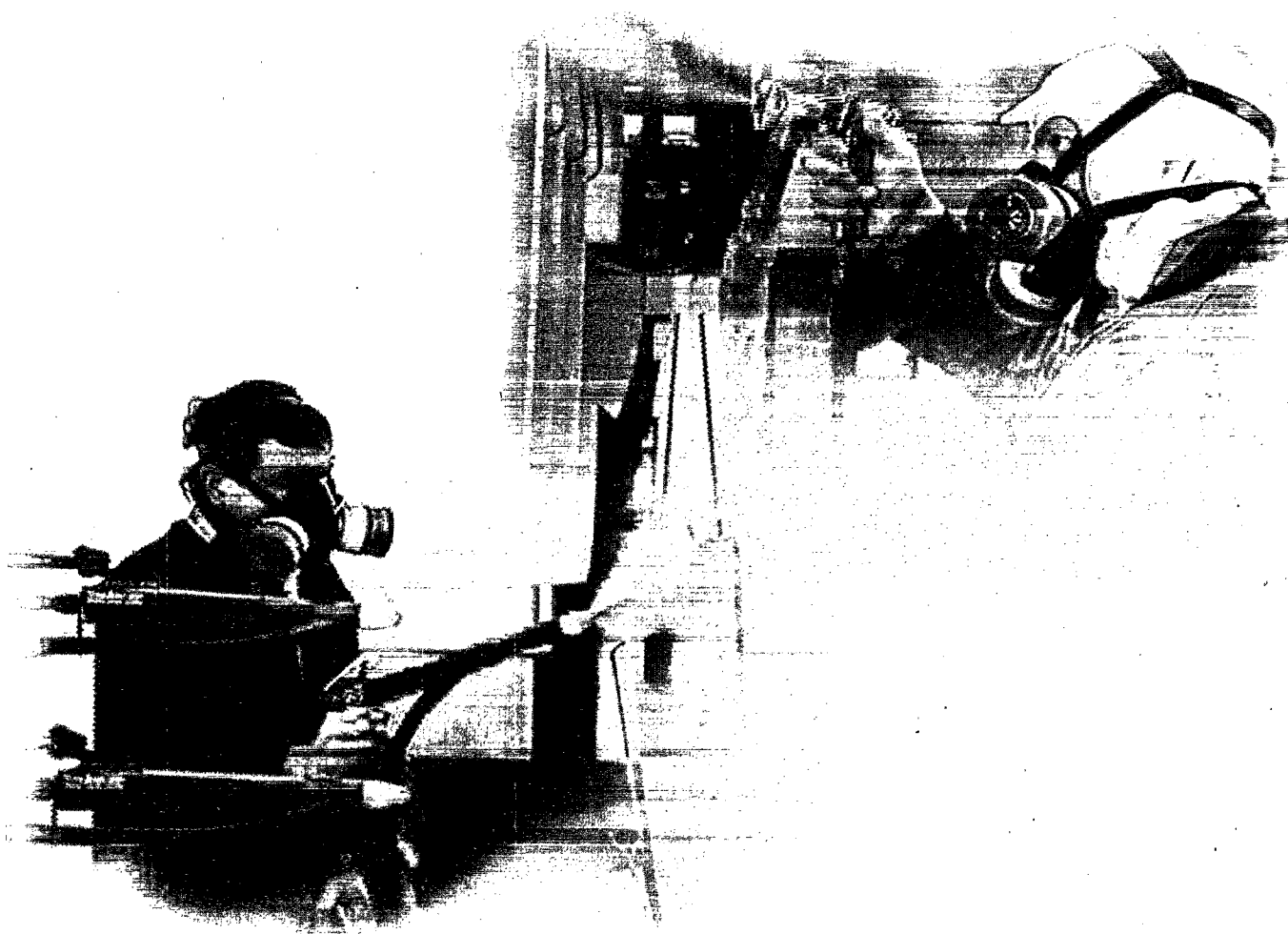
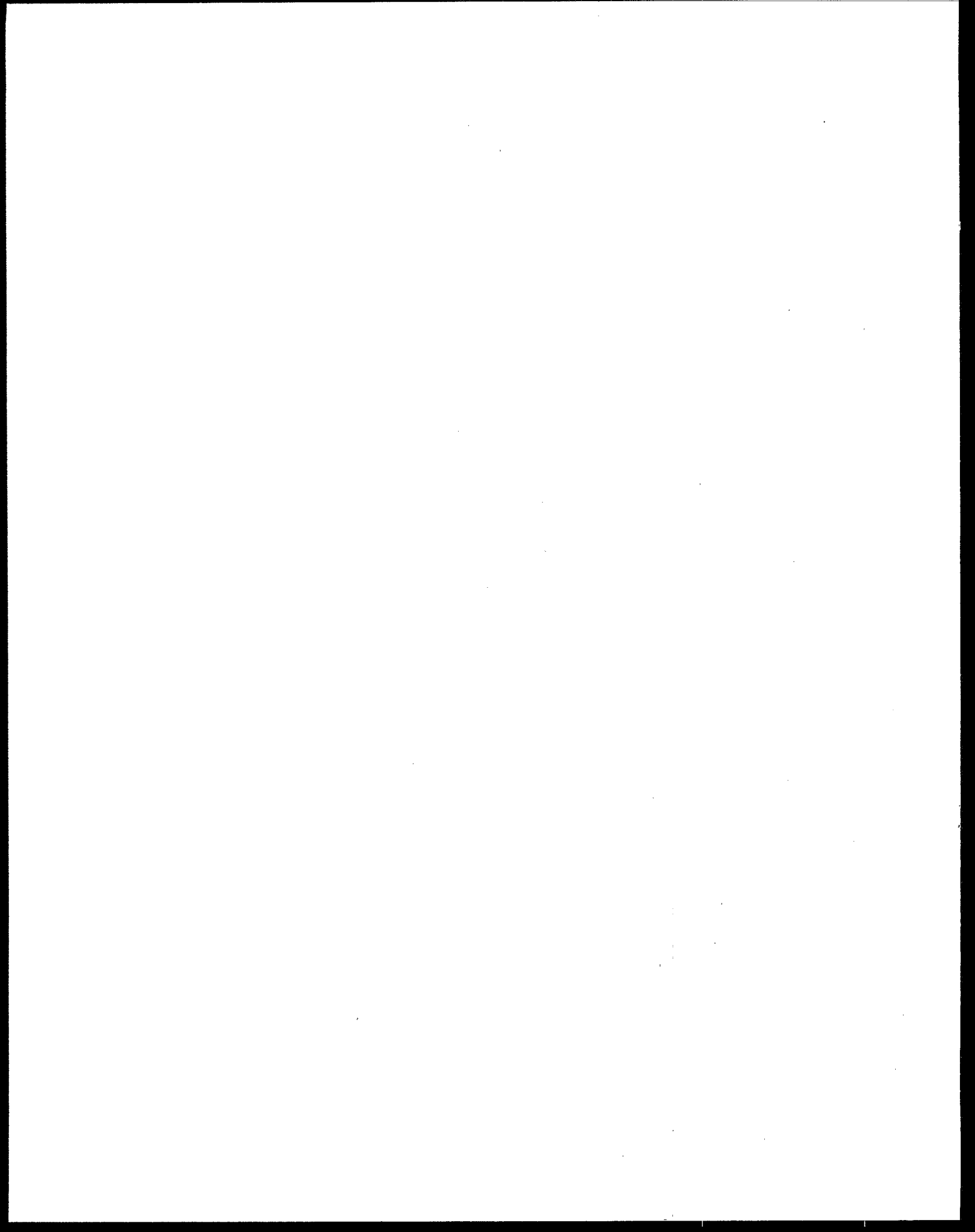




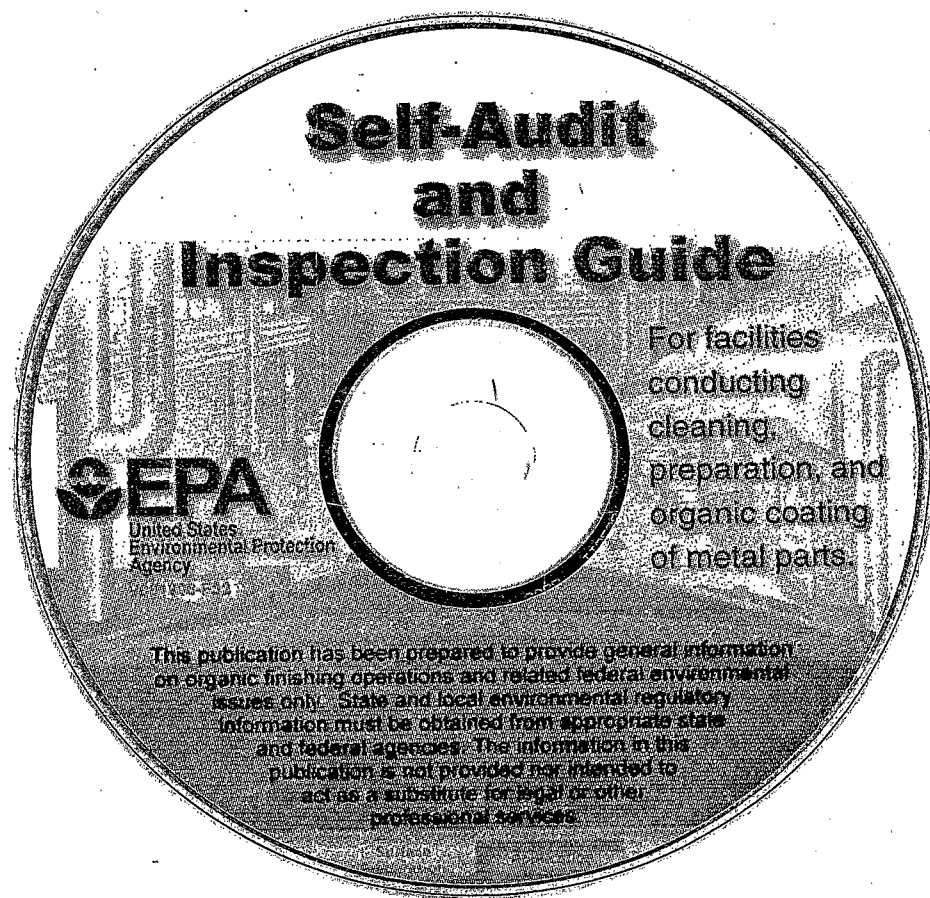
Self-Audit And Inspection Guide For Facilities Conducting Cleaning, Preparation, And Organic Coating Of Metal Parts





Self-Audit & Inspection Guide

For Facilities Conducting Cleaning, Preparation,
and Organic Coating of Metal Parts



EPA United States
Environmental Protection Agency

DISCLAIMER

This publication has been prepared to provide general information on organic finishing operations and related federal environmental issues only. State and local environmental regulatory information must be obtained from appropriate state and local regulatory agencies. The information in this publication is not provided nor intended to act as a substitute for legal or other professional services.

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Foreword

Environmental auditors are charged with inspecting manufacturing facilities in a wide variety of industries to ensure that the proper permits are on hand, record keeping is complete and accurate, monitoring devices are in working order, and regulatory requirements are being followed. Although the auditors may be well versed in statutes regarding pollutant releases to the air, water, and land, their knowledge of facility technology may be limited. This is no surprise considering the wide array of operations and equipment configurations typically found in one facility in order to produce a single finished product. Likewise, facility engineers and workers are charged with maintaining facility operations to ensure high productivity and quality workmanship. They are trained in the proper operation of machinery, but may not be aware of environmental issues surrounding production. This, too, is understandable in light of the many environmental regulations and policies. Individuals unfamiliar with either the industry or the environmental requirements may find it difficult to associate the day-to-day processes of a facility with a specific federal, state, or local environmental requirement. Recognition of the need to bridge the gap between industry operations and environmental issues led to the creation of this Self-Audit and Inspection Guide.

