shipping.

There are 56 people employed in the manufacture of paint at Plant C. Of these, 15 are quality control staff. New employees are trained in-part through learning on-the-job while working with a more experienced employee. Additional training is provided through seminars on how paint is made, how the paint manufacturing equipment works, and what types of paint are manufactured at the plant. Employees may take tours of customer’s plants to understand how the paint is being used and why high quality must be maintained. Formal safety training is also provided. The management at Plant C considers employee training to be a strong point of the company, and continues to look for ways to improve in this area. Plant C is growing rapidly and it is increasingly difficult to keep up with employee training needs. A quality improvement team has been formed to help in this regard. A computerized tracking system is being set up as part of the quality improvement effort to track the status of employees within the training program.

4.3.2 Waste Generation

Wastes are generated in varying amounts at each stage of the manufacturing process. These wastes include: spills (both raw materials and finished product), spoilage or obsolescence, raw material clinging to bags or containers, organic solvent evaporation, airborne dust, spent clean-up solutions and organic solvents, and off-specification paints. The plant manager and the compliance officer provided estimates of annual quantities of wastes generated at Plant C as shown in Table 4.6.
Table 4.6 Waste Quantity Estimates for Plant C

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>13 tons/year</td>
</tr>
<tr>
<td>All Liquid Wastes</td>
<td>145,000 gallons/year¹</td>
</tr>
<tr>
<td>Spent Filters</td>
<td>1,320 gallons</td>
</tr>
</tbody>
</table>

¹ All organic solvent, aqueous wastes, waste paint, and baghouse dust are combined into this single waste stream. Baghouse dust accounts for approximately 6,700 pounds per year.

The greatest single source of waste at Plant C is equipment cleaning. Plant C typically makes 20 to 22 paint batches per day with 6 to 10 different paint types. Due to the batch operations, clean-up generates approximately 60 gallons of waste per 1,000 gallons of paint produced. High-solids coatings make the situation worse since there is less organic solvent in the formula, thereby requiring additional organic solvent to perform clean-up operations. When producing large batches, almost all of the rinse organic solvents are saved for use in the grind stage of some subsequent batch. The rinse organic solvent is stored in 55-gallon drums and computer logged as "Blender Flush". When a batch of paint of identical formulation is needed, the computer flags this saved rinse solvent for use in the grind stage of the new batch. This recycling of rinse organic solvent is not considered feasible when working with specialty paints that aren't produced very often or when producing small batches of less than 200 gallons. Plant C will typically produce 10 blender flushes per day.

Occasionally, dried paint build-up becomes such that measures more drastic than just solvent cleaning are required. Personnel at Plant C have designed and built a special self-contained caustic clean-up unit to clean dried paint from batch tanks. By using high pressure and heat in a closed tank, a caustic "fog" is created. It was found that this fog cleans as well as completely filling the tank and doesn't use as much caustic solution.

Evaporation of organic solvents is the next largest cause of waste. At this plant, a plastic film type covering is used on most of the batch tanks to minimize organic solvent losses. At this plant, it has been found that the plastic wrap works better than metal covers even though the wrap occasionally slips down into the paint. On metal lids the paint has a chance to dry and build-up; removal of the dried paint then requires a good deal of labor and organic solvent.

Although not common, spills do occasionally occur; when they do, the workers try to collect as much of the spill as possible. Spilled paint is then refiltered and tested for specification compliance. Spill control is emphasized, and the plant uses a spill control video as part of employee training.

A small percentage of product fails to meet customer or company specifications. Such a batch is usually reworked and adjusted to meet the specifications. Rarely is a batch of paint sent to the waste stream because it could not be reworked. Reworked product typically accounts for about 0.5 percent of total production. Statistical process control flags those formulations that need review if off-specification paint is produced too often.
Sometimes reworking results in an over-production of the paint formulation needed. Over-production can occur for other reasons as well. Often, when over-production occurs, the customer is asked to buy the over-production quantity. If the customer does not need the over-production, it is put into the finished product inventory. The plant's computer will then recognize the existence of this inventory the next time this formulation is ordered and reduce the production by the appropriate amount.

Customers occasionally return paint which is obsolete or otherwise out-of-date. The experience of Plant C is that typically the paint technology a customer is using will change about every two years. Often, the customer will not use all of their old stock before switching paint formulations. Most of the time, returned paints are reworked into other formulations. If not, they are added to the liquid waste stream.

The plant environmental compliance officer estimated that approximately 13 tons of VOCs were emitted from Plant C in 1990. These emissions were estimated using EPA guidance (EPA, 1987). The plant reported 12.8 tons on SARA Form R based on this guidance. Including organic solvents that need not be reported on the SARA Form R increases the estimate to 13 tons. Annual emissions of particulates by the plant were estimated to be approximately 1,000 pounds in 1990. Based on the EPA guidance, it is estimated that 20 pounds of pigment are lost for each ton of pigment used. The plant baghouse collects 85 percent of this quantity, the remainder (1,000 pounds) is emitted. The plant is considering implementation of VOC control technology but is waiting to evaluate the New Clean Air Act requirements before finalizing this decision.

As shown in Table 4.6, Plant C generated 145,000 gallons of liquid wastes in 1990. This figure accounts for all liquid wastes, both organic and aqueous. Also included in this waste stream is baghouse dust. These liquid wastes leave the plant via a tanker truck, approximately 5,000 gallons at a time. The basic makeup of the 145,000 gallons is approximately 60 percent organic solvent, 30 percent water and 10 percent waste paint (includes paint from clean-up procedures). The mixture is approximately 80 percent by weight liquid (organic and water) and 20 percent solids. Solids are not a factor in disposal costs as long as the waste is a free flowing liquid. Disposal costs are impacted, however if the waste stream BTU content is lower than 10,000 BTU per pound. The plant's waste handler will not accept waste with over 10,000 ppm lead. Typical analysis for Plant C's waste is approximately 4,000 ppm lead. Currently all of this waste material is going to a cement kiln operation in Indiana.

Recently the plant began using a still to recover waste xylene. Currently the still recovers 160 gallons of xylene per day. A down-side to this process is that the lower xylene content of the organic solvent waste stream results in a lower BTU value of the waste stream. If the water content becomes too high and lowers the BTU content below 10,000 BTU per pound, the plant must pay higher prices for waste disposal. The plant, therefore, monitors the organic solvent recovery process and balances between maximizing xylene recovery and maintaining the required minimum BTU value.

Most of the bag filters that are used at this plant are polyester bags. Typically, one filter is used per batch. The total quantity of spent filters has not been tracked very well in the
past. It is estimated that approximately one drum per month of lead contaminated filters, which are hazardous wastes, are generated. The plant also generates approximately one drum per month of lead-free filters. The lead-containing filters are sent off-site for incineration. Costs for incinerating filters which contain lead are approximately $300 per drum.

Rags used at the plant are sent to a laundry service for cleaning. The plant uses between 800 to 1,000 rags per week. Empty pigment bags are sent to a special waste landfill. The plant manager and the environmental compliance officer have both heard of "disposable" filters that after use can be added to the liquid waste slurry and will dissolve. Plant C is seeking more information on these filters.

Costs for paint related waste management were $192,000 for Plant C in 1990. This cost can be broken down into organic clean-up solvent costs of $120,000 per year and waste disposal costs of $72,000 per year. Now that Plant C has an organic solvent still, these costs are decreasing. The still, which cost $35,000, began operation in mid-January and has shown a 6 month payback.

Based on discussions with other paint manufacturers, the plant manager is considering installing an automated tank cleaning system which uses scrubbing brushes and organic solvent. It is claimed that this equipment can clean several hundred tanks while using only 300 gallons of organic solvent. Typical organic solvent usage at Plant C to clean tanks ranges from 2 gallons for 50-gallon tanks, to 20 gallons for cleaning 2,000-gallon tanks. The amount of organic solvent used in tank cleaning also varies with the type of paint being cleaned. At this plant, alkyd type enamels are typically harder to clean from a tank and require more organic solvent than an epoxy type enamel.

### 4.3.3 Waste Reduction

A number of waste reduction methods have already been implemented at Plant C. Those currently being employed are shown in the Table 4.7. This table was developed based on completion of a checklist which was part of the site visit questionnaire. Not all elements of the checklist were discussed in detail during the site visit.

Plant C has set a goal of a 50 percent reduction in waste generation, to be achieved over a five year period. The plant has doubled its sales volume in the last few years, but has generated 17,000 gallons less liquid waste. The goal of the plant is to keep the total amount of waste materials level or reduced even with increased paint production. The plant has developed an employee incentive program with a goal to reduce waste by 10 percent over the same quarter of the previous year. The goal is based on the ratio of waste generated to gallons of paint produced. This ratio is used to normalize waste quantities relative to production levels. Charting of this ratio is performed using statistical process control techniques.
Table 4.7 Waste Reduction Methods at Plant C

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Waste Minimization Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Equipment cleaning waste</td>
<td>Use high pressure wash systems</td>
</tr>
<tr>
<td></td>
<td>Reuse equipment cleaning wastes</td>
</tr>
<tr>
<td></td>
<td>Schedule production to minimize cleaning</td>
</tr>
<tr>
<td></td>
<td>Clean equipment immediately</td>
</tr>
<tr>
<td></td>
<td>Use alternate cleaning agents</td>
</tr>
<tr>
<td></td>
<td>Use de-emulsifiers on spent rinses</td>
</tr>
<tr>
<td>b. Spills and off-spec. paint</td>
<td>Use appropriate clean-up methods</td>
</tr>
<tr>
<td></td>
<td>Recycle back into process</td>
</tr>
<tr>
<td></td>
<td>Implement better operating procedures</td>
</tr>
<tr>
<td>c. Air emissions including pigment dust</td>
<td>Install dedicated baghouse systems</td>
</tr>
<tr>
<td>d. Filter cartridges</td>
<td>Use bag or metal mesh filters</td>
</tr>
<tr>
<td>e. Obsolete products and customer returns</td>
<td>Blend into new products</td>
</tr>
<tr>
<td>g. General</td>
<td>Use statistical process control and data analysis to identify opportunities for waste reduction</td>
</tr>
</tbody>
</table>

Plant C has had some unsuccessful waste reduction efforts. Biodegradable cleaners were tried for tank cleaning but the products did not work well. The plant also previously tried an organic solvent recovery still that did not work very efficiently. The still generated a volume of organic solvent contaminated wastewater which was greater than the original amount of organic solvent. For every drum of reclaimed organic solvent, the system generated 2 to 3 drums of waste material requiring disposal. The experience with this old technology caused some at the plant to be initially opposed to buying the still currently in use.

Besides internal efforts at waste reduction, Plant C has been working with its paint customers to reduce wastes. With its customers, the plant has developed a proprietary recovery system for collection of overspray. A wet overspray recovery system and a dry overspray recovery system have been developed. Patents for the wet system have been applied for. The wet overspray recovery system is a closed loop system for the user. Additional details were not available. In the dry system, dry paint waste (overspray) is returned to the plant to be used as a raw material in a future batch of paint. The plant saves this material, and if used in a batch of the customers paint, the customer receives a credit for the recycled material. This process reduces the amount of paint overspray that might otherwise go into a landfill by incorporating the material into a useful product.
Plant C receives information on waste reduction technologies from technical journals and discussions with other paint companies. The plant is planning to participate in a pollution prevention awards program sponsored by the National Paint and Coatings Association (NPCA).

Plant C has had to overcome obstacles in its efforts at paint related waste reduction. There is the usual reluctance to try something new. Costs are another barrier. In addition, newer technology paint products are not as "forgiving" as the older formulations. A major obstacle to regulatory compliance is the lack of information on the intent of the regulation and "how" to comply. Often there are differences in interpretation of regulations and dollars are wasted trying to find out the "correct" answer. State sponsored training sessions and seminars on newly issued regulations would be a great help to everyone that must comply. Plant C felt it would also be beneficial if there could be a way to receive a standardized answer to regulatory compliance questions.

4.4 Plant D

4.4.1 General

Plant D is a medium sized manufacturer of steel pails. Interviews at the plant were conducted with the plant manager and with the plant technical director. Responsibilities for waste management and environmental issues are shared by these two individuals. The technical director acts as a problem solver and information resource on environmental technical issues.

In 1990 the plant had gross sales of approximately 14 million dollars with a volume of 4,800,000 units. The plant produces three types of steel pails, categorized as nesting open head, straight open head, and tight open head. The pails are manufactured in 3 to 7 gallon capacities. Major customers for the steel pails include the chemical and paint industries, but the pails are also used in packaging such products as refractory for steel mills, drive-way sealer, vegetable oil, popcorn, and fragrances for perfumes.

The plant employs 96 people in manufacturing operations 10 of which operate and maintain painting equipment. The plant manager estimated that 50 percent of the workforce have been employed at the plant for more than 20 years, and that 10 individuals had over 30 years of service. The plant manager himself has worked at the plant for 26 years, having started at the plant after high school graduation.

An overview of the manufacturing process was provided by the plant manager but the specific sequence of operations is considered confidential so will not be detailed here. In general terms, coils of steel sheet are cut into square sheets which undergo various welding and forming operations to produce the finished pail and lid. Pails and lids are painted on separate lines. Pails receive an interior and exterior coating simultaneously. Interior coatings consist of conventional organic solvent-borne phenolics, epoxies, or combinations of epoxy and phenolic resins. Exterior coatings are usually organic solvent-borne alkyds. The plant is currently experimenting with the use of waterborne coatings for both the interiors and exteriors of the pails. The motivation for the transition to waterborne coatings is the reduction of VOC
etnlSSlons. The plant currently must maintain VOC emissions below 4.3 pounds per gallon for interior coatings and under 3.5 pounds per gallon for exterior coatings. These standards are based on the average of emissions for a twenty-four hour period. Paint application techniques used at the plant include roll coating and low pressure air assisted spray. Overspray is captured in water-wall paint booths. No surface preparation is required prior to painting. All steel is purchased "clean and dry". A type of oil known as "vanishing oil" is used to lubricate the production machinery. The oil dries completely from the work piece before painting occurs.

The plant used approximately 68,000 gallons of paint in 1990. Thinners are used with the paint. Thinners used include methyl ethyl ketone (MEK), butyl cellusolve, and mineral spirits. The amounts of organic solvents used for thinning paint in 1990 were 16,000 gallons of MEK, 5,000 gallons of butyl cellusolve, and 2,700 gallons of mineral spirits. The cost of the paint ranged from $11 to $28 per gallon. The plant manager estimated that, with labor, the cost of painting accounts for about 15 to 20 percent of manufacturing costs.

Paint transfer efficiency at the plant, using current spray equipment is estimated to be 75 percent. This represents an improvement over equipment previously used at the plant which was estimated to have a transfer efficiency of about 35 percent. The method used to track paint usage at the plant is to calculate "mileage" in terms of pails coated per gallon of paint. Whenever a new paint is introduced at the plant a 55 gallon sample of the paint is used in a test run and the pails coated per gallon is calculated to determine if the paint is acceptable. Mileage standards for each paint and pail type are maintained in a computer database. Actual mileage is checked weekly; if there is a variance with the mileage standard it is investigated and corrected. Variances can occur for a number of reasons. In one case, a variance was caused by a new worker operating the painting equipment. The new worker was concerned with getting adequate paint coverage so more paint was being used than necessary. The regular operator had learned how to fine-tune the painting equipment to get the optimum balance of coverage and efficiency. In a second case, a variance occurred due to excessively hot weather that reduced paint viscosity so that more paint was required for adequate coverage.

The tracking of mileage appears to be an excellent aid to waste reduction as opposed to merely tracking cost per product produced. A lower cost per product can result in the appearance of improved operations in terms of cost per product but may generate more waste and may actually miss the potential for even greater cost reductions. At plant D it is common practice to pay a premium of between $1.20 and $1.35 per gallon for certain paints because they can paint as many as 60 more pails per gallon than a cheaper paint; the result being lower cost per product and reduced waste generation. The plant manager related that an associate in the steel drum manufacturing industry had recently begun to calculate mileages in conjunction with evaluating some new painting equipment. He had been under the impression that he already had the optimum costs per product produced, but was surprised at the additional savings he found possible when he began tracking mileage.

There is no formal training program for paint equipment operators or for other manufacturing personnel at the plant. Workers are trained on-the-job by more experienced employees. There is a high degree of cross-training at the facility. Each worker is trained in performing several of the steps in the manufacturing process. There are no formal written
standard operating procedures or documentation of particularly effective methods, although some employees keep their own informal notes.

Clean-up of painting equipment is performed by the equipment operators. Also, one worker on the 2nd shift is responsible for cleaning of work holders and paint troughs. These are cleaned using a burn-off oven. The water wall paint booths are cleaned every three weeks by a contractor. Clean-out of the paint booths results in an aqueous paint sludge. In order to insure that this material is solid enough for acceptance at the landfill, the plant has adopted the practice of incorporating portland cement with the sludge.

**4.4.2 Waste Generation**

The primary causes of waste generation at the plant are VOCs released during paint curing, paint overspray, and equipment clean-up. Quantities of waste from all sources were estimated by the plant manager and are shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>120 tons/year(^1)</td>
</tr>
<tr>
<td>Organic Solvents</td>
<td>4,100 gallon/year</td>
</tr>
<tr>
<td>Aqueous Waste</td>
<td>11,000 gallons/year(^2,3)</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>no estimate(^4)</td>
</tr>
</tbody>
</table>

\(^1\) Plant air permits limit emissions to 150 tons/yr  
\(^2\) Paint sludge volume includes addition of concrete to solidify sludge  
\(^3\) An additional 800 gallons per month of effluent is discharged to the sanitary sewer system, the organic solvent content of this water is claimed to be low but supporting data were unavailable  
\(^4\) Drums used for purchased paint are used as containers for sludge and are landfilled. Other containers are sent to a drum recycler. Data on other miscellaneous materials such as clean-up rags were unavailable.