The Self-Audit and Inspection Guide project is sponsored by the United States Environmental Protection Agency (EPA). The guide was developed by the National Defense Center for Environmental Excellence (NDCEE). The Self-Audit and Inspection Guide consists of an audio-visual tool on a CD-ROM and this accompanying written documentation. The multimedia tool utilizes video, photography, animation, graphics, and text to communicate the relationship between technical and environmental information within an industry. The audio-visual tool and written guide identify conventional process steps, associated equipment, potential point source releases or waste generation activities, and federal regulatory requirements only. State and local environmental regulatory requirements must be obtained from appropriate state and local environmental agencies. This tool can be used in a classroom setting or as a self-guided learning tool.

This Self-Audit and Inspection Guide is intended for individuals working in facilities conducting organic finishing (painting) of metal parts. This tool will focus on the conventional and emerging industrial processes that clean, prepare, and apply organic coatings to metal parts. The target audience includes EPA and state inspectors responsible for inspecting conventional organic finishing process activities. The guide will also benefit industry personnel who are responsible for compliance monitoring and assurance in identifying links between the production process and environmental regulatory requirements. The tool will provide an inside look at organic finishing lines so inspectors will recognize the operations and production processes. The Self-Audit and Inspection Guide will assist internal and external auditors in identifying activities and requirements necessary to complete an environmental audit of production processes, equipment, and management systems.

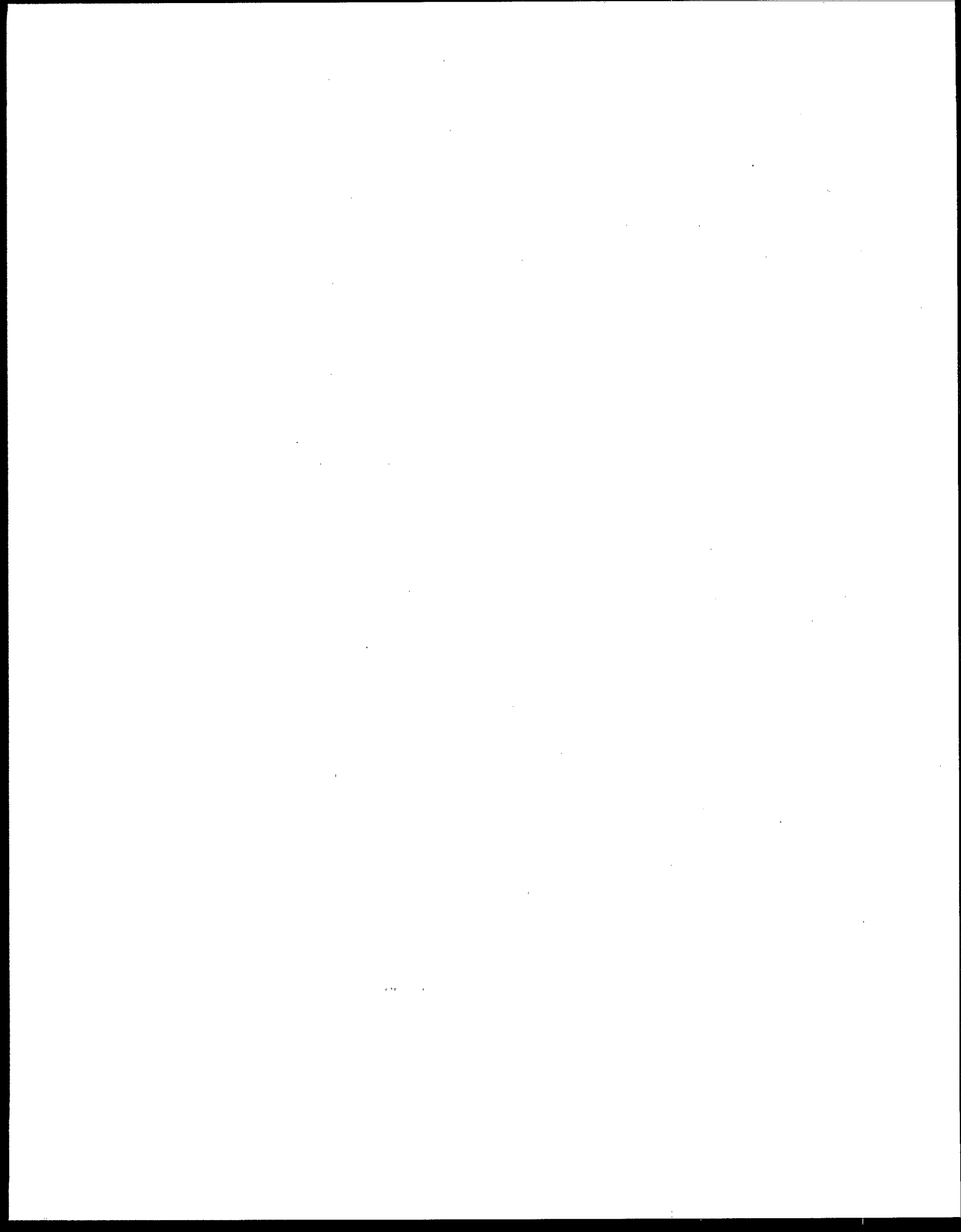
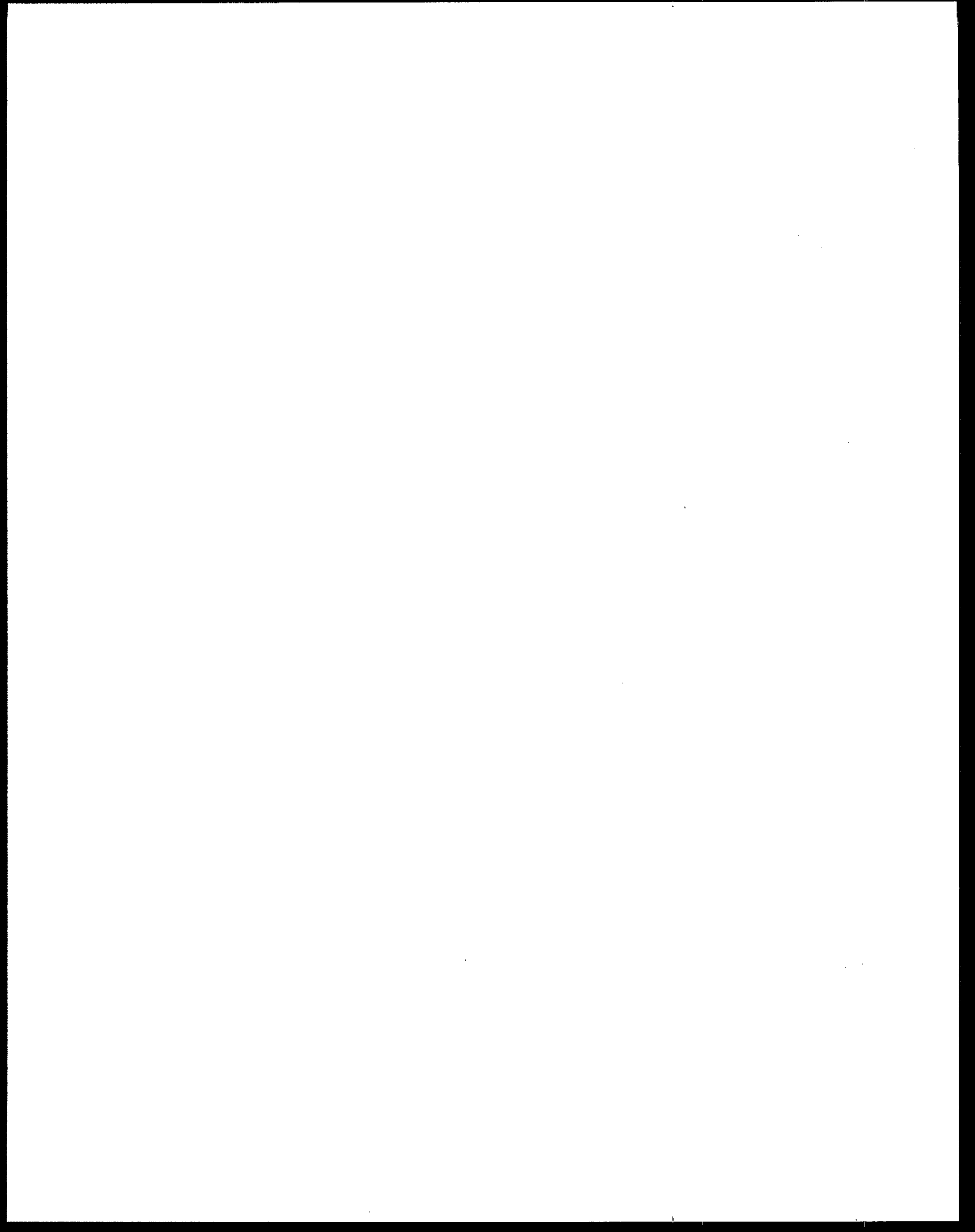


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USING THE SELF-AUDIT AND INSPECTION GUIDE

The Self-Audit and Inspection Guide consists of technical and environmental information that assists personnel linking the two topics. The information is divided into categories representing the major components or process stages that must be considered in the industry to create a final product. Within each category are the conventional and emerging technologies used to complete a task. Using the guide will provide external and internal auditors with the knowledge they need to properly perform an environmental audit of a facility.

Technical and Environmental Information

The technical information includes a description of each individual technology. The equipment used in each technology and the general operation of the process are described. The advantages and disadvantages of the technology, such as restrictions on part configuration or efficiency limitations are discussed as well.

The environmental information is divided into four categories: regulatory requirements, common causes of violations, sources of pollution, and pollution prevention alternatives. The four categories are highly dependent on one another, but each covers different issues that are valuable.

- ◆ The regulatory requirements section discusses Federal regulations specific to the industry and its common pollutants. Statutes such as the Clean Air Act, Clean Water Act and Resource Conservation and Recovery Act are covered.
- ◆ The section on common causes of violations presents areas in which a facility may be breaching the regulatory requirements and will aid the facility in avoiding these problems.
- ◆ The section on sources of pollution identifies pollutant releases to air, water, and land from various operations in a typical facility.
- ◆ The pollution prevention alternative section covers changes to the technology or operating procedures that would reduce or eliminate pollutant releases. Changes may include preventative maintenance, material substitution, process or equipment alteration, production planning, recycling, or waste treatment options.

CD-ROM and Written Guide

The Self-Audit and Inspection Guide includes a multimedia CD-ROM and this written documentation. While the CD-ROM and written guide are intended to work together, each provides valuable information and can be used independently of each other. The CD-ROM puts the user in a virtual factory where a video of a technology in operation may be viewed. The user can navigate to whichever category of operations and technology he chooses, quickly and easily. Technical and environmental information is concise but illustrative. The written guide mirrors the CD-ROM in content, but provides more detail. Each technology and its related environmental issues are covered in more depth. The guide provides a general overview of the industry as a whole, as well as a description of each technical category. The

written guide also includes additional references on the industry, a glossary of industry terms, full part and section titles from the Code of Federal Regulations (CFR), and additional sources for pollution prevention opportunities.

A Guide for Organic Finishing Industries

This Self-Audit and Inspection Guide covers facilities conducting cleaning, preparation, and organic finishing of metal parts. The first chapter provides an overview of an entire organic finishing facility and the main components of producing a final product.

The next four chapters discuss the main components of an organic finishing facility and the technologies of each. Chapter two covers coating materials including solvent-based materials, waterborne materials, and powder coating materials. Chapter three discusses surface preparation technologies. First, coating removal using chemical or mechanical methods is covered, followed by carbon dioxide blasting and cleaning. Second, cleaning techniques using organic solvent or aqueous solutions are explained. Drying is the final surface preparation step reviewed. Chapter four covers application methods for the different coating materials and various part configurations. Both traditional and electrostatic spraying methods are discussed. Other traditional application technologies included are dip, flow, and curtain coating methods and roll or coil coating techniques. Newer technologies including electrocoating and powder coating methods are also explained. The fifth chapter discusses the two major curing methods – conventional oven curing and infrared curing systems. Chapters two through five also include the environmental information specific to each category.

The final chapter presents an auditing preparation guide. The guide includes items to review or investigate in preparation for an audit and is divided into the areas of air, water, solid waste, and hazardous waste. References consulted for developing the Self-Audit and Inspection Guide as well as those that provide developing information in the organic finishing field are provided at the end. Also included in the written guide is a glossary of common terms from the organic finishing industry and environmental subjects.

CHAPTER ONE

ORGANIC FINISHING OF METALS

This Self-Audit and Inspection Guide focuses on facilities conducting organic finishing of metal products. Organic finishing, or painting, involves the application of non-metal materials such as paint, clear films, or varnishes. The resulting finish adds protection and/or decoration to the workpiece during subsequent manufacturing steps or during use. While some smaller facilities may perform only organic finishing of metals, larger plants may include several additional manufacturing stages related to producing a finished product. For example, an automotive factory performs organic finishing, but also performs the prior steps of metal stamping and forming, and final steps of assembling the painted frame with the interior items.

In a typical organic finishing line, three major processes are performed. First, surface preparation of the part removes old coating material, oils and dirt. Second, the coating material is applied. Third, the coating material is cured to create the final finish. Although not a "process" by definition, the coating material also performs important functions in order to create the final coating. Performance of the coating material in the application and curing stages helps achieve the desired physical, chemical, and aesthetic properties of the finish.

While a facility performing organic coating may have a production line including each of the three processes, the specific type used at each stage can vary widely. Several different methods have proven to be successful for preparing surfaces, for applying coating materials, and for curing coating films. The same is true for coating materials. Each brings its own advantages and disadvantages to the production line. Because the different stages are dependent on one another, they must be considered as a system rather than as individual processes when designing the manufacturing line or examining its environmental impacts.

Developing an organic finishing line is equivalent to solving a problem with multiple variables. In addition to the relationships between the

three process steps and the coating material choice, the object being coated must be considered. The substrate - the surface material to which the coating will be applied, will impact the choice of technologies. Aluminum substrates are sensitive to water, and may be adversely affected by aqueous cleaning or waterborne paints. The part geometry must also be considered. Curves, bends, corners, and recesses may be challenging to coat with some techniques. A rounded part may not get a uniform coat with a stationary spray system, while a small part may be difficult to attach to an overhead trolley system. Finally, the end use and the environmental conditions under which it will be used must be taken into account. Harsh environments, such as those encountered by marine vessels, may corrode coating films if not cured at the proper temperature.

The part description and choice of process technologies all contribute to the engineering of an organic finishing system that will provide the required coating characteristics. However, these items are not sufficient determinants for designing and operating a facility. A facility must also consider the environmental regulatory domain to ensure the system complies with federal, state and local laws. Several parts of the Code of Federal Regulations (CFR) cover operations of the metal finishing industry and finishing processes specifically. The restrictions on harmful air emissions, water releases, and solid waste disposal contribute to the operating costs of a facility. Beyond regulatory compliance, facilities must be proactive against waste generation and pollution and emphasize increased efficiency in the use of raw materials and natural resources. Identifying the sources of pollution and finding opportunities to prevent pollution can greatly improve a facility's operations. Thus, all of these technical and environmental issues should be considered when deciding which type of coating material, surface preparation, application method, and curing method is best for a particular facility.

The following chapters detail the individual operations of the organic finishing industry. The guide includes chapters on four categories: coating materials, surface preparation methods, application methods, and curing methods. Each category represents the major components or process stages that must be considered within an organic finishing system. Within each category are the various technologies available. Table 1-1 gives the various technologies discussed in each chapter. The written guide provides a description of each technology, including the equipment involved, operation of the process, and advantages and disadvantages of the technology. With each technology is an overview of specific regulations that apply, and unique sources of pollution and pollution prevention opportunities that exist. Each chapter also provides environmental issues for the process, regardless of the type of technology used.

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Table 1-1: Organic Finishing Stages and Available Technologies

CATEGORIES	TECHNOLOGIES
Coating Materials	Solvent-based - Traditional, High solids Waterborne Powder
Surface Preparation Methods	Chemical Coatings Removal Mechanical Coatings Removal Carbon Dioxide Blasting Organic Solvent Cleaning Aqueous Cleaning Drying
Application Methods	Spraying – Air-atomized, Airless, Air-assisted Airless, High-volume Low-pressure Electrostatic Spraying – Air-atomized, Airless, Air-assisted Airless, Rotary bells & disks Electrocoating Roll and Coil Dip, Flow, and Curtain Powder Coat Methods - Electrostatic spraying, Fluidized bed, Flocking, Flame spraying
Curing Methods	Convection Oven Infrared Radiation

CHAPTER TWO

COATING MATERIALS

Coating materials are applied in a thin film to provide protection or decoration to a surface. Most films are thin in comparison to the workpiece. In order to achieve the desired characteristics from the thin film, the coating material formulation must be carefully considered in relation to the part characteristics, surface preparation, application technique and curing method. The correct combination of components and process steps can lead to a film that provides long-lasting beauty and defense against the elements.

Coatings can be formulated from a wide variety of chemicals and materials or a combination of different chemicals. Each component in the formulation serves a specific function. Four common components, shown in Table 2-1, are pigments, additives, binders and the carrier fluid or solvent.

Table 2-1: Common Components of Coating Materials

COMPONENT	CHEMISTRY	FUNCTION
Pigments	Insoluble solids	Commonly a colorant, used for aesthetic quality
Binders	Polymers, Resins	Adhesive between solids and surface, create the coating film
Additives	Varies	Varies, can include stabilizers, curing agents, flow agents
Carrier Fluid	Organic solvent, water	Liquid portion, means by which to apply paint

♦ **Pigments**

Pigments are defined as any insoluble solid in coating materials. Pigments are typically the colorant portion of a coating material, but can also perform other functions. Some pigments provide corrosion protection, stability in ultraviolet (UV) light, or protection from mold, mildew or bacteria. Others can be used for their conductive ability, texture, or metallic or pearlescent appearance.

♦ **Binders**

Binders primarily function as an adhesive to the substrate. Binders are polymer resin systems with varying molecular weights. The molecules in the binder crosslink during the curing stage to improve strength and create the thin film. The type of binder usually gives the paint formulation its name. Common binders are acrylics, epoxies, polyesters, and urethanes. The viscosity of the paint is often attributed to the binders contained in the coating formulation. Coating viscosity must be considered when choosing certain application techniques.

♦ **Additives**

Additives are usually low molecular weight chemicals in coating formulations that allow coatings to perform specific functions but do not contribute to color. Non-pigment additives include stabilizers to block attacks of ultraviolet light or heat, curing additives to speed up the crosslinking reaction, co-solvents to increase viscosity, or plasticizers to improve uniform coating.

♦ **Carrier Fluid**

The carrier fluid is typically a liquid such as an organic solvent or water. The carrier fluid allows the coating material to flow and be applied by methods such as spraying and dipping. This component may be in the coating formulation before application, but evaporates afterwards to allow the solid materials to immobilize and form the thin protective film. Despite its temporary presence in the coating material, the solvent plays a major role in how well the film will perform. Powder coatings have no carrier fluid; they consist only of the other three components.

While the solids portion adheres to the workpiece, the solvent component of coating materials evaporates and causes the most environmental concern. The solvent materials are mostly volatile organic compounds (VOCs) that may contribute to the creation of ozone (smog) in the lower atmosphere and may be toxic to human health. Some solvents may also be classified as hazardous air pollutants (HAPs). Federal environmental statutes now regulate these VOCs and HAPs. One way organic finishing facilities have responded to these regulations is by creating coatings with lower solvent content.

Coating formulations vary widely, with different types and amounts of pigments, binders, additives, and carrier fluids. The differences in coating formulations provide film characteristics specifically set for the part and its end-use. Often, one type of coating cannot be formulated to provide all of the desired properties. Several layers of different coating material may be applied to a surface to form a coating film that will thoroughly protect the part. The first coat is typically called the primer, or undercoat, and the final layers are called topcoats. Regardless of the coating formulation or number of layers applied, proper part preparation, application techniques, and curing processes are necessary for the desired coating characteristics to be achieved.

Four common types of coating materials are solvent-based coatings, high-solids coatings, waterborne coatings, and powder coatings. The names are descriptive of the main type of carrier fluid present in the coating. The chemical nature, coating characteristics and environmental issues of these four coating materials are described in this chapter.

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Section 1

Solvent-Based Coatings

Solvent-based coating materials have been the traditional coating used for many years in all types of organic finishing industries, such as automotive, aerospace, appliance, and furniture industries. In solvent-based coatings, the final coating offers corrosion resistance, chemical resistance, and is very durable.

♦ High-Solvent Coatings

Solvent-based coatings use organic solvents as the carrier fluid for the pigments, binders and other additives. The organic solvent content of coatings aids in the proper flow of the solids to adequately cover the workpiece. The solvents usually evaporate once the part is cured and dried, leaving behind a film to coalesce, crosslink, and adhere to the substrate. Solvent-based coating materials are very versatile; they provide good coverage and high quality coatings using a variety of application methods.

Typically, solvent-based coatings are composed of 60% to 90% organic solvents and 10% to 40% solids. The organic solvents used in high solvent coating materials are typically low molecular weight hydrocarbons or oxygenated compounds. The choice of solvent is based on its ability to dissolve the other coating components and hold them in solution, as well as its boiling point, evaporation rate, and flash point. These properties determine operating parameters for the application and curing stages. Other characteristics that are gaining importance are odor and toxicity, which have an influence on worker health and environmental safety.

For best results, parts to be coated with solvent-based coating materials should be clean, oil free, and dry for best results. Solvent-based coatings are typically applied using spray application methods, although liquid flow techniques such as dip or curtain coating may be used. Curing and drying takes place after coating applications to fully evaporate all solvent materials.

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The high-solvent, low-solids content of solvent-based coatings requires the application of larger volumes of material to cover a given surface area. Thus, when using solvent-based coatings, a high volume of organic solvents is released. Because the organic solvents used in many solvent-based coatings formulations are volatile organic compounds or hazardous air pollutants, use of solvent-based coatings is being controlled by environmental agencies. Some facilities using solvent-based coatings may be required to use additional control equipment for application or curing systems. Recovery of the evaporated solvents may be required during application and curing stages to prevent volatile organic compound emissions. While the solvent materials can be recovered and reused, often they are incinerated to convert them back into water and carbon dioxide while recovering the heat.

♦ High-Solids Coatings

An improvement in solvent-based coating formulations is high-solids coatings. High-solids coatings are still solvent-based materials, but contain a higher percentage of non-solvent material. Compared to the 10% to 40% solids content of regular solvent-based paints, high-solids coatings contain 40% to 100% solids, and a smaller portion of the formulation is organic solvents.

The higher solids content increases the viscosity of the material. To get the lower viscosity required by many applications, solvents used in these coatings are typically "strong" solvents, such as alcohol, esters, or ketones. The strong solvents improve the dispersion of the concentrated material and aid in the substrate wetting. If the coating material is still too viscous, operation parameters must be adjusted. Heat can be applied, pressure on the fluid can be increased, or components may be mixed just prior to entering the spray gun.

A high-solids coating finish is similar to that of solvent-based coating materials. Less material is needed, however, to cover the same amount of surface area. As with other lower-solvent coatings, high-solids coatings require proper surface preparation of the workpiece to ensure proper adhesion of the coating. Clean up of high-solids coating materials may be more difficult and require more solvents than solvent-based coatings because of the larger percentage of solids.

Section 2

Waterborne Coatings

Waterborne coatings use water as the primary dispersal medium for the pigments, binders, and other additives. However, waterborne coatings still require some organic solvents to aid in proper flow and coalescence of the paint film. The volume of organic solvents in waterborne paints varies between 5% and 20%. Water makes up about 40% to 60% of waterborne coating formulations. Solid materials make up the remainder, 20% to 50%, about the same percentage as in solvent-based coatings. When applied, the water and solvents evaporate, leaving the pigment bound to the surface of the substrate material.