Organic solvent waste is sent to an organic solvent waste handling facility. Costs for disposal of waste organic solvents are approximately $.48/gallon. Costs for hauling paint sludge are $37.50 per 55 gallon barrel. There is currently no formal waste reduction program at plant D, however, control of waste is an obvious concern of the plant manager and the technical director. The primary motivations for waste reduction activities have been reducing manufacturing costs, insuring environmental compliance, and simplifying plant operations. While painting costs are only 15 to 20 percent of the overall manufacturing cost, the industry is highly competitive with several vendors offering essentially the same product. Customers often base their purchasing decisions on price alone. The resulting narrow profit margins insure that the costs of all facets of the manufacturing operation are watched closely.
4.4.3 Waste Reduction

Waste reduction activities at the plant are not formally integrated with quality control programs but the impacts of improper operation of painting equipment are clearly recognized in terms of excessive or inadequate coating thicknesses on the painted product. At the volume of pails being produced, an excess paint thickness of .2 mils can result in additional costs of $130,000 per year.

There have been several successful waste reduction methods applied at plant D. Contributing to the success of these efforts is a climate of innovation. The company president, who was previously the plant manager, is very willing to commit resources for changes in operations, if adequate supporting information is available. Waste reduction efforts at the plant have included an improvement in paint transfer efficiency from 35 percent to 75 percent through changing the type of spraying equipment, the use of a solvent still to recover wash solvent, and the use of a burn-off oven in place of a hot acid bath for cleaning work holders.

The improvement in paint transfer efficiency has had the most dramatic impact on overall waste production. The improvement was accomplished by converting from a high pressure airless spray system to a low pressure air assisted spray system. Sludge from the water-wall paint booths was reduced from approximately 23,600 gallons per year to 11,000 gallons per year. Paint mileage has improved from 125 pails/gallon to as much as 180 pails/gallon. The reduction in paint usage has led to a proportional reduction in VOC emissions. The simple payback for the $40,000 system was less than three months based on paint savings alone. Additional savings in clean-up and waste disposal costs are estimated to be between $15,000 and $20,000 per year. Maintenance costs and down time have also been reduced.

Quantitative data on savings from the burn-off oven were not as significant. It is estimated that about 6 to 10 fewer drums of waste are produced per year. The major impact of the oven is on safety and ease of operation. The workers found the hot acid bath difficult to work with and the plant manager considered it a hazard since, as he put it, "the only thing holding the acid tank together was paint sludge".

The operation of the organic solvent still has not yet been completely integrated into the plant operation. It is projected that savings in costs for organic solvent used in clean-up will be approximately $17,000 per year. Still bottoms from the organic solvent still are incorporated with other plant organic solvent waste sent to a solvent waste handler.

The plant manager has, from time to time, examined other waste reduction methods such as a cyclone separator to remove sludge from the water-wall paint booths. It was determined that in this case, costs for chemicals required in the cyclone’s operation would exceed any savings due to reduction in sludge volume. In most cases, the plant has avoided unsuccessful waste reduction efforts by thorough evaluation of proposed methods prior to installing them in the plant. As an example, in the case of the new spray equipment, the vendor provided a test system which was extensively evaluated at the plant before the final system was purchased. Also, in evaluating changing the plant’s organic solvent waste hauler, the plant manager went to the effort of using the Freedom of Information Act to access the records of his current waste hauler, to determine the hauler’s status with regard to EPA violations. It
was clear from the site visit that both the plant manager and technical director are highly motivated, competent individuals. The quality of this management team is a significant factor behind the successful waste management practices evident at the plant.

As previously stated, the approach to waste management at this plant is an informal integration into overall plant operations. There are no employee incentives for waste management nor is there a formal waste management accounting system. Responsibility for waste management is, however, clearly defined at the plant because of EPA reporting requirements. Information on waste management technology is acquired by the technical director and plant manager mostly through environmental journals and from equipment vendors. Two journals mentioned were the Environmental Quarterly and Environmental Waste Management.

Overall costs for waste management at the plant were estimated at $47,000 per year (or about $0.01 per pail produced). The organic solvent waste stream generated at the plant is either recycled or fuel blended by the plant's solvent waste hauler. Ash from the burn-off oven and the paint sludge from the water-wall paint booths are landfilled. The clear effluent from the water-wall booths is discharged to the sanitary sewer system.

4.5 Plant E

4.5.1 General

Plant E is a small manufacturer of wood kitchen cabinets. The facility employs 50 workers in manufacturing including 5 in painting operations. The plant does not have a formal environmental staff but the plant manager, foreman, and company comptroller are jointly responsible for environmental issues. Annual sales volume in 1990 was $5,000,000. During this period 113,000 kitchen cabinet assemblies were produced. The majority of production is for contractors involved in housing developments. Because most sales are to construction contractors on a low bid basis, the plant’s profit margins are small, on the order of 10 percent.

Individuals interviewed at plant E included the plant manager and the paint shop foreman. Manufacturing operations take place in two separate facilities. In one facility pre-assemblies are manufactured, and in the other these are assembled and packaged for shipment. The site visit occurred at the plant where pre-assemblies are manufactured. At this plant raw materials, either oak or poplar, are cut and formed into cabinet pre-assemblies. These parts are then rough sanded and if necessary, surface blemishes are filled with putty. The part is then painted using a colored stain followed by a clear coat of lacquer. After the first coat of lacquer is applied, the parts are hand sanded and then receive a second coat of lacquer. Following the final lacquer coat, the parts are shipped to the second plant and assembled into completed cabinets.

Painting operations at the plant consume approximately 720 gallons of stain and 1,800 gallons of lacquer per year. Lacquer and stain are applied using low pressure air assisted spray equipment. Painting is performed in a paint booth with dry filters. Three spray guns
are used in the painting operation. Two spray guns are dedicated to stain and one is dedicated
to lacquer. Only two or three different colored stains are used in the painting operations.
Because of the limited number of stains, it is possible to dedicate a spray gun for one color,
reducing the need for gun cleaning. Paint transfer efficiency is not routinely calculated at this
plant and no estimate for this parameter was available. Data on monthly paint and lacquer
consumption, as well as monthly cabinet production, are available but are not used to calculate
the average amount of stain and lacquer used to paint a cabinet. The plant manager estimated
that with labor, the total costs for painting account for between 10 and 20 percent of the
manufacturing costs. Costs for stain average around $9/gallon and cost for lacquer are
between $7 and $8 per gallon.

Application of one of the stains requires thinning using toluene at a ratio of 3 parts stain
to two parts toluene. Toluene consumption for this purpose is estimated at 300 gallons per
year. In some cases lacquer thinner, generally used as a clean-up solvent, may be used as a
stain thinner. The lacquer thinner consists of a mixture of acetone, ethanol, toluene, methyl
ethyl ketone, and small amounts of glycol monoethyl and glycol monobutyl ether, xylene, and
methanol. The amount of lacquer thinner used at the plant was estimated at 600 gallons per
year. Material safety data sheets were acquired for typical stains, lacquers, and thinners used
at the plant.

Five workers are employed in painting operations. Only two of these are spray gun
operators, the rest are helpers who move and position the work-pieces and arrange them on
drying racks. Spray gun operators are trained by the paint shop foreman. The foreman has
gained his expertise from on-the-job training and attendance at seminars given by paint and
equipment vendors. Since a relatively small number of stains and lacquers are used, a simple
matrix of equipment settings has been developed (and recorded on the paint booth wall) as
a guide for the operators. The idea of community colleges as a means of training paint spray
gun operators was discussed with the plant manager. His response was that some benefit
might be gained by providing some uniformity in the workers' painting methods. He has
found it difficult to retrain spray painters who have worked in other industries such as auto
body repair, or who painted other types of products other than wood. These operators tend
to resist changing their methods of painting even if they are not appropriate for painting the
wooden cabinets.

Paint booth clean-up is performed by the painting staff. Spray booth filters are changed
weekly. The total filter area is approximately 15 by 30 feet. The filter media is fiberglass
matt approximately 1/2 to 1 inch thick. The spray booth walls are coated with a "peel off"
material to aid cleaning, but it has been found that this is rarely necessary. The paint shop
foreman indicated that overspray is not excessive. Since painting operations were not taking
place at the time of the site visit, and since filters are changed frequently, it was difficult to
assess overspray. The filters in place at the time appeared to be only lightly loaded with
paint.

The stains used at the plant are made up of alkyd binders and are organic solvent-borne. The
lacquers are also organic solvent-borne and use nitrocellulose and alkyd binders. The
VOC content of the stains and lacquers used at the plant is high, on the order of 5 pounds
per gallon, and with thinner the applied material certainly exceeds 5 pounds per gallon VOCs.
The plant manager indicated that they do not have a set of paint specifications. Most of the stains and lacquers used at the plant are purchased from two vendors. The vendors are provided information about the type of product being coated and the finish desired, and are relied on to provide stains and lacquers with the necessary characteristics. In most cases, the stains and lacquers are off-the-shelf items for each of the vendors. At this plant, the most important factor in the choice of the stains and lacquers is cost, followed by performance and ease of application. In some instances, such as when a lacquer must be used over a light colored stain, resistance to yellowing from ultraviolet light exposure is an important consideration.

4.5.2 Waste Generation

Data on amounts of waste generated in painting operations were generally lacking. The plant manager does not track VOC emissions. The plant does not have an air permit but may not require one due to its size. The plant does not use an organic solvent recycler or an organic solvent waste hauler. Organic solvent use for clean-up is small because the limited number of paint colors used reduces cleaning of equipment due to color changes. The plant manager indicated that the lacquer thinner which is used as clean-up solvent is reused as thinner for certain of the stains. The plant manager stated that for some of the stains, the plant has arranged to return unused stain and related clean-up solvent to the paint manufacturer. The plant manager said that when cleaning paint lines to change color the lines are flushed with organic solvent and the material which exits the lines is reused or returned to the supplier. The plant manager indicated that with the exception of organic solvent on rags used to clean-up spills, no liquid organic solvents are discharged from the plant. No aqueous wastes are generated since the plant utilizes organic solvent-borne paints and a dry filter paint booth. Paint related solid wastes which are generated include paint booth filters, dried paint removed during clean-up of the paint booth walls and work-piece holders, and rags used to clean-up spills. Empty 55-gallon paint containers are returned to the paint supplier. While no quantitative data were available, it was estimated that the largest source of paint waste is VOCs, followed by overspray, equipment cleaning waste, spills, and rework. Surface preparation generates significant quantities of sawdust which currently is sold for reuse in various products.

There is some variation in the amount of waste generated depending on the stain which is being used. In some cases, the lacquer thinner used for clean-up cannot be incorporated into the next stain and must be returned with unused stain to the paint supplier.

4.5.3 Waste Reduction

Waste streams at the plant are not formally assessed. However, a framework exists in which waste assessment could be incorporated. Weekly meetings are currently held to evaluate overall production operations. These meetings are attended by the plant manager, all plant foremen, the company comptroller, and the shipping dispatcher. Waste issues may or may not be discussed at these meetings. Cost impacts of waste generated in painting operations have not been assessed, but the plant manager felt that the greatest impacts of these costs would be in materials, followed by labor, waste disposal, and energy.
The plant has undertaken one successful effort in paint waste reduction which was initially motivated by a desire to improve the finish on the painted product. The plant converted from a high pressure spray system to a low pressure air assisted spray. The plant manager did not present quantitative data but estimated that paint usage was reduced by as much as 50 percent in going to the low pressure system. The use of the low pressure system has also significantly reduced equipment down-time and maintenance costs, although parts for the low pressure system are more expensive than parts for the high pressure system. The low pressure system also produces a better, more consistent finish. This change in spray equipment is the only paint waste reduction technique which has been tried at the plant. Some consideration is being given to a paint booth which can recapture and recycle paint overspray but it is unclear whether this type of system is applicable to the paints being used at the plant. Costs for such a system may also be prohibitive for a facility of this size. In addition, conversion to waterborne stains and lacquers is being considered. The plant manager indicated that the motivation for these efforts is the perception that this is the general trend in the industry due to environmental concerns.

As previously indicated, the plant does not have a formal waste reduction program. There are no employee incentives for waste reduction nor is there a waste accounting system. The plant manager also felt that responsibilities for waste management were not clearly defined since they were shared among several people at the plant. Sources of information on waste reduction used by the plant manager include magazine articles, information provided by equipment vendors, and seminars and conventions provided by the paint and spray equipment industry.

Based on the information gathered, the plant’s organic solvent waste stream is currently reused or returned to the plant’s paint suppliers along with unused paint. Solid wastes are sent to a municipal landfill. Costs for solid waste disposal range from $4,000 to $6,000 per month, or about $.50 per cabinet produced.

4.6 Plant F

4.6.1 General

Plant F is a products finishing contractor. The company has been in business since January of 1990 and is located in a regional Business and Technology Center Incubator. During the site visit the owner and paint foreman were interviewed. The company specializes in painting small metallic parts for various products. Gross sales for the first year of operation were approximately $600,000. The plant employs nine people, all in painting operations. The facility paints a variety of parts used by different industries in manufacturing products such as appliances, automobiles, office furniture, and retail display racks. The facility utilizes an electrostatic powder spray system and can paint small to medium sized, relatively light-weight metal parts. Size and weight restrictions are based on the size of the electrostatic paint booth, the paint curing ovens, the iron phosphate spray unit, and the capacity of the overhead conveyor system. A flow diagram of the plant equipment layout is shown below.
Parts to be painted are received and inspected and then are suspended on metal hangers which are attached to the overhead conveyor system. Parts as received must be free from scale and have only light amounts of grease or oil surface contaminants since surface preparation facilities at the plant are minimal. Parts to be painted are conveyed first through an iron phosphate rinse process which removes oils and grease from the metal and modifies the metal surface to provide corrosion protection and improve paint adhesion. After the parts leave the phosphate rinse they are rinsed with clear water and enter the low temperature side (100° to 150° F) of the paint bake oven where they are dried prior to entering the paint spray booth. As the part passes through the spray booth, it is manually painted by two operators using electrostatic spray guns. Powdered paint from the spray guns adheres to the part due to electrostatic forces. The spray booth utilizes a cyclone to capture overspray for reuse. The part leaves the spray booth and then enters the high temperature side of the bake oven where it is heated to between 325° and 450° F, depending on the paint formulation. The heating process melts the powdered paint into a smooth, continuous film and cures the paint. After leaving the oven, the part cools as it is conveyed to the unloading area where it is packed for shipment.

The powder painting system was assembled by the owner and the paint foreman from a combination of new, used, and self-constructed equipment. The paint bake oven was purchased used and modified slightly for the present operation. The iron phosphate spray system was designed and assembled completely in-house. Capital investment for the entire facility was approximately $300,000.
A variety of powder paints are used depending on the part to be painted. Paint types in use include polyester, epoxy, epoxy-polyester hybrids, and urethanes. No organic solvents are used for thinning or equipment clean-up in the painting operations. The owner indicated that he calculated transfer efficiency by measuring paint before and after painting a fixed number of parts and then determining the paint used per part. However, specific data on paint used per product were unavailable. Data on annual consumption of paint were also not directly available. The owner estimated that his monthly expenditures for paint were in the range of $5,000 to $7,000 per month, with the cost per pound of paint ranging from $2.50 to $7.00 per pound. The owner stated that the cost for paint is a minimal portion of the cost of the painting service, ranging from 3 to 5 percent. Major costs are labor and capital investment.

With the exception of the owner, all employees are involved in painting operations. On a typical shift, two workers are engaged in loading and unloading parts from the conveyor system, while two other workers operate the paint spray guns. Clean-up for color changes is performed by the manufacturing staff using dry squeegees and wiping cloths. Material wiped from the paint booth is reused. This procedure for changing colors does not appear to be trouble-free at this point. During the site visit a client's representative was on site discussing some problems which had occurred in painting a light colored metallic part for office furniture. The paint job had defects consisting of dark specks of paint. Apparently the light colored powder had been contaminated with dark paint from a previous job or from some other source.

Paint specifications vary depending on the customer. Some customers may specify the type of paint to be used, while others may only provide general guidelines regarding color, gloss, and other characteristics, relying on the painter to choose the best paint.

Training of spray gun operators is provided on-the-job. The owner did not believe a community college course in product painting was necessary. He said that, "people with no painting experience could start at 7:00 a.m. and by the first break they could be taught to paint". He qualified this statement by saying that some people have the natural ability to become painters and others did not. He did not believe a person without this ability could become a successful painter. He also indicated that he would rather train an individual with no painting experience than retrain someone with previous experience on a wet paint system.

4.6.2 Waste Generation

For this operation the greatest source of paint related waste is surface preparation, followed by spills, and equipment clean-up. The owner stated he has not yet had to clean the metal hangers used to attach work pieces to the overhead conveyor, therefore it was not possible to estimate quantities for this waste. However, it was noted that the hangers being used during the plant visit were completely clean and new. No storage area for used hangers was observed, so it is possible that the operator is disposing of paint coated hangers with the other solid wastes.

Paint related wastes for the powder painting operation as estimated by the owner are listed in Table 4.9.
Table 4.9 Estimated Waste Quantities From Painting at Plant F

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC</td>
<td>0.0</td>
</tr>
<tr>
<td>Organic Solvent</td>
<td>0.0</td>
</tr>
<tr>
<td>Aqueous Waste</td>
<td>1,000 gallons/year¹</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>120 pounds/year²</td>
</tr>
</tbody>
</table>

¹ Sludge from the iron phosphate system is diluted and discharged about once a year to the city sewer. Waste volume shown is the total of sludge and water for dilution.
² This value only includes waste powder paint from spills. No estimate was available for other solid wastes such as cardboard boxes and plastic bags used as paint containers and waste from cleaning work holders.

4.6.3 Waste Reduction

Because cost reduction is a basic operating philosophy of the owner, overall operations, including waste of paint, are assessed informally on a daily basis. Both the owner and plant foreman are involved in assessing the plant operations. The owner believes that although paint related wastes are not a major portion of the cost of operations, because his profit margins are small, waste reduction is a worthwhile effort. However, he has not quantified waste costs, and lumps these as a cost of operation. The owner is not aware of the New Clean Air Act, and does not have an Air Permit, but because of the nature of his operation believes that he does not need one.

There have been no special efforts at waste reduction other than maintaining employee awareness and fostering good operating practices. Although employee awareness is considered a key factor in reducing waste, there are no employee incentives for waste reduction. Waste reduction is not integrated with quality control but the owner sees little need to do so, since he has experienced very little waste due to rework of painted parts. Still, there may be some waste associated with occasional quality control problems. As previously indicated, during the site visit some parts had been returned by a customer due to problems with the paint finish. In this case, it was decided that the customer would correct the problem by touching up the parts using aerosol spray paint. It is assumed that the cost of this correction, both material and labor, would be borne by the owner of the powder paint operation.