Waterborne coating materials can offer a finish that provides resistance to corrosion, chemicals, weathering and fouling. Waterborne coatings are available in a wide range of colors, although pastels are more difficult to formulate. Waterborne coatings are used as primers or undercoats for subsequent finishing processes, or as a decorative paint. Newer formulations can be used for a variety of high performance applications.

Parts should be cleaned prior to applying waterborne coatings to remove oils and grease and other contaminants that repel the material, inhibit uniform coating, and cause later coating failures. Common application methods for waterborne coatings include spraying, electrostatic spraying, electrocoating, roller or coil coating, and dip, flow, and curtain coating. Drying and curing of the part is the final step.

One of the disadvantages of waterborne coatings is a shorter shelf life. Due to the lower organic solvent content, stringent part cleanliness is required, and the drying stage is longer and more controlled. In addition, if exposed metal surfaces on application equipment corrode in the presence of water, they may need to be replaced with stainless steel. Switching to waterborne materials from solvent-based coatings, typically, does not require extensive capital expenditures because similar equipment is used to apply both. The lower organic solvent content is one of the major advantages of waterborne coatings. The amount of volatile organic compounds or hazardous air pollutants emitted from waterborne coatings is much lower than with traditional solvent-based coatings.

Section 3

Powder Coatings

Powder coatings are close to 100% pigment and resin solids in dry form. Powder coating materials are solid particles composed of pulverized resins, pigment, modifiers, curing agents, and solid additives. Volatile organics in powder coatings are found only in low concentrations, and only as a result of the manufacturing process. Because of the minimal organic solvent content, powder coatings are gaining popularity in many industries.

Unlike solvent-based or waterborne coatings, powder coatings contain no liquid diluent material to carry the solids. To form the final coating, the solid particles are exposed to heat that melts the particles and allows them to flow together and form a continuous film. When cooled, the thin film hardens and protects the substrate. The resulting coating finish is a high quality, durable, and corrosion resistant film.

Powder coating formulations require different types of resins than liquid formulations to produce coating materials that are solid at storage temperatures, yet capable of melting rapidly to low viscosity when heated. Two basic types of powder coatings are thermosetting and thermoplastic powders.

♦ Thermosetting Powder Coatings

Thermosetting powder coatings are based on polymers that chemically change during the cure stage. When heated, the individual particles crosslink to form bonds and become bigger polymer chains. When cooled, the bonds remain to create the durable coating film. If the coated part is later exposed to heat, the coating is unaffected. Thermosetting resins include acrylics, epoxies, hybrids, polyesters, and urethanes.

♦ Thermoplastic Powder Coatings

Thermoplastic powder coatings are based on polymers that physically change during the cure stage. When heated to the polymer melting temperature, the particles flow together to coat the part surface. But the individual particles do not undergo chemical change or form bonds.

When cooled, the film creates a shell that protects the part. If a coated part is heated to the melting point temperature of the thermoplastic resins, the coating will re-melt. While this is convenient for removing the film, it can create problems if it occurs while the part is in use. Common thermoplastic polymer types include polyethylene, polypropylene, nylon, and polyvinyl chloride.

Prior to powder coating application, parts must be clean and dry. Powder coating materials are very sensitive to the presence of surface contaminants. Application methods include electrostatic spraying, fluidized beds, or flame spraying. Parts can be preheated to help the powder particles adhere to the surface during application. The coating material must be heat cured to completely melt the particles and create the final coating. With curing temperatures up to 450°F, melting temperatures of the substrate must be considered; most metals can be coated with powder coating materials with no problems. The main advantage of powder coating materials is the absence of solvent materials that create harmful air emissions.

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Section 4

Environmental Considerations for Coating Materials

Many of the environmental issues that concern organic finishing facilities focus on the impacts from the coating materials. The coating materials contribute significantly to all forms of pollution from a facility. The components of coating materials evaporate to create air pollution, contaminate water to form wastewater, and or contact other materials to generate solid and hazardous wastes. This pollution is generated mostly during the application and cleanup processes within a facility. This section discusses the regulations that restrict use of certain coating materials, types of pollution that are formed, and pollution prevention alternatives when using and handling coating materials.

Regulatory Requirements

♦ Air Emissions

The Clean Air Act regulates the emission of volatile organic compounds (VOCs) (40 CFR Part 60) and hazardous air pollutants (HAPs), (40 CFR Part 61 and 40 CFR Part 63). Coating materials are the main source for VOCs and HAPs from organic finishing operations. Evaporation of the solvents during application and curing may produce sufficient VOC and HAP emissions to subject an operator to major source requirements and Title V permitting requirements. Specific standards of performance to control emissions from various types of coating operations are found in 40 CFR 60 Standards of Performance for New Stationary Sources. Standards cover the level VOC emissions from coating of metal furniture, automobiles and light duty trucks, large appliances, coil coating, and beverage can coating. VOC emissions are defined as the mass of VOCs emitted per volume of solids applied. Operators should refer to the specifications for their coating to determine if they fall within the regulations.

Powder coating materials have very low or no solvent materials, so the regulations for VOC or HAP emissions are less of a concern. In large operations, VOC or HAP emissions may be released during the cure

stage of powder coating materials. The small, dry powder coating particles may fall under particulate matter regulations in 40 CFR Part 50. The particles can be suspended in exhaust air streams in amounts that would subject an operator to Title V permitting requirements. Facilities that utilize recovery systems avoid this problem.

♦ Wastewater

As part of the Clean Water Act, Effluent Guidelines and Standards for Metal Finishing (40 CFR Part 433) have been established that limit concentrations of heavy metals and toxic organics in wastewater streams. Coating materials often contain components classified as toxic organics, and some may include metals. These materials can enter the liquid waste streams through the use of waterwash spray booths, when cleaning coatings from containers or equipment, or following accidental spills. Actual limits for effluent constituents depend on the size of the operation and the amount of wastewater generated from the facility. If the facility discharges directly to receiving waters, these limits will be established through the facility's National Pollutant Discharge Elimination System (NPDES) permit (40 CFR Part 122). Facilities which are indirect dischargers releasing to a publicly owned treatment work (POTW) must meet limits in the POTW's discharge agreement. Wastewater streams with concentrations exceeding permit limits will require pretreatment prior to discharge to receiving waters or to a publicly owned treatment works. Pretreatment may include separation of liquid wastes to remove solvents and settling or precipitation of solid materials.

♦ Solid and Hazardous Wastes

Under the Resource Conservation and Recovery Act (RCRA), organic finishing facilities are required to manage listed and characteristic hazardous wastes (40 CFR Part 261). Coating materials may contain constituents, such as solvents, listed or characterized as hazardous wastes. Residual coating materials, their containers, and contaminated materials (including rags, masking material, coveralls, filters, and other process materials) may require treatment as hazardous waste depending on their formulation. Hazardous waste management (40 CFR Part 262) includes obtaining permits for the facility in order to generate wastes, meeting accumulation limits for waste storage areas, and manifesting waste containers for off-site disposal. Responsibilities will vary according to the amount of hazardous waste material generated; facilities generating at least 100 kilograms of hazardous waste per month must comply with the hazardous waste generator requirements of 40 CFR Part 262.

Each state and/or region is primarily responsible for the regulation of non-hazardous solid wastes (those not governed by the hazardous waste

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provisions of RCRA). Check with state environmental agencies for specific information or guidance.

◆ **Community Right-to-Know**

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires facilities to notify employees, customers and the surrounding community of certain hazardous chemicals and materials (40 CFR Parts 355 and 370) that are present on-site. Coating materials that contain solvents purchased and stored in sufficient quantities may subject a facility to several EPCRA requirements. Facilities may be required to inform the local emergency planning committee (LEPC) and the state emergency response commission (SERC) of the materials stored on site, to devise emergency response plans for reacting to spills, and to notify authorities of accidental spills and releases (40 CFR Parts 302 and 355). Coating materials stored on-site may also require facilities to submit Material Safety Data Sheets (MSDS) for these materials to state, regional, and local organizations, while disposed volumes of the material may have to be documented on annual Toxic Release Inventory reports (40 CFR Part 372).

Common Causes of Violations

Violations can occur when coating materials are not used properly. Facilities may be using a coating formulation with a high VOC content that exceeds the limits for their type of industry. The VOC and HAP content may be allowed to evaporate and accumulate above limits allowed by Clean Air Act Title V permits. Coating materials can contaminate liquid waste streams also. This contamination may be accidental, such as spilt material mixing with wastewater, or intentional, such as with the use of water wash spray booths or during cleaning activities. Contaminated water streams may contain pollutants in concentrations that exceed the limits established by facility NPDES permits or POTW discharge agreements. In such cases, effluent may not be directly released to water systems or to publicly owned treatment works without pretreatment.

Coating materials remaining on rags, filters, masking papers, and coating containers may be considered hazardous waste. If hazardous, the waste must be properly stored, manifested and disposed according to RCRA standards (40 CFR Part 262). Coating materials may contain substances defined as hazardous chemicals or extremely hazardous substances. Depending on the quantity of material on-site, facilities must have an MSDS for each formulation, maintain records for TRI reporting, and cooperate with local emergency planning committees.

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Sources of Pollution

The components of coating materials that create pollution include the organic solvents. These evaporate to create air pollution in the form of volatile organic compounds or hazardous air pollutants. The components can also contaminate water streams or solid materials that would require additional treatment. Cleaning up coating materials may also require the use of solvents, adding to the overall pollution. Another source of pollution is with the coating material as a whole. Coatings may expire or become contaminated with dirt or other coatings and no longer meet quality standards, thus becoming waste. In addition, coatings that are not used completely in a job and have no use in another job may be considered waste as well. The containers for coating materials, unless they can be returned and refilled by the manufacturer, are waste, too.

Pollution Prevention Opportunities

Pollution prevention in an organic finishing facility starts with the coating materials. Substituting high-solids, waterborne, or powder coating materials for solvent-based coatings can greatly reduce the harmful air emissions from a facility. Compared to traditional solvent-based coatings, other high-solids, waterborne and powder coatings contain much lower amounts of volatile organic compounds. In addition, these materials have higher solids contents which results in a lower volume of material needed for a given surface area. If substitutions cannot be made, other actions can reduce the impact from the solvents.

♦ Materials and Waste Handling and Storage

Material handling procedures are another focus. Enclose or cover containers of coating material when not in use to minimize the release of solvent vapors and lower the possibility of contamination from facility dust and dirt. Restrict traffic in storage areas to reduce spills and accidents. Keep storage and work areas clean so that spills and leaks are more noticeable and reaction time to clean up is reduced. Control the temperature in storage areas to prevent the freezing and heating of coating materials that will spoil them. Segregate non-hazardous coating solids from hazardous solvents and thinners, and label containers to prevent mixing. Separation of the materials reduces the amount of hazardous waste that is produced. Coating material solids can be dried and treated as a solid waste, thus allowing for disposal in a landfill.

♦ Operations and Procedures

NOTES

Proper scheduling and procurement can reduce the amount of residual coating material waste. To reduce residual coatings, buy only as much material as needed to complete the job. Mix remaining light colored coatings into darker colored coatings where possible. Purchase coating materials in the largest containers possible for the volume; since the surface area to volume ratio of the container is lower, less material is left on the inside of the containers to be thrown away. Work with coating vendors to have larger containers returned for refilling. Rotate stock of coatings to use older material first (first in - first out practice). Before discarding expired coatings, test to see if they would still meet quality requirements. Donate or sell old and unwanted coating materials as raw material to others or see if the vendor will take it back.

♦ **Training**

Finally, train employees on safe handling of coating materials and wastes and encourage continuous improvement. Training familiarizes workers with their responsibilities, which reduces spills and accidents.

Section 5

Chapter Summary

Coating materials provide the protective finish for numerous manufactured items. Various formulations are available to meet the needs of almost any requirement, from corrosion protection to aesthetic coloring. The main types of coating materials are solvent-based, high-solids, waterborne, and powder. The general composition of these four coating material types is shown in Figure 2-1. Formulations fall into the categories based on the main carrier fluid of the material.