Because the owner has chosen a powder paint application method, he has taken a major step towards reducing wastes from painting. He believes he is operating his system effectively at this point. However, the owner does look for additional information regarding powder painting operations in magazines such as Industrial Finishing, and from vendors of powder paint and powder painting equipment.

For this facility wastes are disposed in a sanitary landfill and through the city sewer system. Powder paint overspray is captured and recycled by the paint spray booth.
4.7 Plant G

Plant G is a medium sized organic solvent recycling facility owned and operated by a large organic solvent waste management company. The company provides fluid recovery services for a number of industries, primarily those which in total generate large quantities of liquid hazardous waste, but whose individual members generate relatively small quantities. Industries supported include auto repair facilities, auto body repair shops, fleet maintenance operations, dry cleaners, manufacturers, and other industries including industrial painting operations and paint manufacturing.

During the Plant G site visit, the plant manager and the corporate marketing manager for paint refinishing were interviewed. The plant manager conducted a tour of the entire organic solvent recycling facility. Waste streams are received at the plant from the dry cleaning, auto body shop, and auto repair industries. Wastes from these industries arrive in 5 and 16-gallon containers. Also received at the plant are organic solvent wastes from various industrial customers. These wastes generally arrive in 55-gallon drums, or in bulk shipments by rail or by tanker truck. All wastes entering the plant in this manner are tested for PCB contamination. In addition, tests for PCBs are performed at several intermediate processing stages, and before any material leaves the plant.

Under the company’s operating procedures the final disposition of most incoming materials is known before they arrive at the plant. Much of the company’s business is in providing services to industries with a clearly defined, homogeneous waste stream. For these industries, much of the organic solvent is recycled. This is the case for the auto repair, auto body, and dry cleaning industries. The company provides a closed-loop organic solvent recycling operation for these industries. For the auto repair industry the company provides a parts washer and regularly services the washer by cleaning the washer, providing clean organic solvent, and picking up used organic solvent. Similarly, for the auto body industry the company provides a paint gun cleaner and regularly services these cleaners by supplying new organic solvent and picking up used organic solvent and paint waste. Currently the company provides organic solvent waste management services to 44,000 auto body repair and industrial painting operations.

For the dry cleaning industry, the company picks up dirty filter cartridges and organic solvent sludges. Perchloroethylene is recovered from this material and sold back to the dry cleaning market. Presently the company provides this service to approximately 50 percent of all the dry cleaning operations in the U.S. and Canada.

In the case of less homogeneous wastes, such as those received from industrial customers in 55-gallon drums, the disposition of the waste is more likely to be fuel blending or incineration. Exceptions are bulk shipments of high value specialty organic solvents which are reclaimed for the chemical process industry.

Operations at the plant include receiving and testing of incoming materials, distillation or fuel blending, and shipping of reclaimed organic solvent or blended fuel. Distillation of organic solvent is performed using a thin film evaporator. Still bottoms and certain solid materials including dry cleaning filters are incorporated in blended fuel. Blended fuels are
stored in large, vertical, above ground tanks. Some solid materials are incinerated. All wastes generated in the plant operations are either disposed through fuel blending or by incineration. As a company policy no wastes from the plant are landfilled.

A summary of the organic solvent wastes processed at the plant, and their ultimate disposition is provided in the table below.

Table 4.10 Wastes Processed at Plant G

<table>
<thead>
<tr>
<th>All Wastes</th>
<th>Recycled</th>
<th>Fuel Blended</th>
<th>Incinerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint Related Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycled</td>
<td>2,600,000 gallons</td>
<td>7,800,000 gallons</td>
<td>8,000 55-gallon drums</td>
</tr>
<tr>
<td>Fuel Blended</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incinerated</td>
<td>1,300,000 gallons</td>
<td>650,000 gallons</td>
<td>1,500 gallons</td>
</tr>
</tbody>
</table>

Customer costs for the paint gun cleaner service are a flat $94 per gun cleaner every four weeks. Charges for handling 55-gallon drums vary depending on the drum contents. Prices range from $200 to $495 for drums of liquid. For handling a drum of solids the price is $995. As previously indicated the company views its major markets as those having high volume homogeneous waste streams or those who have high value wastes. Organic solvent wastes from paint manufacturers and from industrial paint users (not gun cleaner wastes) are considered by the company as being generally uneconomic to recover and are subsequently fuel blended.

4.8 Plant H

Plant H, an organic solvent recycling facility located outside of Illinois, was visited in August 1991. Primary customers of the plant’s services are the automotive industry, the metal products industry, furniture manufacturers, and paint manufacturers. Paint related wastes from these industries are the most common material sent to the plant for processing. Several Illinois paint manufacturers and users send paint related wastes to the plant. The plant manager was interviewed during the site visit and provided a tour of the organic solvent recycling and fuel blending facilities.

The capacity of plant H is 8 million gallons per year. During the visit, construction of eight product storage tanks was underway. Plant H is designed to provide a total package service for handling all of its customers’ hazardous and special wastes. That is, besides
handling hazardous and nonhazardous organic type solvent wastes, the plant will take aqueous wastes and solid wastes such as soiled rags and spent filters. By their nature, the plant's activities are highly regulated by OSHA and the EPA. Plant H recently received an EPA Part-B permit.

Waste streams of potential customers are first profiled by the laboratory at the main plant. Plant H is not equipped to handle certain chemicals. Materials not acceptable for recycling by plant H include:

- benzene and some related benzene compounds
- carbon tetrachloride
- pesticides
- PCBs
- chloroform
- allyl chloride
- explosives
- substances above pH 10 (base) or below pH 4 (acid)
- drugs or drug residues
- radioactive substances

Heavy metal concentrations of the waste stream may not exceed the following amounts:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>100 ppm</td>
</tr>
<tr>
<td>Barium</td>
<td>3000 ppm</td>
</tr>
<tr>
<td>Cadmium</td>
<td>500 ppm</td>
</tr>
<tr>
<td>Chromium</td>
<td>3000 ppm</td>
</tr>
<tr>
<td>Mercury</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Lead</td>
<td>5000 ppm</td>
</tr>
<tr>
<td>Selenium</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Zinc</td>
<td>3000 ppm</td>
</tr>
</tbody>
</table>

There are few restrictions or limits on BTU content, solids content, or moisture content.

Figure 4.6 is a flow diagram of the operation at plant H. Wastes are delivered in 55-gallon drums or in bulk via tanker truck. Currently about half the total volume is received in 55-gallon drums and half in bulk. The 55-gallon drums used to transport the incoming material are sent to a drum recycler for reconditioning. The reconditioned drums are then used to transport recycled organic solvents back to the customer.

As they are received, all liquid materials are pumped into large holding tanks. Laboratory tests are run on the holding tank material to verify material content and to make the decision on whether to recycle or fuel blend. All wastes are screened for PCBs. Based on the laboratory tests, the material is then further processed for recycling or sent to fuel blending. Six cement kilns receive blended fuel from the plant. Currently, about 50 percent of the incoming material goes to fuel blending with the balance processed for recycling. However, according to the plant manager, this trend will move toward increased recycling.

Liquid materials selected for recycling are sent to a thin film evaporator where the solvents are evaporated and condensed back into liquid form. If the liquid phase is a pure material or a standard organic solvent blend, it is sent to the finished product tank farm. Some products require further processing and are sent through a fractional distillation column. Products which meet quality standards are then sold to customers in bulk or in 55-gallon
Figure 4.6 Solvent Recycling Process at Plant H
drums. The still bottoms are incorporated into the fuel blending material. Eventually the plant will recapture the resins and pigments present in the still bottoms for reuse. Plant H currently has eight 6000-gallon and four 15,000-gallon holding tanks and 14 finished product tanks. Most of the plant’s recycled organic solvent customers are also supplier’s of the plant’s incoming waste materials. Some of the paint manufacturers served by plant H participate on this basis. Others supply waste streams that are usually processed into blended fuel for cement kilns, since they contain too little organic solvent to be recycled economically.

Incoming solids are sorted into two categories: material to be sent to a licensed incinerator (e.g., soiled rags, spent filters, drums of solid material) or material to be used in fuel blending (e.g. pigments) through a liquification process. A process for shredding certain types of filters to allow their incorporation into fuel blending is being examined.

Of the materials coming to plant H, 80 percent are organic solvent wastes, typically hydrocarbon solvents and chlorinated solvents. The remaining 20 percent are made up of aqueous wastes and solid materials. Table 4.11 lists the most common organic solvents handled.

<table>
<thead>
<tr>
<th>ALCOHOLS</th>
<th>DILUENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-Butanol</td>
<td>Heptane</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Hexane</td>
</tr>
<tr>
<td>Isobutanol</td>
<td>Lactol Spirits</td>
</tr>
<tr>
<td>Methanol</td>
<td>Mineral Spirits</td>
</tr>
<tr>
<td>Isopropanol</td>
<td>100 Flash Naphtha</td>
</tr>
<tr>
<td>N-Propanol</td>
<td>Stoddard Solvent</td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
</tr>
<tr>
<td>ACTIVES</td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>Xylene</td>
</tr>
<tr>
<td>N-Butyl Acetate</td>
<td>VM&amp;P Naphtha</td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td></td>
</tr>
<tr>
<td>Glycol Ether EB</td>
<td>CHLORINATED</td>
</tr>
<tr>
<td>Glycol Ether EEAC</td>
<td>Methylene Chloride</td>
</tr>
<tr>
<td>Isobutyl Acetate</td>
<td>Perchloroethylene</td>
</tr>
<tr>
<td>Methyl Ethyl Ketone</td>
<td>1,1,1 Trichloroethane</td>
</tr>
<tr>
<td>Methyl Isobutyl Ketone</td>
<td>1,1,2 Trichloro-</td>
</tr>
<tr>
<td>N-Propyl Acetate</td>
<td>1,2,2 Trifluoroethane</td>
</tr>
<tr>
<td>Glycol Ether PM</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Glycol Ether PMA</td>
<td></td>
</tr>
<tr>
<td>Tetrahydrofuran</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.11 Common Organic Solvents Processed At Plant H

62
Of the estimated 2,500,000 gallons to be processed through the facility in 1991, approximately 1,200,000 gallons will be reclaimed. Of the remaining material about 1,050,000 gallons will go to fuel blending and 250,000 gallons of solids will go to incineration. The plant manager estimated that 70 percent of the material compatible for recycling will consist of paint related wastes from paint users. The percentage of that amount that would come from Illinois was not known.

Charges for handling waste are usually set on a case-by-case basis. In the case of high value materials such as freons and ethyl acetate, the plant may pay up to $150 per drum for the material. At the other extreme, for handling drums of solid material the customer may have to pay $600 per drum. Costs for handling a drum of recyclable organic solvent average between $75 and $100 per drum. The customer can receive the best price by doing some segregation of the wastes; keeping the aqueous, non-flammable (chlorinated), flammable, high solids, etc. materials separate rather than mixing them together prior to sending them in for recycling.

At plant H priority is given to recycling as opposed to fuel blending. Plant management believes recycling offers the greatest long term potential. Five years ago, cement kilns paid for blended fuel. Now the kilns are paid to use it. The management at plant H is working towards reducing the amount of material that must be disposed through fuel blending.

4.9 Plant I

4.9.1 General

Plant I is a modern, medium sized, automobile body repair business located in east central Illinois. The business consists of two shops each similarly equipped and operated. The two shops employ 50 workers; 40 in collision repair operations, and 10 in painting operations. In 1990 the two shops combined repaired approximately 6,000 vehicles. Each shop consists of a collision repair area, a surface preparation area, and a paint application and finishing area.

In the collision repair area damaged parts are repaired, or removed and replaced. No painting is performed in this area. However, power tool grinding and hand and power tool sanding are performed. Some of the material generated in these grinding and sanding operations may contain paint. To minimize airborne dust particles from the power tool operations, specially designed tools are used which connect to a vacuum dust collection system. Between four and five gallons of dust per week are collected in this system. This dust is disposed with other solid wastes and picked-up for landfill disposal by the facilities' solid waste hauler.

In the surface preparation area parts to be painted or repainted are prepared for the painting process. Surface preparation performed in this area consists of primer application and wet sanding. This area employs a cross-draft ventilation system to collect paint overspray and dust.
Final painting and finishing is performed in the paint application area. The paint application area includes two controlled environment paint spray booths. Doors on the front of each booth provide a completely enclosed area. Filtered outside air enters the top of the booth and exits at the bottom. Paint overspray and VOCs are removed from the booth area by the air flow. Paint overspray particles are removed from the air stream by a water filtration system. After the paint application is completed the temperature of the booth is raised to between 100° and 120° F for final paint curing.

The controlled environment booths employed at this shop appear to be instrumental in the shop's ability to paint a large number of vehicles. When painting in an open booth or other uncontrolled area, dust particles may adhere to applied paint. Sanding and buffing is then required to produce a high quality final finish. In the controlled environment booths, dust is minimized since the booth area is pressurized by incoming filtered outside air. Since dust is prevented from contaminating the surface of the applied paint, between 3 to 4 hours in sanding and buffing is eliminated. The labor savings as well as material savings (i.e., sand paper and buffing compound) can provide a total savings of about $125 per average paint job. Besides the dust elimination, the baking process provided in the booth results in a durable finish and reduces the curing time to less than an hour. In ambient conditions, the paint may take between 4 to 6 hours to properly cure. Where only one or two cars per day could be painted in a non-baking/ambient temperature system, a baking booth system means 8 to 9 cars can be finished per day. Another advantage provided by the booths is the reduction of the overspray "fog" produced by the spray gun. The downdraft flow of air quickly removes any overspray or mist giving the painter better vision of the surface being painted.

The controlled environment spray booths installed in these shops cost approximately $70,000. The shop owner stated that the building codes used in Illinois require auto body shops to have a system that provides clean air for painting using an outside air make-up system. The environmentally controlled booths meet these requirements. In the opinion of the shop owner, all new auto body shops should be required to install proper booths. He estimated that a maximum of only 10-15 percent of the licensed body shops in Illinois have such booths installed.

This shop uses an epoxy primer and polyurethane topcoat paint system. The urethane system provides a durable finish and works well in the controlled environment spray and baking booths. The owner considers this paint system essential to maintaining the level of quality his shop provides. The cost of the paint is significant, and each shop spends about $15,000 per month for paints and paint materials. This represents an average of 150 gallons of paint, both pigmented and clear, per month. The owner indicated that the cost of some of the polyurethane coatings is between $300 and $450 per gallon depending on color. The owner stated that paint related costs make up approximately 7 percent of the shops' total costs and indicated that this is similar to the national average for auto body shops. According to the owner, unlike this shop, between 70 to 80 percent of the shops in Illinois still use a lacquer system. Although less expensive, lacquer paint systems require extensive buffing between coats, and the additional labor can offset any material savings. Further, the owner indicated that polyurethane coatings are more durable and are recommended by the car manufacturers.
Most paint at this shop is applied with a conventional air assisted spray gun estimated by the owner to have a paint transfer efficiency of about 25 percent. This shop has experimented with other paint guns having greater transfer efficiencies such as the high-volume, low-pressure (HVLP) spray gun system. The HVLP system is estimated to have a transfer efficiency of between 75 and 80 percent. However, the quality of the clear coat finishes obtained with this spray gun at this shop was less than satisfactory. The shop has also experimented with a gravity feed gun (i.e., the liquid paint cup is mounted on top of the gun) which has a reported (per manufacturer’s literature) transfer efficiency of between 35 and 55 percent. This gun is currently being used to spray epoxy primers. These special spray guns are relatively expensive. The owner estimated that an HVLP gun costs about $1,000 compared to $50 for a conventional gun. However, considering the cost of the paint and the increased transfer efficiency, the more efficient guns can pay for themselves in a short time. Plans have already been made to purchase and use the gravity feed guns. As soon as the HVLP system is modified to satisfactorily spray the urethane clear coats, they will also be utilized.

Employee training in safety and painting techniques is primarily conducted by in-house personnel. Periodically, representatives from coating manufacturers or spray equipment manufacturers provide on-site training and additional information about new products. The shop also works with area schools and has employed students from the local high school occupational training program as painters.

The amount of paint used per vehicle is dependent on the extent of the damage. Few vehicles are completely repainted, although by the nature of the repairs (i.e., major collision repair) handled in these shops, painting half of the vehicle is common. To completely paint an average sized automobile, the owner estimated the average paint use at one gallon of paint (pigmented) and 2 to 3 quarts of clear coat. Including additives and thinners, the average total paint and paint related materials to completely paint a vehicle is estimated to be approximately 2.5 gallons. Considering repairs of all sizes, the average paint and paint related materials used per vehicle was estimated to be 1 gallon.

### 4.9.2 Waste Generation

The primary sources of waste generation in these shops are VOCs, paint overspray, leftover paint, and clean-up.

VOCs are released as part of the paint curing process. The paint booth system used at this location is not designed to trap or destroy VOCs. The average percent solids of the paints used at this shop was not determined. However, automotive type coatings typically have a low solids content of between 25 and 40 percent by volume. With a low solids coating and a high volume painting operation, significant amounts of VOCs are released.

Overspray waste is generated in the painting process. As indicated above, the shop owner estimates paint transfer efficiency at 25 percent. The overspray is collected by the booth air filtration system. The booths used in this shop use a water wall process to remove the overspray from the air flow. At the end of each day, maintenance personnel shut down the spray booth and skim the captured paint overspray solids off the top of the water in the collection tank. This material is then placed in a 275 gallon hazardous waste recovery tank.
Filters in the system are changed every two weeks. These filters are allowed to dry and discarded in the solid waste dumpster. About every two months the 30 to 40 gallons of water in the filtration system is evaporated by raising the chamber temperature using the chamber’s gas fired heater. After all the water has evaporated, the semi-solid residue is collected and added to the hazardous waste recovery tank.