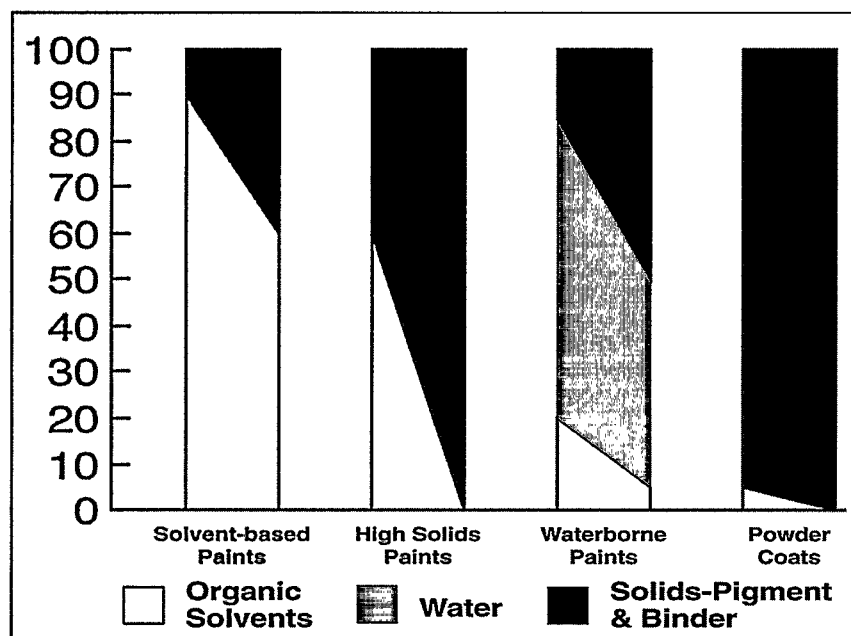


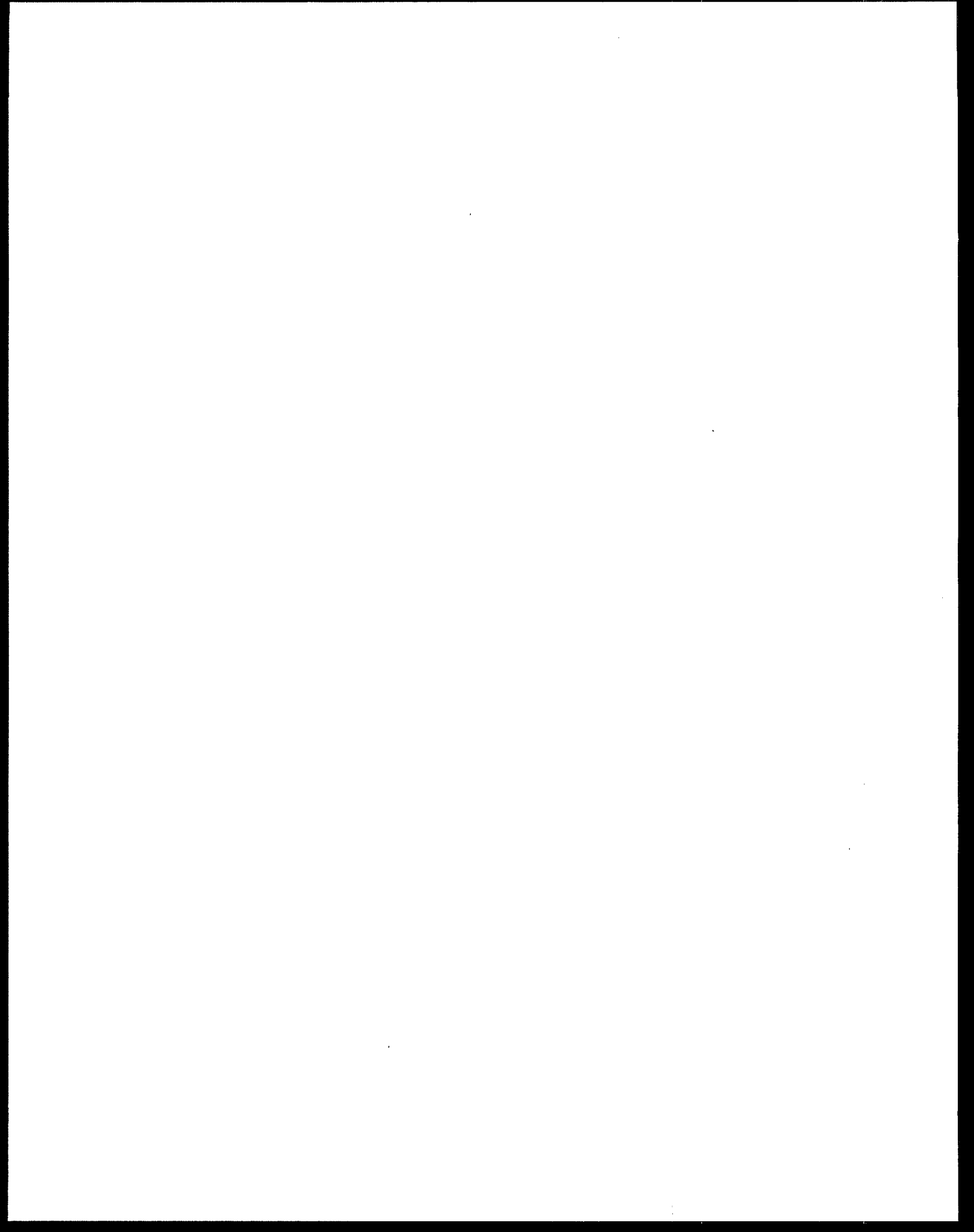
Figure 2-1: Percentage Composition of Coating Materials

Beside the physical and chemical characteristics of the final coating film, organic finishing facilities must consider the environmental impact presented by the various coating materials. The volatile organic compounds and hazardous air pollutants emitted from the coating material creates air pollution. Solvent-based coating materials have much higher levels of these pollutants than waterborne and powder coatings. Additional measures and precautions must be taken within organic finishing facilities when using high-solvent coatings. Equipment

used for applying the coatings must be modified to minimize or capture emissions. Special care is required for handling, storing, and disposing the coating materials. In addition, facilities must protect workers from exposure.

Facilities may reduce the level of air pollutants in two ways. Using less paint during the application stage so that fewer pollutants are released, as discussed in Chapter 4 on application methods. The other way is to use, where possible, coating materials with lower, or no, harmful solvents. Many facilities have opted for the latter, making waterborne and powder coatings common in manufacturing.

NOTES



CHAPTER THREE

SURFACE PREPARATION

Proper preparation of the part surface prior to organic finishing is essential to the performance of the final coating. Improper treatment of the part surface can lead to poor adhesion of the coating material, surface defects, and aesthetic problems. The choice of surface preparation technology used will depend on the part substrate, size and shape, as well as its previous manufacturing steps. Surface preparation includes stripping of previous coatings, removal of contaminants such as grease and oils, and drying. More than one process may be necessary to fully prepare a workpiece for a new organic finish. Regardless, almost all parts will go through a surface preparation step prior to coating.

Old coating material should be completely removed before refinishing. Applying a new coating over previous coatings can hamper its performance, especially if the old coating is flaking or peeling. The new coating will not adhere to the actual part surface but to the old layer of finish and will flake or peel away from the part. Removal of old coatings also provides a flat, even surface so that the new coating will have a uniform thickness. Other coatings or surface damage, such as weld burns, should also be removed. Coatings removal can be completed in several ways, using chemical or mechanical means to prepare the part surface.

Other preparation steps include those where the surface is cleaned and the substrate is activated. Using solvents and water to separate the unwanted materials from the substrate, cleaning removes grease, fingerprints, dirt, and other contaminants that will interfere with the application and curing of the finish. Chemical activation steps promote a chemical reaction on the surface of some metals so that it more readily accepts the coating material. Activation is completed by applying a water-based solution of active ions to the part. These surface preparation techniques are often performed in series with the parts moving from a wash step immediately to a rinse step and then to an activation step.

Drying is often required as a last step, and then the parts move directly to the application process.

Environmental impacts must also be considered when choosing surface preparation methods. The harsh chemicals and cleaners used to remove contaminants can create a large volume of waste liquids. The residual grease, dirt, and coatings must also be disposed. Some of these cleaners and residual material may be classified as hazardous material, adding to the burden on the facility.

Six surface preparation techniques are described in this chapter:

- ♦ Chemical coatings removal,
- ♦ Mechanical coatings removal,
- ♦ Carbon dioxide blasting,
- ♦ Organic solvent cleaning,
- ♦ Aqueous cleaning, and
- ♦ Drying.

NOTES

Section 1

Chemical Coatings Removal

Removal of the old coating on metal parts is essential prior to applying a new coat. Old coatings may not provide a receptive surface and, therefore, would prevent the new coat from adhering. Chemical removal of organic coatings involves breaking bonds between substrates and coating layers. The chemicals soak into the coating and soften or dissolve it. The solutions are designed to effect only the coating material and not the surface of the substrate. A number of chemical agents exist which are able to break the bond between an organic coating and the substrate to which it has been applied. Three traditional methods of removing organic coatings are hot caustic stripping, cold chemical stripping, and molten salt baths.

◆ Hot Caustic Stripping

Hot caustic stripping uses alkaline solutions at high concentrations and temperatures to dissolve coating bonds. Chemicals such as sodium hydroxide or chlorinated solvents are used to create the coatings removal solutions. Some coating materials with low initial solvent content show resistance to hot caustic solutions and must be stripped by other methods.

◆ Cold Chemical Stripping

Cold chemical stripping uses organic solvents such as methylene chloride (MEC), methyl ethyl ketone (MEK), or phenol compounds to remove coating from parts. This method can be used with many different metals and organic coating types, including lower solvent coating formulations.

Hot and cold chemical strippers are typically applied in immersion tanks. Heat, if used, is provided by steam coils. The parts are dipped into the tank that may be agitated. After the coating has been loosened by the chemical solution, parts are rinsed to remove excess stripping solution and coatings. Rinse water tanks are used if the coating will flake off, but pressurized spray rinsing is recommended if the coating will fall off in

sheets or large pieces. Stripping solutions must be cleaned regularly to remove accumulated solids and extend the effectiveness of the bath; overflow screening or filtration can be used to remove coating materials.

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Figure 3-1: Chemical Coatings Removal.

♦ Molten Salt Stripping

Molten salt stripping baths are operated at temperatures between 550° and 900° F and parts are dipped in the solution for a few minutes. The salt solution converts the organic portion of the coating to carbon dioxide and water allowing the inorganic components such as pigments to slough off. Parts must be rinsed to remove excess salt particles which results in an alkaline wastewater stream.

Molten salt stripping is not energy intensive. While the bath must heat the part, the chemical reaction of the coating change creates heat that is absorbed by the bath. Another advantage is that the bath keeps working when coating materials are high, requiring only small additions of chemicals. The inorganic by-products accumulate in the bath, saturate it, and then as more are introduced, they precipitate. The precipitated sludge is easily removed from the bottom of the tank. Sludge might contain some metals that may be characterized as hazardous waste.

Part complexity is not a primary issue in the effectiveness of chemical removal methods. Solutions can easily penetrate small crevices and around bends. Chemical solutions may not remove all coatings,

therefore, they are typically used in conjunction with mechanical coatings removal.

Chemical coatings removal may be considered a pollution prevention alternative since it aids in the proper application of coating materials thereby reducing rework or reject parts. However, other concerns make it less acceptable than other coatings removal methods. Environmental impacts from chemical coating removal systems stem from the large volume of chemical solutions used. The chemical baths must be replaced to maintain effective stripping, resulting in liquid waste disposal problems. Some chemicals may be classified as hazardous, adding to the burden. Rinse waters used after chemical coatings removal and residual coatings must also be treated and disposed properly. In addition, the solutions may pose health concerns for workers.

NOTES

Section 2

Mechanical Coatings Removal

Removal of old coating is essential prior to applying a new coat. Old coatings may not provide a proper surface and would prevent the new coat from adhering to the part. Mechanical removal of coatings is accomplished by methods that mechanically abrade or embrittle the coating. Mechanical removal methods separate the coating from the substrate without chemically altering the composition of the coating. Three types of mechanical coatings removal are dry-abrasive blasting, wet-abrasive blasting, and waterjet blasting.

♦ Dry-Abrasive Blasting

Dry-abrasive blasting physically removes coating material from a substrate using a stream of solid particles propelled at high velocity against the coated surface. On contact with the part, the dry media dislodges the coating and it flakes off. Dry blasting media include inexpensive materials such as sand, steel, glass beads, agricultural media (e.g., wheat starch, crushed nutshells, fruit pits), manufactured sponge, and plastic beads. This makes it a good option to consider for large-area, high-throughput stripping projects. The rate of coating removal is fair to good, depending on the blast media selected. In general, hard abrasive media strip coatings faster than soft media does.

Waste from dry abrasive processes consists of coating chips mixed with abrasive media. Most media can be easily separated from the coating debris, using gravity separation in air or water. Steel, plastic, glass, and sponge media may be recycled and reused. However, dry-abrasive blasting generates excessive noise and dust, which makes it undesirable for use in areas where other manufacturing or maintenance activities are occurring.

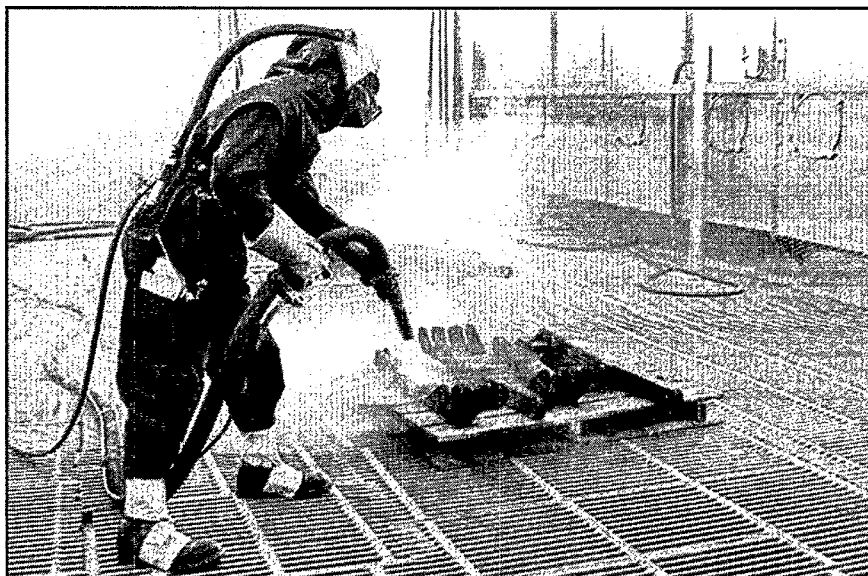


Figure 3-2: Dry-Abrasive Blasting.

◆ Wet-Abrasive Blasting

In wet-abrasive blasting, a stream of low- to medium-pressure (up to 15,000 pounds per square inch (psi)), water containing abrasives, typically sand or sodium bicarbonate, is directed at a coated surface. Solvents, such as alcohols or aliphatic hydrocarbons, may be incorporated into the liquid stream to facilitate coating removal. Wet-abrasive processes remove organic coatings at a moderately fast rate and, thus, may be suitable for large-area stripping projects. An advantage of wet-abrasive blasting over dry-abrasive blasting is that less dust is created. Two major disadvantages of wet-abrasive blasting are wastewater from the process may need to be collected and treated, and the abrasive media is not reusable.

◆ Waterjet Blasting

Waterjet blasting uses the force of water at very high pressure (greater than 15,000 psi) without the addition of abrasives or solvents to remove organic coatings. Waterjet systems use less thrust and, therefore, result in less operator fatigue and better stripping performance than other manually operated blasting systems. Water that is contaminated with coatings particles is generated from waterjet operations. The water can be filtered and reused, leaving only the coating residue and filters to be disposed. Rust inhibitors may need to be applied to water-sensitive substrates during or after liquid blasting to reduce flash corrosion.

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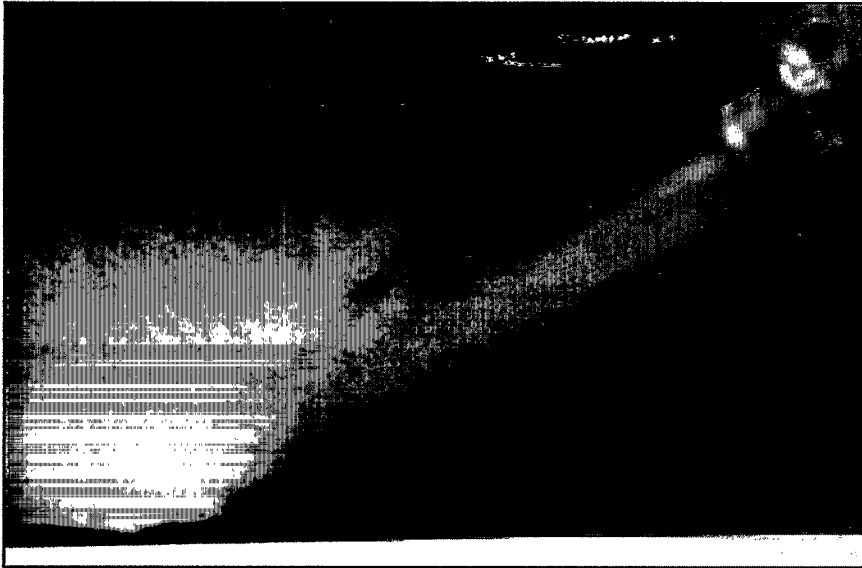


Figure 3-3: Wet Abrasive Blasting System.

Part complexity plays a role in the effectiveness of mechanical removal methods. Blasting techniques are line-of-sight methods so the blast stream may miss some areas on a complex part. Also, blast media used in abrasive blasting may get lodged into recesses and small crevices of a part and require further handling, such as blowing with compressed air, to ensure complete removal. Because of these difficulties, mechanical coatings removal is typically used in conjunction with chemical coatings removal methods. The combination of the two methods helps to remove all coating residue and blast media from the part surface.

Mechanical coatings removal may be considered a pollution prevention alternative since it aids in the proper application of coating materials thereby reducing rework or reject parts. However, other concerns make it less acceptable than other coatings removal methods. Mechanical coatings removal methods have some environmental impacts. For large facilities, a large volume of waste material (dry or wet) may be generated. If the blast media or coating material contain hazardous materials such as solvents or heavy metals, the residual waste may be considered hazardous. Separation and reuse of the blast media will help reduce this. Mechanical coatings removal operations are regulated by 40 CFR Part 63 Subpart GG - National Emission Standards for Aerospace Manufacturing and Rework Facilities. This regulation requires that facilities provide sufficient airflow and air filtration to prevent air particulates from accumulating.

Section 3

Carbon Dioxide Blasting

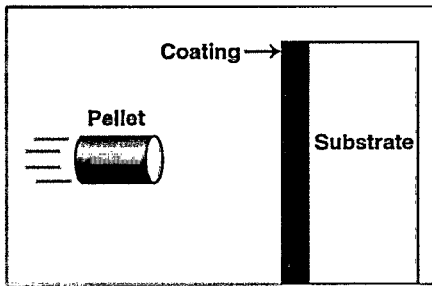
Solid carbon dioxide (CO₂) or "dry ice" blasting processes may be used to remove organic coating materials and particulates by an impact-flushing method. With carbon dioxide blasting, solid CO₂ particles are propelled at the part to dissolve organics and dislodge coating materials.

Unlike other mechanical coating removal methods, carbon dioxide blasting systems remove coating materials when the particles hit *and* bounce back off the surface of the part. The removal action of carbon dioxide systems is depicted in Figure 3-4. Particulate and molecular coating materials are first knocked loose by the impact of the pellet. Then, as the CO₂ pellet undergoes phase transformation from a solid to a vapor (sublimation), the coating materials are carried away from the part. The contaminant matter falls to the ground and may be collected while the CO₂ is free to escape into the atmosphere.

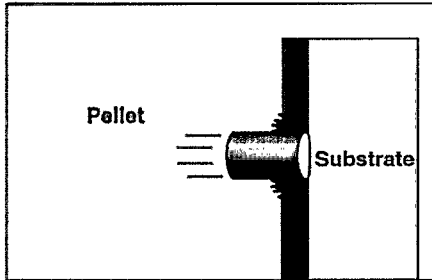
Two types of carbon dioxide blasting, which use either frozen CO₂ pellets or CO₂ snow, are currently available. Carbon dioxide pellet blasting involves projecting small beads of solid CO₂ at high velocities toward the part that is being cleaned. Either a centrifuge or compressed air is used to project the pellets. A centrifuge minimizes pellet degradation by throwing the pellets rather than forcing them along with compressed air. Centrifuges also make contaminant collection less complicated by stirring up less dust. Carbon dioxide snow blasting uses smaller blast particles and utilizes spray systems. Carbon dioxide snow is formed when liquid CO₂ is allowed to expand rapidly through a nozzle. These snowflakes are then carried by a high velocity stream of pressurized CO₂ gas. Carbon dioxide snow is less abrasive than pellets but cleans as effectively.

Carbon dioxide blasting systems are operated at pressures typically between 50 and 300 pounds per square inch (psi). Some systems that operate at pressures below 150 psi are portable which adds to their versatility. Because the CO₂ gas is non-toxic and cleanup is minimal, the system can be used to perform in-line cleaning without dismantling machinery or interrupting production. Another benefit of carbon dioxide blasting is that drying is not necessary.

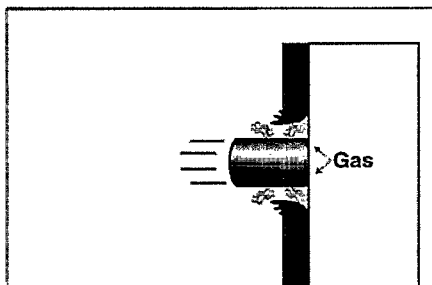
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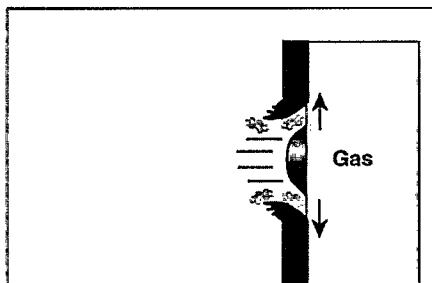
The carbon dioxide pellet is accelerated toward the coated substrate.



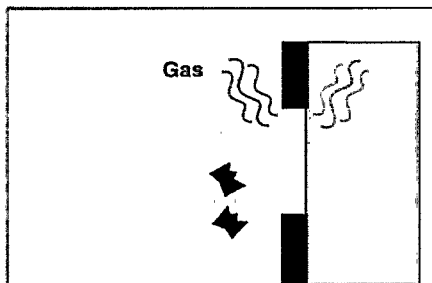
The carbon dioxide pellet penetrates the coating to loosen it from the substrate.



The carbon dioxide pellet sublimates on impact with the substrate turning into carbon dioxide gas.



The "mini-explosion" of the carbon dioxide changing to gas further tears the coating away from the substrate.



The coating material falls to the ground while the carbon dioxide gas is released to the atmosphere.

Figure 3-4: Carbon Dioxide Blasting Action.

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Figure 3-5: Carbon Dioxide Blasting System.

As with any line-of-site process, carbon dioxide blasting is not applicable to some parts with complicated geometries because the projectiles are unable to reach into tight or hidden spaces. The method is not aggressively abrasive so cleaning times may be longer than with other methods. However, other benefits of this coating removal method make this a viable alternative. For instance, carbon dioxide blasting does not alter or damage surfaces of the workpiece. Because the solid CO_2 turns to gas, no abrasive media is entrapped in crevices and both the snow and pellet methods add no excess solids or liquids to the waste. Also, solid CO_2 blasting may be used on parts that are sensitive to water.