Besides overspray, the next biggest generator of waste is the mixing of more paint than is needed for a given job. Efforts to eliminate this problem include the use of digital scales and mixing machines to weigh out and mix only as much paint as needed. The owner indicated that the body shop industry had developed a pint or quart mentality since these were the quantities that paints were sold by. Typically an entire container was used for mixing a batch of paint and left-over paint was discarded. With the high costs of auto body paints and the current environmental concerns, this practice is changing. This shop has now assigned one man to do nothing but mix paint. If this method can reduce left-over paint by 10 percent (with a 25 percent savings not considered unrealistic) the owner believes he can afford to pay labor costs of $300 per week for a mixing specialist. Future installation of a computerized system to aid in mixing is also planned. With this system, the year, make, and model of the car and its color code are entered into the computer, along with an estimate of the surface area to be painted. The computer then prints out a formula for the proper paint mixture.

Wastes are also generated during clean-up of the paint booth and cleaning of the paint spray guns. A water soluble "tackcoat" is applied to the walls of the spray booth to aid in the booth cleanup. Each week maintenance personnel hose down the inside of the booth and reapply the tackcoat material. The washed down material is routed through the water filtration system to trap the paint solids. Each painter is responsible for cleaning his paint gun. It was estimated that each shop uses 20 to 25 gallons of solvent per month for gun clean-up. The owner stated that most of the waste generated at the this shop comes from spray gun clean-up. The shop has an automatic gun cleaner that uses 4 quarts of solvent and one quart of water. The water is used to trap the paint solids. Even though trained otherwise, the painters insist on adding some additional cleaning solvent to pre-clean the gun prior to putting it in the automatic gun cleaner. Maintenance personnel check the solvent in the automatic gun cleaner daily. If the solvent is not too dirty, they only skim off the water layer and collected solids and put this material in the waste recovery tank. The solvent is changed as needed. A recycled lacquer thinner is used for the gun cleaning solvent.

Solid wastes generated in shop operations include 4 to 5 gallons per week of dust solids collected from the sanding and grinding vacuum system which are disposed in the solid waste dumpster. In addition, approximately 3 to 4 cubic yards (bulk, uncompressed) per week of other solid wastes (e.g., tape, cardboard, filters, empty containers) are put into the dumpster for collection.

Together the two shops produce approximately 450 gallons of liquid waste per month. This waste includes the cleanup solvents, excess paint and thinners, and the paint solids collected as overspray and from gun cleaning. These liquid wastes are removed by a solvent waste contractor every 45 to 60 days at a cost of $1.50 per gallon. Even though within 10 miles of each other, each shop uses a different waste hauler. The liquid waste is used for fuel
blending. Overall, waste disposal costs are estimated to be about 1 percent of operating expenses. Estimated total waste quantities generated by each shop are summarized in the table below.

<table>
<thead>
<tr>
<th>Table 4.12 Estimated Waste Quantities From Painting at Plant I</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
</tr>
<tr>
<td>Solvent and paint sludge</td>
</tr>
<tr>
<td>Dry paint solids</td>
</tr>
<tr>
<td>Other solid waste</td>
</tr>
</tbody>
</table>

¹ VOCs estimated based on paint usage of 1,800 gallons/year at 5 pounds/gallon VOC. The estimate does not include VOCs generated through solvent evaporation in clean-up operations.

4.9.3 Waste Reduction

The primary waste reduction activity being explored by this shop is the use of spray guns having better transfer efficiency. The shop is planning to purchase gravity feed guns and may purchase an HVLP gun system. Since the shop owner reports current transfer efficiencies in the range of 25 percent, efforts at improving transfer efficiency should greatly reduce overspray waste and VOC emissions. Test operations using the HVLP spray equipment resulted in savings of $3,000 per month for the months the system was in use. This amounted to a 33 percent savings in monthly paint costs.

A second waste reduction initiative being implemented is the use of digital scales and assignment of one individual to paint mixing duties. Included in this effort will be development of standards for the amounts of paint to be used for typical jobs performed at the shop. Purchase of a computer program to aid in estimating required quantities and paint formulations is also anticipated. Estimated savings for each shop are 10 to 25 percent of annual paint purchases, or for this facility $18,000 to $45,000 per year. This represents a very cost effective waste reduction measure since annual labor costs are estimated at about $16,000 per year for the paint mixing specialist.

Waste reduction at the shop is integrated with quality control through the realization that if customer quality standards are not met, the vehicle must be repainted, using more paint and generating more waste. Quality control issues have impacted the adoption of HVLP spray technology because currently at this shop clear coats produced using HVLP do not meet customer quality standards. There is a general employee incentive program that rewards ideas which improve the quality of shop operations, including waste reduction in painting operations.

Waste management and waste reduction at this shop are primarily the responsibility of the shop owner. Primary sources of information on waste reduction technology are trade shows and paint and equipment vendors. In addition, the owner of this facility is very active in the auto body repair industry through participation in various trade and professional organizations.
4.10 Plant J

4.10.1 General

Plant J is an automobile body repair business located in northeast Illinois. This business repairs approximately 700 vehicles per year. The shop employs 10 people, two in painting operations. The shop has eight stalls for metal repair, two for paint preparation, and one downdraft paint booth.

Paint preparation consists of grinding, sanding, and priming of surfaces prior to final painting. Priming is performed with gravity feed spray equipment. Final painting is performed using conventional spray equipment. Transfer efficiencies for priming and final painting are not routinely measured. The paint shop foreman estimated that transfer efficiency for the conventional spray equipment is in the range of 60 to 70 percent. He indicated that this was an improvement over previous efficiencies of about 50 percent. The improvement was attributed to the use of different paints with higher viscosity. Transfer efficiency for the priming operation is estimated at 80 percent using the gravity feed spray equipment. However, this equipment is not considered suitable for final painting due to difficulties in obtaining a satisfactory spray pattern when held in certain positions.

Because the size of each repair job varies, the amount of paint used per vehicle also varies. A typical paint job consists of two coats of primer, followed by two coats of colored paint (toner), and two clear coats. The owner estimated that to paint an entire vehicle would require 2.8 gallons of material, of which 1 gallon would be primer, 1 gallon would be finish paint, .2 gallons would be reducer (thinner), and .6 gallons would be hardener.

Priming is performed in the paint preparation area and the primer is allowed to air dry for approximately 24 hours. Final painting is performed in the paint booth where the paint is bake dried. Drying time in the paint booth is 1 to 2 hours. The paint booth is a dry filter type. Incoming air is pre-filtered and heated, it enters the booth at the ceiling and flows over the vehicle being painted to capture overspray and then exits through two floor vents. There is a filter in the ceiling where air enters the booth and one filter in each floor vent where air exits the booth. The pre-filter and ceiling filter are changed yearly, while the two floor filters are changed every 6 to 8 weeks. The booth is equipped with an optional device called an "extractor". This device consists of an induced draft fan and a set of impactor plates which remove any residual overspray from air leaving the paint shop. The owner in describing the effectiveness of the extractor, related that at one point he operated the booth without the extractor while the extractor was being cleaned. He immediately received complaints from neighbors who indicated that for years they had never noticed a paint odor from his operation and now noticed a strong paint odor. This is an interesting observation since the booth does not capture or destroy VOCs either with or without the extractor. It may be that without the extractor, escaping overspray deposited near the ground resulted in relatively higher ground level VOC concentrations.

The cost of paint accounts for 6 percent of the annual operating expenses of this shop. Data provided by one of the shop's two paint suppliers indicated that based on one years' paint consumption, the average cost for paint and related material was just over $100/gallon.
Estimated annual paint consumption for the shop is 600 gallons per year. Based on this estimated paint consumption, it is estimated that average paint usage is approximately .86 gallons per vehicle.

Labor and capital costs represent the majority of the business operating expense. As indicated earlier, the shop employs two painters. The painters have received specialized training from the manufacturers of the paints used in the shop. While labor costs are a greater percentage of overall operating expenses than paint, on a unit basis, paint costs are higher. The owner provided the following costs for some of the typical paint materials used in the shop.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>surface primer</td>
<td>$80/gallon</td>
</tr>
<tr>
<td>colored paint</td>
<td>$128/gallon</td>
</tr>
<tr>
<td>clear coat</td>
<td>$118/gallon</td>
</tr>
<tr>
<td>hardener</td>
<td>$135/gallon</td>
</tr>
</tbody>
</table>

This shop uses a urethane paint system. Presently the shop uses systems provided by two separate paint manufacturers. Paint quality is essential to the operation of the shop and paints are purchased which conform to vehicle manufacturer recommendations and specifications.

4.10.2 Waste Generation

Wastes are generated in the form of dusts from paint preparation operations such as sanding and grinding, as overspray and VOCs from priming and painting, and as liquid wastes during clean-up of spray guns and the paint spray booth. Additional solid wastes are also generated in the form of paint masking materials such as paper and tape.

The owner estimated that the greatest source of waste was VOCs, followed by left-over paint, equipment clean-up, and paint overspray. Estimates of waste quantities were only available for left-over paint and equipment clean-up. This shop currently has two gun washers. One is owned by the shop and the other is owned and serviced by a solvent waste hauler. Wastes from both gun washers are handled by this waste hauler. Currently the shop generates 32 gallons of solvent waste per month. Cost for disposal of this solvent waste is $110/month. This waste consists of clean-up solvent, paint removed in cleaning paint guns, and left-over paint which is added to the waste solvent drums. Lacquer thinner is used as clean-up solvent. The shop purchases 55 gallons per month of this material to be used in the gun cleaner owned by the shop. The shop purchases both virgin and recycled lacquer thinner. The solvent hauler provides an additional 15 gallons per month. From the difference in the amounts of lacquer thinner purchased and the amount of solvent waste handled each month, it is clear that a significant portion of thinner evaporates during cleaning operations and contributes to the overall VOC generation of this operation. Left-over paint is mixed with used clean-up solvent. The owner estimated that left-over paint accounts for 10 percent to 20 percent of paint usage.

Waste in the form of overspray was difficult to estimate. Overspray is captured by the paint booth filters and extractor assembly. It would require weighing filters before and after usage, and also weighing material removed from the extractor during cleaning to estimate the
quantities of overspray being generated. This is obviously beyond the scope of day-to-day operations in the body shop. As indicated previously, paint shop personnel estimated that the transfer efficiency of their equipment ranges from 60 percent to 80 percent.

Solid wastes include dry solids from surface preparation, spray booth filters, paint cans, masking materials, and wastes from cleaning the interior of the spray booth and the extractor portion of the booth. These materials are currently handled by a local solid waste hauler. The materials are landfilled but information on the type of landfill used was not available. The volume of these materials was also difficult to estimate. From the dimensions of the filters used in the paint booth it is estimated that the volume of filters disposed each year is in the range of 10 to 15 cubic yards. Based on an average transfer efficiency of 70 percent and assuming 3 pounds of solids per gallon of paint, paint overspray on these filters would be in the range of 540 pounds. A summary of waste quantities for this facility are listed in the table below.

<table>
<thead>
<tr>
<th>Table 4.13 Estimated Waste Quantities From Painting at Plant J</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
</tr>
<tr>
<td>Solvent and paint sludge</td>
</tr>
<tr>
<td>Paint booth filters</td>
</tr>
<tr>
<td>Other solid waste</td>
</tr>
</tbody>
</table>

¹ VOCs estimated based on paint usage of 600 gallons/year at 5 pounds/gallon VOCs. The estimate does not include VOCs generated through solvent evaporation in clean-up operations.

Waste generation at the shop is not regularly assessed, but because of the high cost of paint there is emphasis on paint waste reduction. Cost impacts of waste generation on the facility are relatively small. Solid and liquid waste hauling and the cost for a local hazardous waste license (paid to the fire department) amount to $3,410 per year or .34 percent of gross sales. Waste paint costs approximately $12,000 per year or 1.2 percent of gross sales based on the owner's estimate of waste paint at 20 percent of paint usage.

The owner felt that current trends in paint formulation have made it easier to reduce paint waste. In particular, the mixing of paint in the shop as needed rather than buying in pints and quarts greatly reduces waste from left-over paint.

The owner was not aware of implications of the New Clean Air Act. He does not have an air permit, and at the level of paint usage at this shop an air permit is not required.

4.10.3 Waste Reduction

While there is no formal written waste reduction program in place, the owner emphasizes paint waste reduction as part of employee training. Reducing paint waste is part of the shop production manager's incentive package.
Quality control is closely linked to paint waste reduction since a correct color match is essential to the body shop paint jobs. Incorrect mixing of paint results in wasted paint and wasted labor. As the owner put it, quality control is emphasized because "we only get paid for painting the car once."

There have been two changes in shop operations which have resulted in waste reduction. The first of these is the use of the gun cleaner provided by the solvent waste hauler. This gun, which uses a counter-current cleaning process, has resulted in monthly reduction in solvent waste of about 23 gallons/month and savings of $80 dollars per month for solvent waste hauling.

The second change in operations has been the use of a new paint which provides better coverage. While the paint itself is slightly more expensive, it appears to have greater hiding power or results in better transfer efficiency so that paint jobs are finished faster, resulting in labor and material cost savings. The paint shop foreman estimated that the transfer efficiency improved from about 50 percent to between 65 and 70 percent. This would result in saving of approximately 150 to 200 gallons of paint per year.

4.11 Plant K

4.11.1 General

Plant K is a manufacturer of wood kitchen cabinets. The plant currently employs 65 people, and employees as many as 120 when demand for cabinets is high. In 1991 gross sales volume was 4 million dollars. Approximately 8,000 complete kitchen cabinet sets were manufactured in this period. Primary customers of this plant are general contractors constructing apartments, homes, and condominiums. At this plant the general manager, who is also an owner, was interviewed.

Manufacturing the kitchen cabinets proceeds through cutting of materials, sub-component assembly, pre-assembly, final assembly, and shipping. As orders enter the plant, material cutting requirements are determined by computer and automatically transferred to the cutting stations. At the cutting stations, saws are used to cut raw materials in the necessary shapes and sizes. Materials used include particle board, oak, cottonwood, and birch. Following cutting, parts are pre-assembled. Most painting follows immediately after pre-assembly. Steps in painting consist of applying putty if necessary to fill wood blemishes, followed by staining, sanding, and application of a clear coat. Painting is performed using air-less and air-assisted spray guns and by a curtain coating process. Paint transfer efficiency is not routinely calculated. However, some accurate spot measurements of transfer efficiency have been performed at the plant by the spray gun equipment supplier. The results of these tests indicated transfer efficiencies for the spray guns in the range of 40 percent. Transfer efficiencies for the curtain coater have not been measured, but are estimated to be in the range of 95 percent.

Annual consumption of paint is estimated to be approximately 3,000 gallons. There has been no determination of the amount of paint used to paint each product. Cost of paint is a
small portion of the cost to produce each cabinet. Annual paint costs were estimated at $40,000 dollars or 1 percent of gross sales. Labor costs for painting are estimated to be less than the annual cost for paint. One reason for this is the use of the curtain coater which rapidly applies large quantities of paint using only minimal labor. The overall cost structure for manufacture of the cabinets is 40 percent materials, 20 percent labor, 30 percent overhead, and 10 percent profit.

Six people are employed in painting operations, two of these on the curtain coater. Painters receive training in-house and by equipment suppliers. Nearly all of the paints used at the plant are organic solvent-borne. Paint materials include stains, vinyl sanding sealers, pre-catalyzed clear nitrocellulose lacquers, and pigmented nitrocellulose lacquers. Five different stains are used in painting operations. Stains and clear lacquers are off-the-shelf materials, while the pigmented lacquers are custom blended by the plant’s suppliers. Specifications for the paints used are maintained by the plant’s paint suppliers. The types of paints used have been developed based on supplier recommendations. No thinners are used in the application of the paints at this plant. Material safety data sheets were obtained for a representative sample of the paints used in the plant’s coating operations. VOC contents of these materials ranged from 3.2 to 6.2 pounds per gallon. It is estimated that the majority of the paint materials used have VOC contents in the range of 5 pounds per gallon.

4.11.2 Waste Generation

At this plant wastes are generated in the form of VOCs from paint curing, as waste solvent from equipment cleaning and other clean-up activities, as overspray from spray painting operations, and as solid wastes such as empty paint containers and rags used in spill clean-up and equipment cleaning. Data on quantities of waste generated were generally unavailable. Based on the annual paint consumption of 3,000 gallons per year, and an estimated VOC content of 5 pounds per gallon, VOCs from painting operations are estimated at 15,000 pounds per year. An additional source of VOC generation is the relatively large quantity of lacquer thinner used in paint equipment cleaning and to clean overspray from certain parts of the product. At one stage of the cabinet manufacturing process, the edges of certain cabinet panels are sprayed with a sealer. This operation deposits spray on the already finished cabinet surface. This overspray is removed by wiping with lacquer thinner. Painting equipment which is cleaned with lacquer thinner includes the spray guns and the curtain coater "paint head". The paint head is cleaned in a tank approximately 10 feet long by 1.5 feet wide by 2 feet deep. This tank contains approximately 100 gallons of lacquer thinner. Lacquer thinner consumption is currently 55 gallons per week. Presently, the thinner used to clean paint guns and for cleaning overspray is all allowed to evaporate. The thinner used to clean the paint head is partially allowed to evaporate and the remainder is being stored on site. As a means of disposing of this stored thinner, employees have been allowed to use quantities as fire starter. The plant does not presently use a solvent waste hauler of any kind. For this reason, it is estimated that all of the lacquer thinner used results in VOC waste. This amounts to 55 gallons per week of material with a VOC content of approximately 7 pounds per gallon or about 20,000 pounds per year.

The plant generates no aqueous waste from painting operations. As indicated above, liquid organic solvent wastes from various cleaning activities are currently being allowed to evaporate
or are being burned off-site by employees. Paint waste from cleaning spray gun lines is recycled. Lacquer thinner is run through the lines in a back-flushing operation and the discharged material is placed back into the paint container feeding the gun. Apparently the paints being used are tolerant to small additions of thinner without adversely affecting their quality. The plant also does not presently generate left-over paint. Apparently the paint colors used in the cabinet production mix have remained constant enough so that all paints can eventually be used.

Solid wastes from painting operations are generated in the form of empty 55-gallon drums, smaller paint containers, filters from spray booths, and rags used in various clean-up operations. Empty lacquer thinner drums are returned to the lacquer thinner supplier. Empty 55-gallon paint drums are currently either used in-house or sold to employees to use as burn barrels. Spent fiberglass filters are generated by 5 active paint booths. Each booth uses eight filters each approximately 2 feet wide by 2 feet long and 2 inches thick. Filter change rates range from once every two weeks to once every two months. All solid wastes from the plant are disposed in a 40 cubic yard dumpster. The plant currently generates 80 cubic yards of waste per week. Annual costs for solid waste hauling are approximately $26,000 per year. The table below summarizes waste quantities for which data were available.