Carbon dioxide blasting is a good alternative to other coatings removal and cleaning methods due to the low environmental impacts. No additional liquid, solid, or hazardous waste beside the coating residual is created since the carbon dioxide turns to gas and is released to the atmosphere. One worker safety issue with carbon dioxide blasting must be addressed, however. Carbon dioxide gas is denser than air and may accumulate in work areas. Without proper ventilation, oxygen levels may fall and pose problems for workers.

Section 4

Organic Solvent Cleaning

Organic solvent cleaning applies an organic chemical to a part to remove organic coating materials such as grease or dirt. Applied in liquid form, the solvents dissolve the coating materials to separate them from the substrate. Organic solvents do not usually chemically affect the surface of metal substrates, which makes these solvents useful on a wide variety of materials. Some solvents evaporate after application, leaving no liquid waste. Others are effective for many cleaning cycles, which reduces the need to change cleaners often. In addition, some coating materials are easily separated from organic solvents by settling or skimming, further extending the effectiveness of the solvent.

Traditional organic solvents, provided in Table 3-1, include fluorinated compounds, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). These materials have been used extensively because of their effective cleaning nature, low flash point, and low toxicity to humans. However, they have been targeted as ozone depleting substances and are not as widely accepted as in the past.

Aliphatic hydrocarbons consist of naphtha, mineral spirits, kerosenes, and straight chain hydrocarbons. Chlorinated solvents, such as trichloroethylene, perchloroethylene, and methylene chloride, are also widely used. These materials effectively clean a variety of contaminants, especially heavy grease, tar, waxes, and soils. They, too, have been targeted for phase-out by environmental regulations due to their toxicity.

Alcohols, ethers, ketones, and esters also work well as organic solvent cleaning agents. Alcohols (such as ethanol and isopropanol) and several glycol ethers are effective solvents, but are highly flammable. These organic solvents are typically used only in small-scale cleaning processes. Esters have good solvent properties, but some dibasic esters have such low vapor pressures that a residual film is left on a surface after application.

Table 3-1: Common Organic Solvent Cleaners.

SOLVENT GROUP	EXAMPLES
Fluorinated solvents	chlorofluorocarbons, hydrochlorofluorocarbons
Aliphatic solvents	hexanes, mineral spirits
Chlorinated solvents	methylene chloride, trichloroethylene, perchloroethylene
Alcohols	isopropanol, methanol, ethanol, isobutanol
Ketones	acetone, methyl ethyl ketone, methyl isobutyl ketone
Ester solvents	ethyl acetate, isopropyl acetate, glycol ether acetate
Aromatic solvents	toluene, xylene

NOTES

Organic cleaning solutions may be applied to a part by immersion, spraying, hand wiping, or vapor systems.

♦ Immersion

For immersion, parts are dipped and soaked in a bath of solvent. The cleaning effectiveness of the solvent may be augmented by the addition of heat or by agitation of the bath fluid. Agitation is done by mechanical means or through ultrasonic bombardment. Immersion baths need to be changed or filtered to maintain appropriate levels of cleaning performance. Parts must be dried after immersion to remove excess solvent. Immersion is adaptable to a variety of part geometries and sizes but may not be as fast as other cleaning technologies.

♦ Spraying

Spray cleaning is performed by spraying the part with a low-foaming organic solvent cleaner. Low-pressure nozzles are arranged to spray the part from many angles. Spray washing provides a high level of cleanliness, is inexpensive, and offers a high throughput rate. However, it is a line-of-site process making it difficult to clean complex parts thoroughly.

♦ Hand Wiping

Hand wiping involves the manual application of the cleaner to an area and then wiping with a rag or brush. This process is not applicable to

large-scale cleaning or to solvents that pose a health risk. However, it is typically used to clean small areas, or for touch-up work.

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♦ Vapor Systems

In vapor degreasing processes, organic vapors are condensed onto dirty parts in an enclosed chamber. After parts have been in the vapor system for a set time, the chamber or part is heated to vaporize the solvents and “dry” off the parts. Vapor degreasing can be done under vacuum conditions or with a cooling zone above the vapor area to prevent loss of solvent vapors. Part complexity is a concern in vapor degreasing applications because undercut and bottom surfaces will not be coated with vapors. Part orientation is essential to maximize the upward surface areas and achieve proper cleaning.

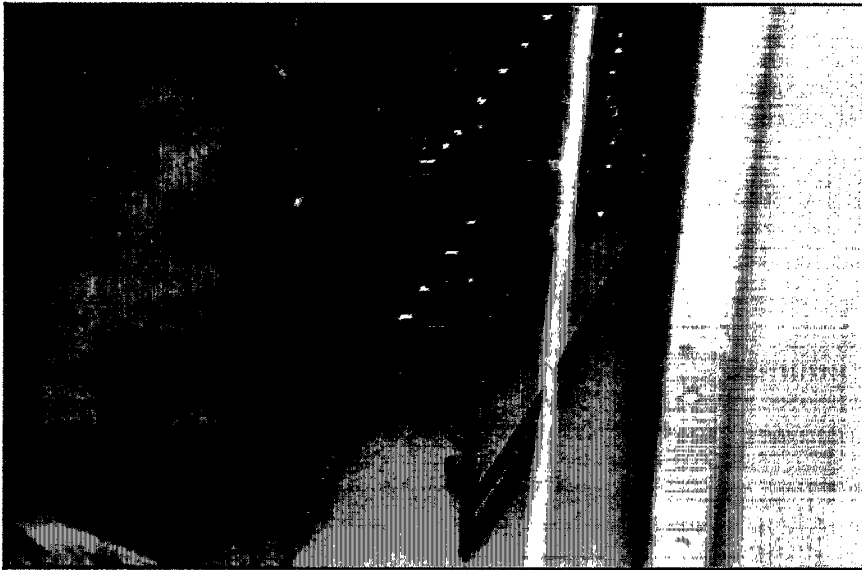


Figure 3-6: Vapor Degreasing System.

The effectiveness of the organic solvent solution can be reduced by minimizing the contamination level of the fluid and reducing the fluid evaporation rate. Coating materials that build up in the solution must be removed regularly for the solution to retain its cleaning capability. Because organic solvents have high evaporation rates at room temperatures, care must be taken to cover solvent cleaning systems to avoid unnecessary loss of solution. Organic solvents are also highly flammable and may require explosion prevention equipment.

NOTES

Organic solvents have been targeted for reduction due to the environmental impacts they impose. The solvents evaporate to form volatile organic compounds and hazardous air pollutants. Worker health is also a concern. Environmental regulations have been written which impact solvent cleaning systems. 40 CFR Part 63 Subpart T - National Emission Standards for Halogenated Solvent Cleaning applies to all batch vapor, in-line vapor, in-line cold, and batch cold solvent cleaning operations using methylene chloride, perchloroethylene, trichloroethylene, 1,1,1-trichloroethane, carbon tetrachloride, or chloroform. The regulation requires proper design of cleaning systems to minimize evaporation and release of the solvent vapors. Other industry-based regulations put restrictions on organic solvent cleaning systems (40 CFR Part 63 Subpart GG). Facilities can prevent some impacts by proper use of the solvent materials. This includes careful handling of materials, analytical testing to determine solvent effectiveness, and segregation from non-hazardous materials.

Some organic solvents can be combined with water to help reduce their negative environmental effects, while maintaining their cleaning capability. Semi-aqueous cleaners degrease metal parts with an organic solvent wash and a water rinse, or with an emulsion of the organic solvent and water. Organic solvents used in semi-aqueous cleaners include aliphatic hydrocarbons and terpenes. These cleaners have a neutral to slightly alkaline pH and are less corrosive toward reactive metals, such as beryllium, than strong alkaline aqueous cleaners.

Although using semi-aqueous cleaners reduces environmental concerns, the cleaners still produce vapor emissions that may be toxic or odorous. In addition, semi-aqueous cleaning systems produce and increase volume of wastewater that must be treated to remove the organic solvents. Safety concerns, such as flammability, must still be considered when choosing this alternative.

Section 5

Aqueous Cleaning

Aqueous cleaning processes use solutions which consist of water and a small concentration of chemical cleaning agent to remove coating materials by chemical dissolution or emulsification. Additional washing and rinse stages can be included as needed to achieve proper surface preparation. Water is an effective solvent for ionic and other water-soluble coating materials. Hard water or process water may leave a film or deposit on the substrate; therefore, water softening or the use of deionized water may be necessary. Aqueous cleaning solutions may also include additives such as surfactants, saponifiers, and anti-foaming agents to enhance cleaning. Depending on the additive, aqueous cleaners can be neutral, alkaline, or acidic.

The most commonly used aqueous cleaners are alkaline cleaners. Most alkaline solutions have a pH of 10 to 12. They are used to remove flux, emulsify oils, break apart fats and solid soils, neutralize fatty acids, and precipitate hard water ions.

Acidic cleaning solutions have a pH of less than 7. They are used to remove oil, grease, shop soils, drawing compounds, light rust and scale, or to etch metal surfaces for better adhesion in subsequent processes. A common type of acid cleaning is phosphating in which iron, zinc or magnesium ions in a water solution are applied to a part. The phosphate pretreatment improves the paint bond and prevents the spread of corrosion under the coating. Acidic cleaners require a preliminary alkaline rinse to effectively remove heavy deposits of oil or grease.

Typical aqueous cleaning systems include several stages: washing with an aqueous solution, rinsing with clean water, and drying. Aqueous cleaning is performed in several ways. Aqueous cleaning solution can be sprayed onto parts via nozzle manifolds. The spray manifolds facilitate the cleaning process by showering the solution directly on to the surface of the parts. The cleaning capability is further enhanced by fixturing the parts in such a way that exposes their maximum area to the cleaning solution. Aqueous cleaning is also performed in immersion tanks that are equipped with mechanical or ultrasonic agitation capability. A water rinse is typically required as a final step to remove any residual cleaning

solution. Complete removal of coating materials and the cleaning solution is necessary to allow proper adhesion of coatings materials. Drying is then performed to remove excess water from the part.

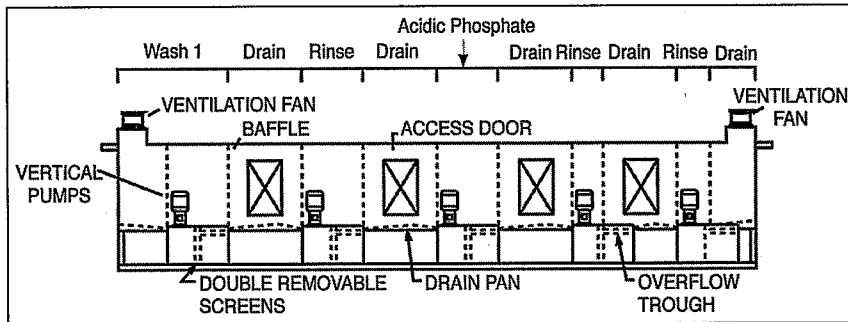


Figure 3-7: Aqueous Cleaning System with Wash, Rinse, and Dry Stages.

The wide range of available aqueous cleaners makes it possible to find a cleaner for virtually any substrate, as long as the substrate is not adversely affected by water. The type of aqueous cleaner to be used is determined by the substrate and the contaminant, as well as part size and geometry. In order to achieve acceptable cleanliness levels with aqueous solutions, the cleaning system must be optimized according to temperature, agitation, concentration, and time. Proper adjustment of the four variables will ensure that all coating materials are sufficiently removed.