<table>
<thead>
<tr>
<th>Table 4.14 Estimated Waste Quantities From Painting at Plant K</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
</tr>
<tr>
<td>Solvent and paint sludge</td>
</tr>
<tr>
<td>Paint booth filters</td>
</tr>
</tbody>
</table>

1 The plant does not currently have a solvent waste hauler, all solvent is currently allowed to evaporate or is burned as a means of disposal. For this reason all solvent used is assumed to result in VOC waste.

Assessment of waste streams is performed by the owner and by the plant manager. At this time the perception is that paint wastes are not a major problem. Of greater concern is the large volume of wood wastes generated and a customer for these waste materials is currently being sought. Cost impacts of waste generation are seen primarily in the form of solid waste handling costs.

The owner believes that current trends in paints and in particular painting technology, are making it easier to control paint wastes. The owner mentioned the use of the curtain coater and also indicated that there was some interest at the plant in ultraviolet curing technology. There are currently no plans to switch to waterborne paints. The owner is concerned about overall durability of these paints and the possibility that their use may result in raising of the wood grain resulting in an unsatisfactory finish. The plant is currently not required to have an air permit. The owner is aware of the New Clean Air Act but is not sure how it will impact his operations.
While there is no formal waste reduction program at the plant, there has been emphasis on waste reduction. This emphasis has been primarily in the area of reducing wood scrap generation. However, the plant has implemented a very effective paint waste reduction technology through the purchase of a curtain coating system.

In the curtain coating system, paint exits from a horizontal trough and flows in a continuous curtain under the influence of gravity. Parts to be painted are conveyed through this curtain and quickly receive a uniform paint coating. Paint which is not applied to the object to be coated is captured in a trough beneath the conveying system and is recycled to the application trough. Transfer efficiencies for this technology are very high, often greater than 90 percent. Irregular flat shapes such as cabinet frames can be coated very efficiently compared to using a spray system. Coating speeds are also high, allowing rapid coating of large numbers of parts with low labor expenditure. A limitation to the system is its ability to paint only flat surfaces.

The owner estimates that the use of the curtain coating system has reduced paint consumption by as much as 50 percent. This estimate has not been verified as yet. The curtain coating equipment has been in operation for six months so that data on last years paint consumption includes use of the curtain coater as well as the conventional spray equipment. At the end of this year's operation, it will be possible to compare paint consumption with data from two years ago, to better estimate the savings from using the curtain coating equipment.

Motivations for purchasing the curtain coating system were improved efficiency, better quality finish, and cost reductions. An important factor in the decision was the start of production of a cabinet requiring a relatively large amount of coating and also having primarily flat surfaces.

Quality control programs are linked somewhat to waste reduction. This occurs mostly in the area of wood waste reduction. Errors in material cutting resulting in "re-cuts" are analyzed monthly in an effort to reduce wood waste. Waste reduction responsibilities are shared primarily by the owner and the plant manager. There are no employee incentives for waste reduction nor is waste management accounting implemented. However, there is a general employee suggestion program.

The most successful paint waste reduction effort to date has been the application of the curtain coater. Previously, some paint waste reduction occurred in switching from high pressure spray guns to low pressure air assisted guns. Training programs for painters have also helped reduce paint waste. The practice of back-flushing to clean spray guns and adding this material to paint has eliminated this source of clean-up waste. One unsuccessful waste reduction method which was tried to reduce wood waste volume was the use of an incinerator. This proved unsuccessful because the incinerator generated too much smoke.

The plant owner obtains information on waste reduction technologies through seminars, suppliers, trade journals, and wood product publications. The plant owner is a member of the National Kitchen Cabinets Association. The owner also indicated that the Illinois Power Company provided useful programs to industry. Currently Illinois Power is providing seminars.
on advanced paint curing technologies such as ultraviolet curing. The plant owner will be attending one of these seminars.

Paint waste disposal methods at the plant presently consist of allowing waste solvents to evaporate and disposing of paint solids such as filters and rags in a general purpose landfill. The plant does not currently utilize the services of a solvent waste hauler.

The owner felt that the State of Illinois has been relatively helpful in providing aid in waste reduction. He is aware that engineering assistance is available from the state EPA. He also is preparing to participate in a training grant program called Prairie State 2000, some of these funds will be used in paint application training.

4.12 Plant L

4.12.1 General

Plant L is a medium sized manufacturer of lawn and garden equipment. Its primary product is lawn mowers which it manufacturers for several major retail and hardware stores. The plant employs approximately 380 people. Sixteen people are employed in painting operations. In 1991 the plant produced approximately 250,000 lawn mowers. At Plant L interviews were conducted with the safety coordinator, the fabrication manager responsible for painting operations, and a manufacturing engineer working in painting operations.

Manufacturing operations at the plant proceed from receipt of sheet steel through fabrication, assembly, packaging, and shipping of the final product. Body panels and other parts are painted using electrostatic spray and dip coating processes. Materials to be painted first pass through an alkaline rinse which is followed by a clear water rinse. The part then passes through an iron phosphate rinse, a clear water rinse, and a de-ionized water rinse. After the de-ionized water rinse the part enters a drying oven. After leaving the drying oven the part enters the priming spray booths. Following priming, the part enters the top-coating spray booth and following top-coating enters the curing oven. Both the priming and top-coating spray painting operations utilize spinning disc electrostatic spray equipment. Paints used are solvent-borne high solids polyester. No thinners are used in paint application. Spraying is completed in water-wall paint booths. If quality control inspection indicates painting flaws, the part may be spray painted in a touch-up booth, or may be stripped of paint and completely re-coated. The touch-up painting is accomplished using non-electrostatic spray equipment and is performed in dry filter paint booths. When required, paint stripping is accomplished in a hot caustic dip tank.

In addition to the paint process described above, some parts are painted using a dip coating process. The surface preparation processes are the same as above. The paint used in the dip coating process is a water-reducible alkyd. Figure 4.7 provides an overview of the paint manufacturing process at Plant L.

Paint transfer efficiency is periodically estimated based on amounts of paint purchased and volumes of paint waste generated. The paint transfer efficiency is estimated to be between
55 and 70 percent using these methods. Paint usage per product or number of products coated per gallon of paint is not calculated. Data on coverage potential for various paints in terms of square foot per gallon is maintained in a computer system. Likewise, square footage of various parts to be painted is also pre-calculated and stored within the computer. These figures are used to estimate paint quantities required for purchase. However, a measured value of actual paint used per part is not tracked or used to evaluate painting system effectiveness. One reason that this measurement is not made is that the plant operates in a "just-in-time" manufacturing mode. Many different components may be on the paint line and even identical components may receive a different color or type of paint depending on for whom they are being manufactured. Since the color and part being painted can vary frequently, it is difficult to track paint consumption for various parts. The plant uses seventeen different colors of paint. The plant has an automatic color change system that automatically flushes lines and spray guns when making a color change. About 6 ounces of solvent are used in this color changing process.

Annual paint consumption was 19,308 gallons in 1991. Paint costs average approximately $25 per gallon. Capital costs for painting are significant, however, it was not possible to obtain an estimate for these costs at the time of the site visit. Operations costs for painting were estimated to be between 5 and 10 percent of manufacturing costs. Sixteen people are employed in painting operations. Paint booth operators have received specialized training from...
both spray equipment manufacturers and by paint suppliers. Clean-up of spray booths is performed by spray booth operators and by in-house maintenance personnel.

As stated earlier, both solvent-borne high-solids polyester and water reducible alkyd paints are used at this plant. The plant maintains a set of specifications regarding various performance characteristics of the paint such as VOC content, gloss, and durability. These specifications have been developed together with the plant’s paint suppliers. Factors important in developing the paint specifications in order of importance are: performance, application technique, environmental concerns, and cost. The present paint formulations are considered essential to the quality of the product being produced. Several years ago the plant used red and yellow paints containing lead. The use of these paints was eliminated for environmental reasons. Elimination of these paints required a substantial improvement in surface preparation systems since the paints having lead also had higher solvent levels. It was estimated that the investment in improved surface preparation facilities was approximately $3,000,000. This investment may soon pay dividends, since it has given the plant greater flexibility in the types of paint it can use. One of the plant’s paint suppliers is developing a "non-hazardous" paint which contains no SARA listed materials. The use of this paint would be impossible without the improved surface preparation system currently in place.

### 4.12.2 Waste Generation

Wastes are generated from several sources in the painting operation. Surface preparation wastes consist of aqueous sludges and liquid effluent from the alkaline and phosphate rinse systems. Aqueous paint sludge is generated in the water wall paint booths from overspray capture. VOCs are released during the paint curing process. Solvent wastes are generated through automatic spray gun cleaning for color changes; most of this material is included with paint booth sludge. Other solvent wastes are generated by various painting equipment clean-up operations. A caustic sludge is generated from the caustic paint stripping operation. Solid wastes generated include paint containers, dry paint removed during sanding in small re-work operations, and filters from dry filter paint booths. Approximately 350 paint containers are used per year. These are disposed through a drum recycler. Estimates for dry filter wastes and dry paint were unavailable. The table below lists estimates for the quantities of certain wastes generated in painting operations at Plant L.

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>31 tons/year</td>
</tr>
<tr>
<td>Organic solvents</td>
<td>1,210 gallons/year</td>
</tr>
<tr>
<td>Aqueous paint sludge</td>
<td>8,855 gallons/year</td>
</tr>
<tr>
<td>Alkaline rinse sludge</td>
<td>19,200 gallons/year</td>
</tr>
<tr>
<td>Phosphate rinse sludge</td>
<td>12,000 gallons/year</td>
</tr>
</tbody>
</table>

Table 4.15 Estimated Waste Quantities From Painting at Plant L
The greatest source of waste generation at Plant L is VOCs, followed by surface preparation waste, overspray from paint application, equipment clean-up, and spills and rework. While the volumes of surface preparation waste are greater than for paint sludge, the disposal costs are lower. Costs for surface preparation sludge disposal are in the range of $.56 per gallon, costs for paint sludge disposal are approximately $4.00 per gallon. For this reason, while the volume of preparation waste is larger, paint sludges are considered a greater problem. Organic solvent waste is sent to a solvent recycler who sells recycled solvent back to the plant for $1.38 per gallon. Paint sludge is disposed through fuel blending. Surface preparation sludges are dewatered and landfilled.

Waste streams at the plant are assessed approximately six times per year. Personnel responsible for paint waste assessment include the general manager, the manufacturing manager, the safety coordinator, and the fabrication manager. Overall costs for paint waste management are between $120,000 and $150,000 per year. The plant has an Illinois EPA air permit. The company legal staff is currently evaluating the potential impacts of the New Clean Air Act on plant operations.

4.12.3 Waste Reduction

The plant has implemented a technique for capturing and recycling paint overspray waste in its water-wall paint booths and is currently evaluating other waste reduction options. The paints used at this plant are solvent-borne high-solids polyester which do not cure rapidly until baked. The plant has installed a set of baffles in each of their water wall paint booths to capture paint for recycle. Figure 4.8 illustrates the general arrangement of this baffle system.

![Figure 4.8 Side View of Water Wall Paint Booth With and Without Overspray Baffle](image-url)
In this arrangement, overspray collects on the baffle plate where it drains into a trough and then into a drum. The waste paint collected in this manner is returned to the paint manufacturer where it is remanufactured, primarily through addition of solvent and filtering. This remanufactured paint is then sold back to the plant at about a 42 percent price reduction over new paint. The baffling system captures about 27 percent of the paint sprayed. The capture system works well, but two problems have arisen which the plant is working to solve.

The first of these problems is the color of the recycled paint. Because the plant uses multiple colors, the recycled material is a black or dark brown color. The plant has consulted with its marketing department and determined that this paint can be used to paint the wheelbarrows it manufactures. The second problem is that there is not enough in-plant demand for the recycled paint, again because of its color. Efforts are underway to identify an outside market for some of the recycled paint. While this recycling technique is experiencing difficulties, it is an innovative approach which would be well suited to a facility using less colors or operating separate booths for each color.

Two other waste reduction initiatives are underway at this facility. The first is an evaluation of a new paint which contains no SARA listed materials. This paint has been independently developed by the plant’s paint supplier. If use of this paint is successful the volume of hazardous waste generated in painting will be reduced. Part of the plant’s evaluation of this option is consideration of its solvent costs. Some of the new paint materials could result in the plant having to use solvents costing $4.00 per gallon versus the $1.38 it currently pays.

A second waste reduction initiative is the evaluation of a filter system for the caustic paint stripping operation. The filter would be used to remove suspended solids from the caustic solution allowing it to work more effectively and extend the life of the caustic bath.

The potential for using powder paint in the plant’s coating operations has also been extensively evaluated. At present, the costs of such a system are considered prohibitive. One area of difficulty is the plant’s use of seventeen different colors. Color changes using powdered paint were considered to be more difficult than with the liquid paint system. This problem also affected considerations of the amount of powdered paint which could be recycled. Obviously, if separate booths were not used for each color the potential for contamination would be high. Some overall doubts of high recycle rates for powder were also expressed. Depending on the type of powder and application system, powder size breakdown can occur resulting in a less effective powder coating.

While waste reduction in painting is clearly important in the plant operation, there is no formal written waste reduction plan. Incentives for waste reduction have been reduced costs for raw materials and reduced costs for waste disposal. While the waste reduction options implemented to date have been considered successful, cost savings data for these options were unavailable at the time of the site visit. Quality control programs are integrated with waste reduction in that they have impacted certain waste reduction activities such as use of recycled paint. Quality standards and color requirements for many of the plant’s products cannot currently be met with its recycled paint.
There is a general employee suggestion program relating to improvements in plant operations which would include painting operations. Waste management accounting is not currently implemented at the plant. However, waste management responsibilities are clearly identified and waste generation is regularly reviewed. Sources of information on waste management techniques have included vendors, trade shows, training courses and magazine articles. Vendors in particular were cited as providing much useful information.

4.13 Plant M

Plant M is a paint waste recycling facility. The facility is located outside of Illinois. Aqueous paint sludge is dried and processed at this plant, to produce a dry granular inert powder which is marketed as a raw material for various products. Primary usage for the material to date has been as filler in the roofing, rubber, paint, plastics, and sealer/caulking industries. Fifteen people are employed at the facility. Ten are employed in waste processing and five are employed in management.

Characteristics of the materials accepted for processing at the plant are such that it does not compete with fuel blending or solvent recycling operations. Among the general requirements for material acceptance are VOC content less than 8 percent and BTU content less than 5,000 BTU’s per pound. Typical sources of input material to the process are paint sludges from water-wall paint booths and aqueous sludges from manufacturers of waterborne paints. Typical processing costs are in the range of $125 per drum or $2.27 per gallon.

Full scale operations began at the plant in 1991. In its first twelve months of operation the plant processed 3,000 cubic yards or 605,880 gallons of material. The plant has a capacity to process 12,000 cubic yards per year. The plant operates 24 hours per day six days per week. Currently the plant is experiencing rapid growth in the volume of material processed. Long term goals of the company are to operate five such plants whose geographic distribution will be determined by market factors. The Illinois EPA has been in contact with this facility to investigate the prospects of siting a plant within Illinois. Material sent to the plant for processing earns a recycling credit from the standpoint of EPA reporting. Criteria for materials to be processed at the plant are listed in the Table 4.16.

Types of paint and related waste which are acceptable include: latex, urethanes, lacquers, acrylics, enamels, epoxies, can coatings, inks, pigments, resins, powder coatings, and lean water. Material containing oil having a boiling point above 500 deg. F. is unacceptable. This criteria eliminates certain ink wastes which may contain vegetable oils.

Industries being served by the plant at this time include automotive, furniture, plastic painting, latex paint manufacturing, construction equipment manufacturing, and lawn and garden equipment manufacturing. The plant presently serves four clients in the State of Illinois. At present levels of operation, about 7 percent of the material processed at the plant is from Illinois industries. The stream of materials entering the plant for processing is extremely variable. Even waste streams from a single client may vary considerably from month to month.
Table 4.16 Material Acceptance Criteria For Plant M

1. Less than 1,380 ppm volatile chlorides
2. Less than 8 percent VOCs
3. Less than 5,000 BTU/pound
4. TCLP metals

<table>
<thead>
<tr>
<th>Metal</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) D001D (Copper)</td>
<td>less than</td>
<td>500.0 ppm</td>
</tr>
<tr>
<td>b) D003D (Zinc)</td>
<td>less than</td>
<td>1,000.0 ppm</td>
</tr>
<tr>
<td>c) D004 (Arsenic)</td>
<td>less than</td>
<td>200.0 ppm</td>
</tr>
<tr>
<td>d) D005 (Barium)</td>
<td>less than</td>
<td>500.0 ppm</td>
</tr>
<tr>
<td>e) D006 (Cadmium)</td>
<td>less than</td>
<td>100.0 ppm</td>
</tr>
<tr>
<td>f) D007 (Chromium)</td>
<td>less than</td>
<td>200.0 ppm</td>
</tr>
<tr>
<td>g) D008 (Lead)</td>
<td>less than</td>
<td>200.0 ppm</td>
</tr>
<tr>
<td>h) D009 (Mercury)</td>
<td>less than</td>
<td>1.0 ppm</td>
</tr>
<tr>
<td>i) D010 (Selenium)</td>
<td>less than</td>
<td>100.0 ppm</td>
</tr>
<tr>
<td>j) D011 (Silver)</td>
<td>less than</td>
<td>200.0 ppm</td>
</tr>
<tr>
<td>k) D018 (Benzene)</td>
<td>less than</td>
<td>20.0 ppm</td>
</tr>
</tbody>
</table>

The sludge drying process employed at the plant is illustrated in Figure 4.9. Upon arrival at the plant sludge is unloaded into receiving hoppers. From the receiving hoppers the sludge is conveyed into the sludge dryer. In the sludge dryer the sludge is agitated by a twin screw auger. The auger and sludge dryer jacket are heated using hot oil. Included in the sludge dryer is trap rock which assists in the agitation, mixing, and crushing process which occurs in the dryer. During the drying process, VOCs are evaporated from the sludge and collects in the vapor dome. From the vapor dome, the VOC vapors enter the natural gas fueled boiler where they are burned at 1,600 deg. F. for a two second residence time. Heated air from the boiler passes through an air to oil heat exchanger where it heats the oil used by the dryer. Crushed and dried sludge exits the dryer as a cured powder and then passes through a screening mechanism. Oversized or incompletely dried powder which does not pass the screen is returned to the dryer for further processing. Cured powder which passes the screen flows into 1,500 to 1,700 pound "super-sacks". The powder is stored in these sacks until shipment to a customer. Powder is shipped in the super-sacks or in 50 pound bags.

Presently, none of the material produced at the plant is being utilized in Illinois. Primary users at this time are roofing mastic manufacturers and cement block manufacturers. Small additions of the cured powder material to cement blocks has been found to enhance the water resistance of the blocks. Investigations have begun to determine the potential uses for the cured powder as a filler in the heavy rubber industry. There is potential for using the material in making paint but there are obstacles to be overcome. Problems exist in the ability to disperse the powder as part of the paint manufacturing process. Also the ability to produce...
a uniform fine particle size powder is limited at this time. The material has been used successfully in the manufacture of an auto-body undercoat.

![Diagram of sludge drying process at Plant M]

**Figure 4.9** Sludge Drying Process at Plant M

The BTU content of the cured powder is in the range of 8,000 to 17,000 BTU per pound which makes it a potential powdered coal substitute. There is some reluctance by the company to market the material in this fashion because of their requirement to operate as a recycler and not a fuel blender. Additional physical properties of the cured powder material are listed below.

<table>
<thead>
<tr>
<th>Table 4.17 Physical Properties of Recycled Paint Powder Produced at Plant M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color shades</strong></td>
</tr>
<tr>
<td><strong>Raw bulk density</strong></td>
</tr>
<tr>
<td><strong>Specific gravity</strong></td>
</tr>
<tr>
<td><strong>pH</strong></td>
</tr>
<tr>
<td><strong>Ash content range</strong></td>
</tr>
<tr>
<td><strong>Solubility</strong></td>
</tr>
<tr>
<td><strong>Particle shape</strong></td>
</tr>
</tbody>
</table>

Particle size distribution (run-of-mill), 8 mesh to 400 mesh, approximately 50 percent greater than 50 mesh and 50 percent less than 50 mesh.
Cured powder product currently is being sold by the plant for between $.02 and $.05 per pound. Annual powder output is approximately 3,000,000 pounds per year. It would appear based on estimated revenues for processing services and powder sales, that powder sales do not presently play a large role in plant economics. However, powder sales are critical in maintaining the plant's status as a recycler.

Development of markets for the plant's powder product is an on-going effort. It appears that some post-processing of run-of-the-mill powder will be necessary to satisfy certain markets. An inherent difficulty in marketing the product is its variability. Because plant input streams are variable it is inevitable that output characteristics will vary as well. One method of reducing overall output variability may be to blend output streams. In any event, the marketing challenges faced by the plant are similar to those faced by most recyclers. Market acceptance of the plant's product will grow as users become familiar with its useful characteristics.

4.14 Plant N

4.14.1 General

Paint manufacturing Plant N was visited in October 1991. The inspection team met with the plant's Product Quality/Environmental Manager. The paints manufactured at this plant are interior and exterior latex paints used as architectural coatings. The parent company operates another plant within Illinois that produces solvent-borne coatings. In 1990 the output of Plant N was approximately 7.0 million gallons of paint. In 1990 the plant manufacturing solvent-borne coatings produced approximately 2.0 million gallons of paints. Of this 2.0 million gallons, some was aerosol paint concentrate which was shipped to Plant N where it was packaged into aerosol containers. In another section of the plant, Plant N manufactures and packages various chemical products, such as: floor waxes and strippers, glass cleaners, latex caulks, and paint strippers (methylene chloride based). These various chemical products account for approximately 1.0 million gallons per year additional product output at Plant N. The focus of the site visit was on the paint production operations. However, some of the waste generation data given below is by necessity a combination of all operations at Plant N.

Specific paint formulation data was considered proprietary and was not provided. A variety of raw materials are used at the plant in making paint, including: titanium dioxide, zinc oxide, acrylic resin, PVA, ethylene and propylene glycols, glycol esters, magnesium aluminum silicate, colloidal clay, calcium carbonate, surfactants, biocides, and water. Material safety data sheets were collected for the entire line of paint products manufactured at both plants, as well as non-paint chemical products.

All of the paint products manufactured at the plant(s) are for retail sale. The primary customers for paints manufactured at Plant N are homeowners, although one product line of paints is manufactured especially for building contractors. Most of the paints are packaged in one gallon metal cans with some paints also packaged in quarts. The paints manufactured for building contractors are typically packaged in 5 gallon pails. The aerosol paints packaged at the plant are typically in 16 fluid ounce containers. All latex and water-reducible paints
manufactured at Plant N are formulated to contain less than 2.1 lbs of volatile organic compounds (VOCs) per gallon of paint (i.e., <250 grams per liter which is the California limit, therefore allowing the plant’s water-reducible paints to be sold in all 50 states). The average VOC value for all of the plant’s latex and water-soluble paints is approximately 1.7 pounds per gallon (200 grams per liter). Most of the paints are formulated for brush, roller or pad application. They can also be applied using spray equipment with appropriate thinning. The contractor line of finishes are formulated for spraying without additional thinning.

The paint manufacturing process at Plant N is shown in Figure 4.10. Paint is manufactured in a batch process. The first step is the high speed dispersion of the pigments and inert ingredients (extenders). After the proper grind is achieved, the slurry is pumped to another tank where additional resin, glycols, pigments, colorants, and other additives are added. After meeting quality control standards, the paint is filtered and packaged. Batch sizes range from 750 to 6,000 gallons. Although occasionally a smaller batch is made, most of the paint production is done in 6,000 gallon batches. The plant was built in 1976 and was the state-of-the-art at that time. Most operations (i.e., opening and closing of valves, turning on and off of pumps, etc.) are controlled from a central control station. The plant has one 50-horsepower, two 100-horsepower and two 200-horsepower high speed disc mills. The plant has eight 750-gallon, eight 2,000-gallon, six 4,000-gallon, and eight 6,000-gallon tanks used for paint production. The plant also has four 25,000-gallon, ten 16,000-gallon (some split), and twelve 6,000-gallon tanks to store titanium dioxide slurry, acrylic resin, PVA, ethylene and propylene glycol and other liquid raw materials.

Approximately 50 people are directly employed in the paint manufacturing process including the aerosol paint packaging operation. Besides hazard and safety training, no specialized, formal training regarding the making of paint is provided to new employees. Training of new personnel is accomplished on-the-job in the form of learning from other experienced personnel.
Wastes are generated at the plant due to spoilage in inventory, spills of solid and liquid raw materials, mistakes in formulation, spills of finished material, and equipment cleaning. Of these, the major cause of waste generation is equipment cleaning. Spills in the latex paint manufacturing area were reported to be rare. When spills do occur, the spilled material or finished paint is washed into floor drains which connect to an in-plant water treatment and
filtration system. Estimates for the waste stream quantities from all sources at this plant (including the chemical products manufacturing, e.g. paint strippers, and the aerosol paint filling operation) were provided by the plant environmental manager and are listed in the table below.

Table 4.18 Waste Quantity Estimates for Plant N (1991)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>48,600 pounds/year(^1)</td>
</tr>
<tr>
<td>Organic Solvent</td>
<td>24,000 gallons/year(^2)</td>
</tr>
<tr>
<td>Aqueous Waste</td>
<td>Unknown, not recorded(^3)</td>
</tr>
<tr>
<td>Solids (sludge)</td>
<td>96 cubic yards/year(^4)</td>
</tr>
<tr>
<td>Waste Paint</td>
<td>0(^5)</td>
</tr>
<tr>
<td>Spent Filters</td>
<td>2,000-3,000 pounds of bag filters/year(^6)</td>
</tr>
</tbody>
</table>

---

1 The majority of this amount is acetone (40,000 lbs) and methylene chloride (7,000 lbs) from the aerosol packaging and paint stripper production. Ethylene glycol used in the latex paint production accounted for only 450 lbs of the total.

2 This quantity was from solvent washing of the aerosol packaging operation. A solvent recycling company picks up the waste solvent about every 3 months.

3 The volume of waste water sent to the municipal water treatment system has never been measured by Plant N.

4 Material filtered from the aqueous waste stream using a vacuum drum filter (current year rate). In the previous year (1990), the filter cake amount was seven times greater while paint production volume was the same. The reduction in filter cake amounts was due to changes in plant efficiency resulting from the saving and reusing of equipment wash water. Solid material is sent to special waste landfill and the filtered, clear liquid is sent to the local municipal water treatment system.

5 No paint leaves the plant as "waste" paint. Any off-specification paint is reworked or sold off at a reduced cost.

6 Estimated

In the aerosol production area, organic solvents are used in the filling of the containers and the cleaning of the equipment after each color. The filling is done in an enclosed area which is designed to protect personnel in the event of an explosion. An average of 43,000 cans of paint are filled each day. The solvents used in the equipment clean-up are sent to a solvent recycler for distillation and reuse. The solids content of the clean-up solvent is typically in the range of 2 to 3 percent. No VOC collection system is employed or currently required by local air quality regulations.

4.14.3 Waste Reduction

While Plant N does not have a formal waste reduction plan, a number of waste reduction methods have been implemented at the facility. As part of his duties, the environmental manager continually looks for opportunities to reduce wastes in the plant operations. Although
he did not have a copy of the EPA document, "Guides to Pollution Prevention - The Paint Manufacturing Industry" (EPA, 1990), several of the recommended waste reduction techniques had been employed at the plant. The table below provides a summary of the waste reduction methods being employed at Plant N. The table was developed based on completion of a checklist which was part of the site visit questionnaire. Not all elements of the checklist were discussed in detail during the site visit.

Table 4.19 Waste Reduction Methods at Plant N

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Waste Minimization Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Equipment cleaning waste</td>
<td>Use high pressure wash systems</td>
</tr>
<tr>
<td></td>
<td>Use foam/plastic pigs to clean lines</td>
</tr>
<tr>
<td></td>
<td>Reuse equipment cleaning wastes</td>
</tr>
<tr>
<td></td>
<td>Schedule production to minimize cleaning</td>
</tr>
<tr>
<td></td>
<td>Clean equipment immediately(^1)</td>
</tr>
<tr>
<td></td>
<td>Use de-emulsifiers on spent rinses</td>
</tr>
<tr>
<td>b. Spills and off-spec. paint</td>
<td>Recycle back into process</td>
</tr>
<tr>
<td></td>
<td>Sell off at a reduced cost(^2)</td>
</tr>
<tr>
<td>c. Leftover inorganic pigments in bags and</td>
<td>Use mostly bulk materials in closed handling system.</td>
</tr>
<tr>
<td>packages.</td>
<td></td>
</tr>
<tr>
<td>d. Air emissions including pigment dust</td>
<td>Modify bulk storage tanks(^3)</td>
</tr>
<tr>
<td></td>
<td>Install dedicated baghouse systems</td>
</tr>
<tr>
<td></td>
<td>Use pigment slurries</td>
</tr>
<tr>
<td>e. Filter cartridges</td>
<td>Use bag or metal mesh filters</td>
</tr>
<tr>
<td>f. Obsolete products and customer returns</td>
<td>Blend into new products</td>
</tr>
<tr>
<td></td>
<td>Sell off at reduced cost</td>
</tr>
</tbody>
</table>

\(^1\) If no compatible paint batch follows immediately.
\(^2\) No paint leaves the plant as "waste" paint.
\(^3\) Not really a "modification" of the storage tanks but an increase in the use of bulk storage facilities thereby reducing the handling of individual drums or bags of raw materials.

The plant operates an in-house wastewater treatment facility made up of a collection tank, a treatment tank, and a vacuum drum filter. The collection tank is connected to floor drains in the paint manufacturing area. All wastewater from the paint production goes through this treatment system. After chemical coagulant treatment, the slurry is ready to be filtered. The vacuum drum filter is first coated with a layer of diatomaceous earth which acts as the filter media. The concentrated waste slurry is then pumped into the filter slurry holding tank.
Where the drum contacts the slurry in the holding tank, vacuum is applied to pull the water through the diatomaceous earth filter media leaving the paint solids on the surface. As the drum rotates around and out of the liquid, it comes in contact with a knife blade which shaves the solids from the filter media surface and exposes a fresh surface for further filtration action. As the paint solids are shaved from the filtration surface, some diatomaceous earth is also removed. The solids generation rate of 24 cubic yards per 3 month period also includes some diatomaceous earth. The de-watered filter cake is approximately 50 percent solids when first removed from the filter. The de-watered solids are sent to a special waste landfill. The water effluent from the vacuum filter is discharged directly to the municipal sewer. The water effluent is checked daily by the local sanitary district. One unsuccessful waste reduction effort occurred relative to the wastewater treatment process. In seeking ways to improve the performance of the process, the plant experienced less than satisfactory results with certain coagulants used in the treatment stage.

The vacuum filter was installed between 1983 and 1984 at a cost of approximately $56,000. At the time of installation, the cost difference between having the liquid waste slurry hauled away and processed (de-watered and landfilled) by a contractor and having the waste de-watered in-house and landfilled, resulted in an estimated payback period of about 2.5 years.

One of the most successful waste reduction techniques applied at the plant is the incorporation of wastewater from equipment cleaning into subsequent batches of paint. This practice has only been in effect at the plant for the last nine months. The plant has six 5,000-gallon tanks for wash water holding. A major concern with this process, which prevented its earlier adoption, is the problem of bacteria growth in the retained wash water. If bacteria contaminated water was inadvertently used, the entire batch of paint would be ruined. To combat the bacteria problem, an extra dose of bactericide is added to the wastewater before holding. The stored wastewater is usually scheduled for use as soon as possible and usually within a twenty-four hour period. The retained water is almost never held over a weekend. Extra care is exercised if longer than 24 hours elapses. The making of tint bases (for in-store tinting) or dark brown colored paints makes the recycling of the clean-up water from these paints impractical. The color intensities of these products would not be compatible with the plant’s typical pastel colored paints. Given the production volume of this plant, the practice of reusing the wastewater from equipment washing greatly reduces the plant’s total waste generation. The plant’s large production volume and its ability to schedule production of various paints of different types and colors weeks and months in advance, makes the wash water recycling very efficient for this facility. Formal estimates of cost savings from wastewater reuse were not available at the time of the site visit.

Plant N also has an organic solvent waste stream resulting from the chemical products manufacturing and aerosol paint can packaging operations. The waste organic solvents, comprised mostly of toluene with lesser amounts of xylene and acetone, are handled by a solvent recycler. The waste solvent results mainly from solvent used in clean-up and only contains between 2 to 3 percent solids. The waste organic solvents are processed into clean solvents by the recycler (as opposed to being used for fuel blending). The recycled solvents are bought back by the plant for use in clean-up operations.
Waste management decisions at Plant N are made jointly by the environmental manager, the plant manager, and plant laboratory manager. The environmental manager periodically assesses the current operations to identify opportunities to reduce waste. He includes waste management information in his report to upper management every three months. The plant has a county air permit. The environmental manager is aware of the New Clean Air Act. There is no formal employee incentive program for waste management.

Surprisingly, the costs related to the various waste management operations (i.e., costs of materials, energy, and labor to perform such operations as equipment washing or use of the filtration system) have not been formally compiled. Waste reduction processes are being employed at the plant to satisfy environmental concerns but without an assessment of their impact on overall costs. The costs associated with waste reduction and/or pollution control are lumped in the total cost of operating the plant.

The environmental manager indicated that his primary sources for information on waste management were shows and seminars sponsored by the paint industry (e.g., NPCA) and the waste treatment industry, as well as articles in various trade magazines for the paint and waste treatment industries.

4.15 Plant O

4.15.1 General

Plant O was visited in July 1992. This plant is a medium sized manufacturer of specialty metal containers and metal cabinets. The plant serves primarily industrial customers. The plant employs approximately 120 people. At this facility the plant project manager was interviewed.

At the plant, metal containers and cabinets are manufactured from sheet and coil steel through various metal cutting, forming, welding, and assembly operations. Following assembly, cabinets are painted using a solvent-borne paint system, while containers are painted using a powder paint system. A powder paint system for cabinets is currently under construction and will begin operation shortly.

The process of painting cabinets presently consists of a manual iron phosphate wiping operation, followed by air drying and manual spray painting using air-assisted air-less electrostatic spray guns. Cabinet spray painting is performed in cross-flow dry-filter paint booths. Following spray painting the cabinets are allowed to air dry. The cabinets are painted using a solvent-borne modified alkyd paint system having a VOC content of 3.45 pounds per gallon. The paint used in painting cabinets is purchased ready-to-apply and requires no additional thinning. Toluene is used as a clean-up solvent.

Containers are painted on an automated line using a polyester powder coating system. Finished containers are leak tested under water and this rinse is the only surface preparation performed. Following leak testing the containers are suspended on hangers attached to an overhead conveyor and are passed through a drying oven. The immersion during leak testing
and the subsequent oven drying are sufficient to remove any contaminants which would interfere with paint adhesion. After oven drying the containers enter an automated multi-gun electrostatic powder spray booth. After receiving a coating of powder paint, the containers are conveyed from the booth to a curing oven. The plant produces containers in several colors. The automated powder booth is used for applying the plant’s primary color. Other, low-volume, colors are applied in a manual electrostatic powder spray booth which is located in parallel with the automated booth. The automated booth recycles powder while the manual booth does not.

In the future, the painting of cabinets will be performed on an automated epoxy powder coating line. Surface preparation will entail a three stage system consisting of a wash and iron phosphate treatment, a clear water rinse, and a non-chromic sealer rinse. Following the surface preparation the cabinets will be oven dried. After drying, those cabinets to be painted the plant’s primary color will be powder coated in a multi-axis, multi-gun, automated booth with powder recovery. Cabinets to be painted in the plant’s lower volume colors will be manually powder coated in two opposed, cross-draft, non-recovery booths. After coating the cabinets will be oven cured.

Transfer efficiency for the solvent-borne paint operations has been calculated to be 67 percent. The transfer efficiency is calculated based on surface area coated, film thickness, and overall paint usage. The plant maintains data on the amount of paint used to cover a given surface area. This information has been used in monitoring the performance of the solvent-borne painting operation.

Transfer efficiency for the present container powder coating operation has not been calculated. It was estimated by the project manager that the efficiency of the automated booth is approximately 95 percent while the transfer efficiency of the manual booth, which does not recycle powder, is between 60 and 65 percent.

Annual paint consumption for painting cabinets is approximately 14,000 gallons per year. Powder paint consumption for painting containers is between 20,000 and 25,000 pounds per year. Liquid paints used for cabinets cost approximately $14.00 per gallon and powder paints for containers cost approximately $3.25 per pound. In addition, the plant uses about 2,400 pounds per year (330 gallons year) of toluene as a clean-up solvent at a cost of $2.13 per gallon. The cost of paint is an important consideration at the plant. Overall costs for product painting are estimated to be approximately 10 percent of production costs.

Six people are employed in painting operations. In the past, operators of the solvent-borne paint equipment received no specialized training and learned on-the-job. With the introduction of the powder coating system, paint booth operators receive training from both the spray equipment manufacturer and the powder paint supplier. In addition, there have been in-house seminars and visits to other plants using powder paints. Clean-up of paint booths and equipment is performed by the equipment operators. A strippable booth coat is used on the paint booth walls to aid in paint removal.

Selection of paints used at the plant is based on a set of product specifications such as solvent resistance, abrasion resistance, gloss, etc. Two of the most important characteristics
in choosing paints at this plant are compliance with environmental regulations and performance. The plant competes in its market niche based on providing high quality products and service rather than price alone. This contributes to the importance of obtaining a high quality paint finish on its products.

4.15.2 Waste Generation

Wastes are generated in the plant’s painting operations due to surface preparation, overspray, equipment clean-up, and VOCs from paint curing. Waste due to left-over paint is minimal since the plant uses only a few colors and operates in a continuous fashion. Waste from paint spills and rework is also minimal. Estimates for the various quantities of paint-related waste generated at the plant are listed in the table below.

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOCs</td>
<td>24 tons/yr</td>
</tr>
<tr>
<td>Waste Paint (solvent-borne)</td>
<td>15 tons/yr</td>
</tr>
<tr>
<td>(92 drums/yr w/filters)</td>
<td></td>
</tr>
<tr>
<td>Waste Paint (powder)</td>
<td>.75 tons/yr</td>
</tr>
<tr>
<td>Organic Solvent and Paint Sludge</td>
<td>1,850 gallons/yr</td>
</tr>
</tbody>
</table>

In addition to the quantities listed in the table above, there is a quantity of surface preparation waste generated during the manual wiping of cabinets with an iron phosphate solution prior to painting. It was estimated by the project manager that approximately 100 gallons of this material is used per day and discharged to the sanitary sewer system. The greatest source of paint related waste at the plant is VOC emission followed by waste paint due to overspray of the solvent-borne paint used in the cabinet painting operations. Clean-up solvent usage is relatively low since the plant produces most of its cabinets in one color and uses no clean-up solvent in the powder coating operation.

4.15.4 Waste Reduction

Waste streams at the plant are assessed quarterly and annually. Cost impacts of waste are estimated to be greatest for materials usage, followed by overhead (equipment, management, and reporting), labor, and energy. The plant has in-place a waste reduction plan which calls for the elimination of all hazardous wastes from its painting operations. Waste reduction is not currently integrated with quality control operations. The plant does not offer employee incentives specifically for waste reduction, but has an employee of the month program to recognize overall superior performance.

Several successful paint waste reduction methods have been employed at this plant. The most important of these is the present usage of powder paints for container finishing and the near-term conversion of all remaining paint operations to powder coating. In addition, the plant recently installed a burn-off oven for cleaning work piece hangers from the powder coating line.
Conversion of the container coating operation from a solvent-borne paint to a powder paint is estimated to have reduced VOC emissions by 5 tons per year. Elimination of clean-up solvent and waste paint were estimated to result in a waste reduction of 5,428 pounds per year. In addition the amount of spent fiberglass filters from paint booths was reduced by 28 drums per year.

Within the next several months the cabinet painting line will also be converted to a powder coating operation. This conversion will reduce VOC emissions by about 28 tons per year. Overspray waste will be reduced from about 17 tons per year to about 2 tons per year of powder waste. Nearly all of the current 1,850 gallons per year of clean-up solvent waste will be eliminated.

Motivations for converting from solvent-borne paint to powder paint were primarily environmental compliance and coating quality. Prior to switching its container coating operations to powder, the plant had experimented with several different environmentally compliant solvent-borne paint systems without satisfactory results. Extensive analysis by the project manager has indicated that powder is not the lowest cost alternative at this facility, but provides superior coating quality. Included in this analysis was consideration of waterborne coatings. The conclusion reached at this facility was that the use of waterborne coatings would result in safety concerns due to more difficult equipment grounding and would not produce a satisfactory finish.

The plant project manager indicated the use of magazine articles, seminars, and vendors as sources of information on waste reduction technologies. The greatest obstacle which has been encountered in reducing waste in paint operations is obtaining a high quality finish while meeting environmental and cost constraints.

The plant has air permits for both the container and cabinet coating lines. Impacts of the New Clean Air Act on plant operations have not been assessed, but it is believed that conversion to powder coating will eliminate most impacts of changes in air quality regulations.

At the present time, the plant’s organic solvent waste is being disposed through fuel blending. Spent filters with paint overspray are being disposed in a special waste landfill. Costs for solvent waste disposal are currently $125/drum. Disposal cost for spent filters is $80/drum. Annual paint related waste disposal costs for the plant are approximately $12,000 per year.
CHAPTER 5

CONCLUSIONS

5.1 General

The data presented in the case studies support the conclusion that greater emphasis should be placed on reducing wastes by Illinois paint users than by Illinois paint manufacturers. For the sites included in this study, the relative material efficiencies of paint manufacturers were found to be greater than that of paint users. Using the case study data, it is possible to estimate approximate material efficiencies for three of the five paint manufacturers surveyed. These estimates are shown in the Table 5.1.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Estimated Material Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>93 percent</td>
</tr>
<tr>
<td>B</td>
<td>92 percent</td>
</tr>
<tr>
<td>C</td>
<td>92 percent</td>
</tr>
</tbody>
</table>

The estimate was provided by the plant based on the ratio of dollars of product produced to dollars of raw material.

Also based on the case study data, material efficiencies for most paint users (with the exception of powder paint users) are estimated to be in the range of 25 to 70 percent when transfer efficiencies and VOC losses during curing are considered.

The driving force behind the relatively high material efficiency of paint manufacturers is simple economics. Paint manufacturers are motivated to reduce wastes of raw materials to maximize the production of their finished product. On the other hand, for most of the paint users in the study, the cost of paint, and the disposal of paint related wastes, represent a relatively small portion of overall production costs.

This conclusion is not meant to imply that opportunities for further waste reduction do not exist within the paint manufacturing industry in Illinois. On the contrary, it must be remembered that it is likely that the facilities surveyed represent best cases. All of the paint manufacturers in the study have implemented a number of waste reduction measures that contribute significantly to their high efficiency. The fact that several of these facilities have only recently implemented these measures implies that greater efforts in waste reduction technology transfer to the paint industry are appropriate.

A second finding of the study was the lack of formal waste reduction plans at most of the facilities surveyed, even though significant paint waste reduction efforts had been undertaken. Of all the sites visited, only two of the paint manufacturers reported having written, goal-oriented, paint waste reduction plans, and these had only recently been developed. Also, it
was found that in some instances significant paint waste reduction efforts were implemented apparently without a rigorous cost analysis. Frequently, it was found that the total costs of implementing waste reduction programs, and the benefits that accrued, were not compiled.

Similarly, at facilities not operating under air permits, paint waste management costs and sometimes even paint costs, were not separately reported. In some instances, where paint costs were known, total paint consumption was not known. While the lack of this information at a site did not appear to preclude waste reduction efforts, the availability of such data would certainly enhance the likelihood of implementing cost effective waste reduction measures.

5.2 VOC Emissions

The case studies show that both paint users and paint manufacturers in Illinois produce VOC wastes when manufacturing and using most paints. In general, VOC emissions are much higher per gallon of paint used than per gallon of paint manufactured, due to the emission of VOCs which occurs during the curing of paint.

Methods of reducing VOC emissions by paint manufacturers center primarily on material handling techniques such as storage tank vent design, covering of batch tanks, minimization of the use of organic solvent in equipment clean-up, and minimization of spills. For paint users, techniques for reducing VOC emissions include using paints with low or no VOC content, reducing overall paint consumption through improvements in transfer efficiency, and minimizing the use of organic solvents in surface preparation and equipment clean-up.

The results of the case studies suggest that existing environmental regulations, and the New Clean Air Act, are already sufficient to provide powerful legal and economic incentives for both users and manufacturers of paint to implement VOC waste reduction measures. Paint users operating under air permits, such as medium and large size product manufacturers, face limits on their daily production that are driven by restrictions on VOC emissions. These users are increasingly demanding paints formulated with lower VOCs, either as high-solids, waterborne, or powdered paints. The paint industry in turn, is producing paints to supply this demand. In addition, because VOC limitations can impact production, VOC regulations also motivate users to adopt application technologies having higher paint transfer efficiencies, resulting in overall paint waste reduction.

The case studies showed that auto body repair shops, while generally not operating under air permits, also have a significant incentive to reduce paint usage and hence VOC emissions. For these shops the motivation for waste reduction is the high cost of paint. All of the auto body shops included in this study were actively seeking ways to reduce paint consumption.

The case studies also suggest that the VOC emissions of some wood finishing industries in Illinois may deserve closer examination. Both facilities in this study operate without air permits, and based on annual paint usage, these permits are not required. However, one of the facilities uses significant amounts of organic solvent in certain cleaning operations, all of which is emitted as VOCs. If the solvent usage for this facility were counted as paint, the facility would require an air permit to operate.
5.3 Liquid Wastes

The study indicates that liquid wastes from paint users and paint manufacturers can consist of a variety of materials. These wastes may consist of primarily organic solvent-borne materials, aqueous materials, or mixtures of solvent-borne and aqueous material including, in some cases, certain solid wastes such as baghouse dust.

Methods of reducing liquid wastes by paint manufacturers center primarily on reduction in waste from equipment clean-up. For paint users, reduction of liquid waste is accomplished primarily through improvements in transfer efficiency, reducing surface preparation wastes, minimizing equipment cleaning waste, and minimizing the generation of left-over paint.

The case studies also indicate that cooperation between paint users and paint manufacturers is leading to the emergence of technologies to reduce paint related liquid wastes by capturing and reusing overspray generated in the application of liquid paints. Technology of this type was found being at two independent user sites, each using different types of paint and cooperating with a different paint manufacturer.

Based on the site visits, it would appear that most paint related liquid wastes do not reach the environment untreated. With the exception of two paint users, all paint users and paint manufacturers visited had made provisions for handling their liquid wastes, either in-house, or through a liquid waste hauler. Both users and manufacturers seem to be aware of the environmental hazards, and legal penalties, associated with improper handling of liquid paint related wastes. The study indicated that there is a viable liquid waste handling industry which will process liquid paint related wastes from both small and large users and manufacturers. Based on the case studies, the cost for these services is competitive and affordable for all generators of paint related liquid wastes. For liquid wastes disposed in liquid form, i.e. not dewatered and landfilled, the methods of disposal are fuel blending, recycling, and incineration. The data from the case studies suggest that a significant portion of solvent-borne paint related liquid wastes are recycled. Options for recycling aqueous liquid wastes are not as favorable at this time, although industries are emerging to process aqueous liquid waste into a dry powder which may be recyclable if sufficient markets can be developed.

The case studies suggest that the wood finishing industry in Illinois may require some guidance in management of its organic solvent-borne liquid wastes. One facility reported burning this material as a means of disposal. Personnel at both wood finishing sites were not familiar with options available for proper disposal of organic solvent-borne liquid wastes.

5.4 Solid Wastes

The data presented in the case studies indicate that both paint users and manufacturers generate various forms of solid waste. Solid wastes generated by paint manufacturers include spent filters, raw material packaging, baghouse dust, and dewatered sludge from in-house wastewater treatment facilities. For paint users, solid wastes include paint booth filters with overspray, dewatered sludges from water-wall paint booths and surface preparation, paint containers, and paint dust from surface preparation or rework activities.
Methods of reducing solid wastes by paint manufacturers include reusing equipment cleanup waste and using liquid slurry pigments. For paint users, methods for reducing solid wastes include improving transfer efficiency, reducing surface preparation waste, and minimizing leftover paint. As indicated above, technologies for recycling liquid overspray are emerging. These technologies are being developed to recycle dry overspray as well.

Based on the site visits, it appears that opportunities for improvement exist in the area of solid waste handling for both manufacturers and users of paint. In particular, while larger users and manufacturers tended to indicate they disposed paint related solid waste in a special waste landfill, smaller facilities, such as auto body shops and small paint manufacturers, tend to rely on general purpose landfills. Data on quantities of solid wastes generated were also often lacking at many of the sites. The case studies suggest that both paint users and manufacturers would benefit from additional guidance on proper handling of paint related solid wastes.

5.5 Recommendations

Although much has been accomplished by both manufacturers and users to reduce paint wastes, more is possible and desirable. Distribution of information on waste reduction techniques/technologies should be increased. Assistance with regulatory compliance should be standardized. Pollution prevention planning for facilities and processes should be encouraged and assistance provided to develop formal planning documents. Support of these types of activities would provide dividends to the state in the form of increased profits for industry and reduced environmental risks.
REFERENCES


APPENDIX A - PRETEST SITE VISITS

Pretest site visits were performed to evaluate the site visit methodology and survey instrument. Site visits included an auto body repair shop, a manufacturer of product coatings, and a manufacturer of construction equipment.

Plant P1

Plant P1, an auto body repair shop located in central Illinois, was visited in March of 1991. The owner of the shop was interviewed at this site. Ten people are employed at this facility, six in production and four in administration. In 1990 the business repaired 1,200 vehicles.

Two painting processes occur at this shop; new part painting, and painting of repaired metal. In the case of new parts, the part is primed and sanded and then a finish coat is applied. In the case of a repaired part, a plastic fill material is usually first applied. Then the filled section is ground, primed, and sanded, followed by the application of a finish coat. The finish coat consists of a colored base coat, followed by a clear coat. The shop owner indicated that very little waste material is generated in surface preparation. However, there is a moderate quantity of plastic, paper, and cardboard masking material used.

The paint application technology being used at this facility is a high-volume, low-pressure (HVLP) spray system. All painting takes place in a down-flow paint booth and baking system. Overspray is collected by dry filters which are replaced every three months. Paint transfer efficiency is estimated to be approximately 60 percent. It was difficult for the owner to estimate the amounts of paints and solvents used for each vehicle because generally only portions of vehicles are painted. It was estimated that to paint an entire vehicle would require 2 gallons of material (including paint, solvent, hardener, and activator). The shop owner did not believe that the cost of paint was a major influence in the cost of his service, but that parts and labor were his major costs. The owner did not have data available for the shop's annual paint usage. With the owner's permission, the shop's paint supplier was contacted and data for two months of operation were acquired. Based on this data, the shop's annual paint consumption is estimated to be approximately 450 gallons per year.

This shop is currently using a polyurethane paint system. The choice of this paint system appears to have occurred through the owner's past experience with products made by this paint system manufacturer. He is very pleased with this paint system because it allows him to mix only the quantity of paint which he needs for a job, and results in easy and accurate color matching.

The shop owner indicated that he has no paint waste from spoilage. The paint shelf life is never exceeded under the shop's current operating conditions. The owner believes that very little waste is generated in his painting operations. Spills are rare, and wastage due to improper mixing of paint, or mixing too much paint, seldom occurs.

Waste solvent is generated in cleaning the painting equipment. Presently, virgin solvent is used in the cleaning operations. Waste paint and solvent are mixed as they are collected.
and are stored outdoors in covered 55-gallon drums. It was not noted if the drums are on bare soil or on concrete. The operation generated 590 gallons of mixed solvent and paint waste in 1990. Mixed solvent and paint waste are disposed through a solvent waste hauler.

Solid wastes consisting mainly of masking materials, filters, small plastic parts, cardboard boxes, etc., are picked up twice a week. The dumpster size is about 2 to 3 cubic yards. The shop owner indicated that it is always full when picked up. Estimated solid wastes are approximately 260 cubic yards per year. These solid wastes are disposed in a general purpose landfill.
Plant P2

Plant P2 is a manufacturer of product coatings, located in northeastern Illinois. The plant was visited as a pretest in March of 1991. At this plant, the sales vice-president was interviewed and provided a tour of the paint manufacturing facilities. The plant employs 19 people and in 1990 had sales of $3 million. The volume of paint produced in 1990 was approximately 240,000 gallons.

This plant manufactures a variety of low-VOC paints such as water reducibles and high-solids, as well as conventional organic solvent-borne paints. Information on paint formulation was considered proprietary. A number of resins are used at the plant, primarily alkyds, along with some epoxy and polyester. Solvents used include xylene, toluene, and glycol ethers. Paints produced are marketed under the company's brand name. All of the paints manufactured are custom formulated to meet customer specifications. The company considers its market niche to be service related. It provides fast and reliable supply of custom finishes.

The plant serves a broad customer base of manufacturers, mostly in the Chicago area, but some products have been shipped nationally. All of the coatings manufactured are for use on metal, but the products coated range from farm machinery to computer hardware. The coatings are suitable for application by all types of spray equipment and dip coating. Usually, the customer provides details on his application technique and the paint is formulated accordingly. Customer preferences in paint characteristics range from those who want the lowest price possible, to those emphasizing quality with little concern for price.

The plant manufactures paint to order in quantities ranging from 1 quart to 1,200 gallons. The manufacturing process used at the plant is shown below.

![Diagram of Paint Manufacturing Process at Plant P2](image-url)

**Figure A1** Paint Manufacturing Process at Plant P2
At this plant pigment, resin, and solvent are ground in a ball or sand mill (depending on paint type) and stored as an intermediate material according to color. These intermediates are then mixed with additional material as necessary in a batch tank. After mixing is complete, a sample of the paint is tested by the plant's quality control department to determine if the paint meets customer specifications. If necessary, additional material is added. When the customer specifications are met, the paint is filtered and packaged for shipment. Paint is packaged in containers ranging from quarts to 350 gallon returnable tanks.

Plant P2 has an active waste minimization program. The plant uses a number of sources for information on paint technology and associated waste issues. Past sources of information have been trade magazines such as Industrial Finishing, seminars at the University of Wisconsin, trade shows, and special industry programs sponsored by groups such as the Chemical Coaters Association.

Presently, no waste water is generated from cleaning waterborne paint manufacturing equipment. All rinse water is segregated and recorded in the computer-based inventory system as a raw material. Eventually the rinse water is used in making a compatible batch of paint. Virgin organic solvents are not used in cleaning equipment. All solvent for the purpose of equipment cleaning is recycled solvent which when contaminated, is sent to the plant's solvent recycler. Other sources of waste such as human errors, spills, spoilage, and return of paint by customers are rare. When a batch of paint has an error in formulation it is stored and "worked off" by incorporating in other products. If a customer returns a batch of paint because it doesn't meet specifications, the batch is either re-manufactured and returned to the customer, or it is stored until it can be used in other paints. Waste paint is disposed only on rare occasions, in which case it is also handled by the plant's solvent waste hauler. All material handled by the plant's solvent waste hauler is processed to recover solvent and the remaining sludges are incinerated.

Data on liquid waste generation is shown in the table below.

<table>
<thead>
<tr>
<th>Month</th>
<th>Paint Produced</th>
<th>Liquid Waste</th>
<th>Percent of Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23081</td>
<td>1165</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>21524</td>
<td>1185</td>
<td>5.5</td>
</tr>
<tr>
<td>3</td>
<td>26541</td>
<td>1650</td>
<td>6.2</td>
</tr>
<tr>
<td>4</td>
<td>15700</td>
<td>1100</td>
<td>7.0</td>
</tr>
<tr>
<td>5</td>
<td>21993</td>
<td>700</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td>20022</td>
<td>800</td>
<td>4.0</td>
</tr>
<tr>
<td>7</td>
<td>16663</td>
<td>800</td>
<td>4.8</td>
</tr>
<tr>
<td>8</td>
<td>20837</td>
<td>800</td>
<td>3.8</td>
</tr>
<tr>
<td>9</td>
<td>15996</td>
<td>800</td>
<td>5.0</td>
</tr>
<tr>
<td>10</td>
<td>20535</td>
<td>1100</td>
<td>5.4</td>
</tr>
<tr>
<td>11</td>
<td>14645</td>
<td>850</td>
<td>5.8</td>
</tr>
<tr>
<td>12</td>
<td>13933</td>
<td>700</td>
<td>5.0</td>
</tr>
</tbody>
</table>
For the data shown, the annual generation of solvent waste is approximately 5 percent of the volume of paint produced. The excellent data would allow some analysis of the trends in waste production. Points to note are that the waste percentage varies significantly by month, and that there may be a seasonal trend in waste production.

Solid wastes generated include spent filters, paint contaminated sand from sand mills, empty paint cans with dried paint residues, and other paint bearing materials such as rags. Data on quantities of solid waste generated were not available. Solid wastes are currently disposed in a general purpose landfill.
Plant P3

Plant P3, a manufacturer of construction equipment, was visited as a pretest site in March of 1991. At this facility, the coatings engineer and the environmental engineer were interviewed.

The plant manufactures tractors for use in mining and construction. Tractor components are fabricated throughout the plant. After a component is manufactured it is painted and sent to the final assembly area. After the complete tractor is assembled the entire vehicle receives final painting. There are three electrostatic liquid spray paint lines for painting the component parts and there is a new electrocoat paint line used for painting spare parts track shoes.

Almost all tractors produced are painted a single color. The exception is when a customer requests a specific paint color. The figure below provides an overview of the painting process at this facility.

![Figure A2 Paint Process at Plant P3](image)

The first step in the painting process is a four stage surface preparation rinse. This process consists of two stages of phosphate rinse followed by two stages of clear water rinse. After the phosphate process, parts are passed through a drying oven. After the parts are dried they are painted using electrostatic spray equipment. The electrostatic spray lines use a high-solids, solvent-borne alkyd paint. Spraying is done manually in down-flow water-wall paint booths. After spray painting, parts are air dried. Transfer efficiency for spray painting is estimated to be between 40 and 60 percent.
The electrocoat (E-coat) line uses a waterborne acrylic. The electrocoat line incorporates an ultra-filtration system to reclaim paint from the parts rinse portion of the line. Transfer efficiency for this system is estimated to be approximately 90 percent. After painting in the electrocoat system, parts are oven cured.

It was estimated that from 8 to 16 gallons of paint are used to paint each tractor. Annual production of tractors is 3,311 per year. Annual paint consumption is estimated at 40,000 gallons. In terms of cost to produce a tractor, the labor and materials for painting are minimal. However, the painting facilities at the plant are extensive and capital costs are considerable. It was not possible, during the pretest visit, to gather data on this portion of painting costs.

The plant coatings engineer indicated that the VOC content of the organic solvent-borne paint used at the plant is 4.3 pounds per gallon or less. No organic solvent is added to the paint, but the paint is heated. When the plant is shut down for an extended period, a layer of solvent is added to paint tanks to cover the paint. This procedure is followed based on their paint manufacturer's recommendation.

The plant maintains a set of performance specifications for its paints, and those used by its parts suppliers. Cost, performance, ease of application, and environmental characteristics all play an equal role in the plant's choice of paint. The purchasing philosophy is to buy the lowest cost paint which meets the plant's specifications. The plant has two primary paint suppliers. The paint formulation used at the plant has remained relatively constant in recent years. However, about five years ago the plant eliminated all paints containing lead and chrome.

The coatings engineer at the plant did not expect that powder coating technology could be used for most of the component parts. He indicated that because most of the parts are heavy castings, a good deal of time would be spent heating and cooling the parts.

Paint related wastes generated at this facility include; organic solvents from equipment cleaning, water with paint solids from paint spray booths, paints which have exceeded shelf life, left-over paint, spent filters, empty paint containers, and other miscellaneous paint bearing materials.

Annual generation of waste solvents used for cleaning in painting operations was 2,970 gallons in 1990. This figure includes maintenance painting and traffic marking as well as production painting. The estimated solvent usage (xylene) for cleaning equipment in production operations is between 400 and 600 gallons per year. This would seem to be quite low for the size of the operation, but is due in part to the use of mostly one color paint. Virgin solvents are used for cleaning.

Left-over paint is generated primarily as a result of changes in customer orders. A customer may require a custom color paint and then reduce the overall tractor order or change their requirements from two coats to one coat. The plant goes to great lengths to avoid disposing of left-over paints. Usually a buyer is sought for the paint among other divisions of the company or its suppliers. Waste paints (not recovered) from all operations were 2,750 gallons in 1990. Waste paints and waste solvents are sent to a solvent waste hauler.
Wastewater generated in surface preparation is treated in-house. The coatings engineer stated that sludges generated in the water-wall paint booths are being recycled through a proprietary process.

Generation of paint bearing solid waste sent to landfills is estimated to be 750 cubic yards per year.

There are a number of waste minimization efforts on-going at the plant. Perhaps the most significant of these is the process being implemented to reclaim paint from spray booth water. This process is being patented by the plant and so could not be discussed in detail during the pretest site visit.
APPENDIX B - SITE VISIT QUESTIONNAIRE

1 General Information for All Sites

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Name</td>
<td></td>
</tr>
<tr>
<td>Division</td>
<td></td>
</tr>
<tr>
<td>Street Address</td>
<td></td>
</tr>
<tr>
<td>City/State/Zip</td>
<td></td>
</tr>
<tr>
<td>Name of Contact</td>
<td></td>
</tr>
<tr>
<td>Title/Position</td>
<td></td>
</tr>
<tr>
<td>Telephone Number</td>
<td></td>
</tr>
<tr>
<td>Type of Business</td>
<td></td>
</tr>
<tr>
<td>SIC Code</td>
<td></td>
</tr>
<tr>
<td>Number of Employees</td>
<td></td>
</tr>
<tr>
<td>Production/Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Painting Operations</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td></td>
</tr>
<tr>
<td>Environmental Staff</td>
<td></td>
</tr>
<tr>
<td>Annual Gross Sales (Units)</td>
<td></td>
</tr>
<tr>
<td>For Year Ending 19__</td>
<td>106</td>
</tr>
</tbody>
</table>
2 Questions for Paint Manufacturers

I. Types of paint

1. What types of paint do you manufacture? How much of each?
   a. Organic solvent borne
   b. Water borne
   c. Powder

2. What are the trade names for these paints?

3. What information can you provide on the formulations of these paints?
   a. Do any formulations contain heavy metal pigments or additives?
   b. Are any of the formulations particularly toxic?
   c. Has the proportion of water-borne to solvent-borne paints manufactured changed over time, if so how?

4. Can you provide MSDS sheets?

5. What industries are the primary customers for your paint products?

6. How are your paints packaged? (Cans, toters, etc.) Typical sizes?

7. Are any of your paints formulated to reduce VOCs or otherwise reduce impact on the environment? Which paints?

8. Are any of your paints formulated to reduce waste either in manufacture or application?

9. Are your paints best suited for any particular application technique? Which paints? Which techniques?

10. Are any of your paints custom manufactured to meet specifications of a particular customer?
II. How paints are manufactured

1. Please provide a simple flow chart of your paint manufacturing process. Use the reverse side of this form if necessary, or attach additional sheets.

2. What types of equipment are used in your manufacturing process? Can you provide some idea of the age of your equipment and its initial cost?
   a. Grinding mills (number, type, manufacturer)
   b. Mixers (number, type, manufacturer)
   c. Storage/holding tanks
   d. Other equipment

3. How many people do you employ in manufacturing paint? Do they receive any specialized training? Who performs clean-up, manufacturing staff or maintenance personnel?

4. What are the raw materials for each of your paint products?

5. What processes do you use in the manufacture of your paints? How do these processes vary from one paint type to the next?
III. Waste Generation in the Manufacture of Paint

1. What types of waste do you generate and how much of each?

   a. VOCs (other air toxics, particulate etc.)

   b. Liquid wastes
      i. organic solvents
      ii. aqueous wastes
      iii. waste paint

   c. Solid wastes
      i. spent filters
      ii. other paint bearing solids

2. What are the primary causes of waste in your operations?

   a. evaporation of solvents
   b. equipment cleaning (describe methods used)
   c. off-spec. paint
   d. spills
   e. other

3. How do the waste types and quantities vary by paint type?

<table>
<thead>
<tr>
<th>Paint Type</th>
<th>Waste(s)</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

109
4. How often are waste streams assessed? What personnel are involved in waste assessment?

5. What cost impacts do wastes have on your operations?
   a. materials
   b. energy
   c. labor
   d. other (waste management and disposal, capital expenditures, etc.)

6. Do you believe the current trends in paint formulation make it easier, or more difficult, to control waste in the paint manufacturing process?

7. Are you aware of the New Clean Air Act Requirements? Do you have Air Permit(s)?
IV. Waste Reduction Methods

1. Do you have a waste reduction plan for your facility?

2. What methods have you tried to reduce wastes?

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Waste Minimization Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Equipment cleaning waste</td>
<td>Use mechanical wipers on mix tanks</td>
</tr>
<tr>
<td></td>
<td>Use high pressure wash systems</td>
</tr>
<tr>
<td></td>
<td>Install teflon liners on mix tanks</td>
</tr>
<tr>
<td></td>
<td>Use foam/plastic pigs to clean lines</td>
</tr>
<tr>
<td></td>
<td>Reuse equipment cleaning wastes</td>
</tr>
<tr>
<td></td>
<td>Schedule production to minimize cleaning</td>
</tr>
<tr>
<td></td>
<td>Clean equipment immediately</td>
</tr>
<tr>
<td></td>
<td>Use countercurrent rinse methods</td>
</tr>
<tr>
<td></td>
<td>Use alternate cleaning agents</td>
</tr>
<tr>
<td></td>
<td>Increase spent rinse settling time</td>
</tr>
<tr>
<td></td>
<td>Use de-emulsifiers on spent rinses</td>
</tr>
<tr>
<td>b. Spills and off-spec. paint</td>
<td>Increase use of automation</td>
</tr>
<tr>
<td></td>
<td>Use appropriate clean-up methods</td>
</tr>
<tr>
<td></td>
<td>Recycle back into process</td>
</tr>
<tr>
<td></td>
<td>Implement better operating procedures</td>
</tr>
<tr>
<td>c. Leftover inorganic</td>
<td>Use water soluble bags and liners</td>
</tr>
<tr>
<td>pigment in bags and packages</td>
<td>Use recyclable/lined/dedicated containers</td>
</tr>
<tr>
<td>d. Air emissions including</td>
<td>Modify bulk storage tanks</td>
</tr>
<tr>
<td>pigment dust</td>
<td>Use paste pigments</td>
</tr>
<tr>
<td></td>
<td>Install dedicated baghouse systems</td>
</tr>
<tr>
<td></td>
<td>Reduce usage of organic solvents</td>
</tr>
<tr>
<td>e. Filter cartridges</td>
<td>Improve pigment dispersion</td>
</tr>
<tr>
<td></td>
<td>Use bag or metal mesh filters</td>
</tr>
<tr>
<td>f. Obsolete products and customer</td>
<td>Blend into new products</td>
</tr>
<tr>
<td>returns</td>
<td>g. General</td>
</tr>
</tbody>
</table>
3. Have you integrated your quality control programs with waste reduction?

4. What methods of waste reduction have been successful for you?

5. What methods of waste reduction have been unsuccessful? Why?, what lessons were learned? (Technical limitations, personnel limitations, etc)

6. What is your organization’s overall approach to waste reduction?
   a. Employee incentives
   b. Waste management accounting
   c. Identify waste management responsibility
   d. Who are waste management decision makers

7. What are your sources of information on waste reduction technologies? (trade shows, magazine articles, training courses, etc.)

8. What obstacles have you encountered in your efforts to reduce waste in your paint manufacturing operation?

V. Paint Related Waste Management

1. How do you manage (dispose, treat, recycle) the wastes which are generated in your paint manufacturing operation?
   a. VOCs (recapture, incinerate, etc.)
   b. Organic solvent liquids (recycle, incinerate, fuel blending)
   c. Aqueous wastes (dedicated treatment facilities, de-water, etc.)
   d. Solid wastes (municipal landfill, special waste landfill)

2. What costs are associated with these waste management activities?

3. Is there anything the State can do to help you reduce the volume and/or toxicity of paint related waste generated at your facility. (Not just compliance assistance)
3 Questions for Users of Paint

I. Description of Operations

1. What kind of product (or service) do you produce? If applicable, please provide a simple flow diagram indicating where painting is a portion of your process or service. Try to indicate where paint related waste generation occurs.

2. How do you use paint in your manufacturing (or service) operations?
   a. What kind of surface preparation do you perform as part of your painting operations?
   b. What kind of application techniques do you use in your painting operations?
   c. Do you routinely calculate paint transfer efficiency?
   d. How much paint do you use for each product (or service)?
   e. How much does the cost of paint influence the cost of your product (or service)?
   f. Which is greater, the cost of paint, or the cost to apply it?
   g. What percentage of your total costs are paint related?
3. How many people do you employ in painting operations? Do they receive any specialized training? Who performs clean-up, manufacturing staff or maintenance personnel?

4. What kinds of paint do you use?
   
a. Do you have a set of specifications for the paints used in your operations? If so, what are the specifications?

b. What types of thinners do you use? Amounts?

c. What factors were most important in developing your paint specifications? (cost, performance, application technique, environmental concerns etc.)

d. Is the paint formulation you use essential to the quality of your product (or service)?

e. Have you had to switch paint types due to environmental regulations or concerns? If so, what type of paint did you previously use?
II Waste Generation in Painting Operations

1. How much waste do you generate in your painting operations?
   
   a. What types of waste do you generate and how much of each?
      
      i. VOCs (air toxics, particulate, etc.)
      ii. organic solvents
      iii. aqueous wastes (pretreatment rinses, post-paint rinse, spray booths, etc)
      iv. solid wastes (empty paint containers, filters, masking, etc.)

2. Where do you generate more waste?
   
   a. in surface preparation
   b. the actual painting operation (transfer efficiency)
   c. VOCs released in paint curing
   d. equipment clean-up
   e. other (spills, rework, etc.)

3. How do the waste types and quantities vary by paint type and application technique?

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<tr>
<th>Paint Type</th>
<th>Waste(s)</th>
<th>Quantity</th>
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</table>
4. How often are waste streams assessed? What personnel are involved in waste assessment?

5. What are the primary causes of waste in your painting operations?

6. What cost impacts do wastes have on your operations?
   a. materials
   b. energy
   c. labor
   d. other (waste management and disposal, capital expenditures, etc.)

7. Do you believe the current trends in paint formulation make it easier, or more difficult, to control waste in your painting process?

8. Are you aware of the New Clean Air Act Requirements? Do you have Air Permit(s)?
III. Waste Reduction Methods

1. Do you have a waste reduction plan for your facility?

2. What methods have you tried to reduce wastes?
   a. What were the motivations for waste reduction?
   b. What costs/savings were associated with reducing paint related wastes?
   c. Have you switched paints as part of your waste reduction efforts?

3. Have you integrated your quality control programs with waste reduction?

4. What methods of waste reduction have been successful for you?

5. What methods of waste reduction have been unsuccessful? Why?, what lessons were learned? (Technical limitations, personnel limitations, etc)

6. What is your organization's overall approach to waste reduction?
   a. Employee incentives
   b. Waste management accounting
   c. Identify waste management responsibility
   d. Who are waste management decision makers

7. What are your sources of information on waste reduction technologies? (trade shows, magazine articles, training courses, etc.)

8. What obstacles have you encountered in your efforts to reduce waste in your painting operation?
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   b. Organic solvent liquids (recycle, incinerate, fuel blending)
   
   c. Aqueous wastes (dedicated treatment facilities, de-water, etc.)
   
   d. Solid wastes (municipal landfill, special waste landfill)

2. What costs are associated with these waste management activities?

3. Is there anything the State can do to help you reduce the volume and/or toxicity of paint related waste generated at your facility. (Not just compliance assistance)