To extend the life of aqueous cleaning solutions, coating materials should be removed from the solutions at regular intervals. Many cleaners hold soils in suspension while agitated. After the solution cools or sits for a period of time, the contaminant materials will separate from the solutions in the holding tank. Oils float to the surface and can be skimmed off while particles fall to the bottom as sludge. The cleaning solution can then be pumped out and reused. This type of separation can be done in a holding tank or during a daily shutdown of the cleaning system. If gravity separation alone does not provide sufficient contaminant removal, filtration may be necessary. Typically, operators face a trade-off between how well the aqueous cleaner removes oils and dirt from the part and how well coating materials can be separated from the cleaner.

Compared to cleaning with organic solvents, aqueous cleaning may require longer wash cycles and more space for equipment. The process also requires that parts be rinsed thoroughly, which may be difficult to do with complex parts. Care must be taken to reduce flash rusting of water

sensitive substrates. But aqueous systems do not create as many environmental concerns for facilities. Aqueous cleaning methods provide a relatively safe cleaning system because solutions have low toxicity and are typically nonflammable. The large volume of water used can usually be treated to remove dirt and grease, cleaning solutions, or other coating materials, allowing the water to be reused in subsequent cleaning operations. Aqueous cleaning systems are sited under some industry-based air regulations (40 CFR Part 63 Subpart GG) which place limits on the percentage of water in the solution.

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Section 6

Drying

Drying is the final step in many surface preparation operations for organic finishing. Drying removes any residual liquid remaining after organic solvent or aqueous cleaning. Parts must be free from cleaning solutions and water prior to paint application to ensure that the coating properly adheres to the surface.

Drying typically occurs in convection ovens, although radiation systems can also be used. The heat generated in an oven accelerates the evaporation of liquid cleaning solutions or rinse solutions from the part. Conventional dry-off ovens consist of a large metal, brick, or ceramic housing structure where the heat is circulated. The heat can be generated by electricity, gas, or other energy sources. Ovens can be of a batch type where parts remain stationary inside and are put in and removed at various times. They can also be continuous systems where parts move through the heated area on a conveyor or overhead trolley. Some dryers are a continuation of the washer system, rather than a separate unit.

Dry-off ovens are similar in theory to ovens used after coating application for curing and drying. The heated air is circulated through the oven shell to evaporate the residual liquid. Parts are usually contained in the ovens for three to five minutes. Dry-off oven temperatures are usually operated around 100° to 200° F. Temperatures and times will vary with the size of the part and if the dry-off stage is used for a preheating step as well. Because the temperature of the part may affect some application methods and coating materials, the part temperature is monitored during the drying stage.

If an aqueous cleaning system is used, the oven removes rinse water; for solvent cleaning systems, excess cleaning solution is removed. Care must be taken when drying parts after solvent cleaning to prevent the temperature from reaching the flash point of the solvent to avoid combustion. Exhaust systems may have to capture solvent vapors prior to release to the atmosphere as well.

Drying systems have very low environmental impacts. Gas-powered ovens may create additional nitrous oxides (NO_x) emissions for a facility. Otherwise, ovens are a major source of energy consumption.

Section 7

Environmental Considerations for Surface Preparation

Surface preparation methods create large volumes of waste material, consisting of old coatings, dirt and other coating materials, blast media, solvents or liquid solutions. Only the last preparation step, drying, poses few environmental burdens for facilities. This section discusses the regulatory requirements, common causes of violations, sources of pollution, and pollution prevention opportunities for surface preparation methods.

Regulatory Requirements

♦ Air Emissions

Except for the standards for halogenated solvent cleaning discussed in section 4, few regulations specifically address surface preparation methods. Facilities must be aware of the overall emission of volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and particulates from their operations, however. The VOC and HAP emissions may be formed from chemicals, solvents, or other additives to stripping and cleaning solutions. Particulates may accumulate during dry media or carbon dioxide blasting. Release of these pollutants are governed by 40 CFR Part 60, 40 CFR Part 61, 40 CFR Part 63, and 40 CFR Part 50. Facilities may produce sufficient levels of emissions to subject them to major source requirements and Title V permitting requirements.

♦ Wastewater

Wastewater issues are also a concern for organic finishing facilities. As part of the Clean Water Act, Effluent Guidelines and Standards for Metal Finishing (40 CFR Part 433) have been established that limit concentrations of heavy metals, toxic organics, and conventional pollutants in wastewater streams. Several components of surface preparation operations are classified as water pollutants including

chemical stripping solutions, caustic solutions, wet-abrasive blasting residue, organic solvent solutions, or aqueous cleaning solutions. Also, the residual coating solids or sludge in the solutions may contain metals. These materials can enter the wastewater through liquid dripping off of parts, through rinse activities, when cleaning equipment, and from accidental spills or leaks in equipment. Actual limits for effluent constituents are dependent on the size of the operation and the amount of wastewater generated from the facility. If the facility discharges directly to receiving waters, these limits will be established through the facility's National Pollutant Discharge Elimination System (NPDES) permit (40 CFR Part 122). Facilities which are indirect dischargers releasing to a publicly owned treatment works (POTW) must meet limits in the POTW's discharge agreement. Wastewater streams with concentrations exceeding permit limits will require pretreatment prior to discharge to receiving waters or to a publicly owned treatment works. Pretreatment may include separation of liquid wastes to remove solvents, and settling or precipitation of solid materials.

◆ Solid and Hazardous Wastes

Under the Resource Conservation and Recovery Act (RCRA), organic finishing facilities are required to manage listed and characteristic hazardous wastes (40 CFR Part 261). Several materials from surface preparation methods may classify as hazardous materials including chemical stripping solutions or organic solvent cleaners. Sludge from these operations and even dry coatings residual may also qualify and will add to the overall volume of waste generated. Hazardous waste management (40 CFR Part 262) includes obtaining permits for the facility in order to generate wastes, meeting accumulation limits for waste storage areas, and manifesting waste containers for off-site disposal. Responsibilities will vary according to the amount of hazardous waste generated; facilities generating at least 100 kilograms of hazardous waste per month must comply with the hazardous waste generator requirements at 40 CFR Part 262.

◆ Community Right-to-Know

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires facilities to notify employees, customers and the surrounding community of certain hazardous chemicals and materials that are present on-site. Large organic finishing facilities may use hazardous materials in sufficient quantities to subject a facility to several EPCRA requirements. Facilities may be required to inform the local emergency planning committee (LEPC) and the state emergency response commission (SERC) of the materials stored and used on-site, devise emergency response plans for reacting to spills, and notify authorities of accidental

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spills and releases (40 CFR Parts 302, 355, and 370). The materials used in chemical coatings removal solutions may also require facilities to submit Material Safety Data Sheets (MSDS) for these materials to state, regional, and local organizations, while disposed volumes of the material may have to be documented on annual Toxic Release Inventory reports (40 CFR Part 372).

♦ Material Substitution

Although not directly regulated by the EPA, mechanical coatings removal and carbon dioxide blasting technologies generate a high level of noise. Equipment used to compress and pump materials, the exhaust of the blast stream, and the media striking the substrate create sufficient decibel levels to require process engineering controls and hearing protection.

Common Causes of Violations

Common causes of violation of regulatory requirements occur typically on a facility level. Most regulations cover the facility as whole, rather than individual processes. Facilities must be aware of the total generation of pollution from all sources in order to obtain sufficient permitting or treatment processes. Facilities must also maintain all monitoring, recordkeeping, and reporting documents as required. Emission of volatile organic compounds or hazardous air pollutants from chemical solutions or accumulation of particulates may occur and exceed limits established in a Clean Air Act Title V permit. Blast media, coating material, and substrate residue form dust in the blast area. Some particles may be small enough to qualify as respirable particulates capable of penetrating lung tissue. Typical hazards include exposure to silica and lead.

Wastewater may exceed permit limits for solvents, solids, oils or other contaminants. Excess concentrations can occur during normal operations, when cleaning systems or work areas, or through accidental spills of material. If the effluent exceeds the limits established by facility NPDES or POTW permits it may not be directly released to water systems or to publicly owned treatment works without pretreatment.

Facilities must assure that all hazardous materials are handled properly. The materials must be labeled, stored, and disposed according to regulations. Materials should be tested to determine if they qualify as listed or characteristic hazardous wastes. Items such as sludge from strip tanks, coating residual, or used liquid solutions may qualify based on additional contaminants in the material. In addition, the facility must be

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aware of the total quantity on the site. Total volumes are considered for emergency planning and notification regulations. MSDS for all chemicals should be available for employees and the public.

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Sources of Pollution

Surface preparation methods generate a large portion of the waste from organic finishing facilities. Air pollutants may be generated from the coatings removal and cleaning solutions that have organic solvents. Particulates can accumulate when stripped from a part. Facilities may take measures to capture these pollutants by including ventilation systems with filtration and chemical recovery or incineration. The large volume of liquid materials used in chemical coatings removal, wet-blasting, organic and aqueous cleaning systems adds a significant amount of waste to facilities. These materials must be replaced regularly and old solution treated or disposed properly. Residual coating materials and other contaminants also add to the amount of waste generated by a facility. Even if the materials can be separated from the stripping or cleaning solution, the materials must be disposed, and may qualify as hazardous materials.

Pollution Prevention Alternatives

Facilities can reduce the pollution from surface preparation methods in numerous ways. If possible, processes can be exchanged for those that create less waste. Chemical coating removal may be replaced with a mechanical coating removal method, organic solvent cleaning replaced with an aqueous system. Carbon dioxide blasting, with the lowest impacts, may be able to replace both removal and cleaning steps. Perform all operations in designated areas and enclose them if possible. This will contain wastes to smaller area and prevent contamination of parts or facilities. If this is not an option, steps can be taken to improve the current process and reduce pollution.

◆ Material Substitution

Facilities can reduce pollution by switching to materials that are less polluting. Chemical coatings removal solutions are available that do not contain organic solvents and that are less harmful to workers. Aqueous solutions have been proven to be as effective for organic solvent cleaners. Substituting semi-aqueous solutions or organic solvents with lower vapor pressures can also help reduce risk. Carbon dioxide blasting uses gas that is not harmful.

♦ Material and Waste Handling and Storage

Even if harmful chemicals are still required for adequate surface preparation, proper handling and storage can reduce pollution and hazards. Restrict traffic in chemical storage areas to reduce spills and accidents. Keep storage and work areas clean so that spills and leaks are more noticeable and reaction time is reduced. Enclose or cover containers of chemical coatings removal and cleaning solutions when not in use to minimize the release of solvent vapors and lower contamination from facility dust and dirt. Segregate non-hazardous wastewater and other materials from hazardous liquids and organic solvents, and label containers to prevent mixing. Separation of the materials reduces the amount of hazardous waste that is produced. For non-hazardous materials, recycle if possible by removing residual coatings from blast media. Recycle water from wet-abrasive blasting to other processes such as rinse baths, facility cleanup, or other uses where a small concentration of coating materials will not matter.

♦ Operations and Procedures

Minor changes to current operations and procedures can also reduce waste generation. Pre-inspect parts prior to processing. Optimize processes to perform properly with minimal solution additions, with lower concentrations, and shorter processing times. Proper adjustment of operating parameters, such as time, agitation, solution concentration, blast pressure, and temperature, will improve surface preparation without requiring stronger solvents or longer processing times. Modify part arrangement to ensure that all surfaces are reached. Use counter-current systems for liquid solutions, especially rinse cycles. Backflow the cleaner water from the final rinse stage to the tanks for previous rinses and finally into the stripping or cleaning solution itself. Remove coating materials from the solutions regularly so that effectiveness of the solution is maintained and lasts longer. Separate coating residue, dirt, oils, and other contaminants using filtration, gravity separation, or membrane technologies (crossflow filtration). Reducing heat and stopping agitation will promote separation of coating materials in batch systems.

♦ Maintenance and Housekeeping

One of the most important steps for pollution prevention is a regular interval of maintenance and housekeeping. Check equipment regularly for leaks, broken valves, incorrectly operating monitoring devices, etc. This will ensure that processes are running at optimal settings. Regular cleaning of equipment and surface preparation areas quickly identifies problem areas and creates a safer work environment. Minimize accumulation of soils, dirt, and oils by practicing good housekeeping.

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Keep the facility clean and use proper part handling procedures to reduce part contamination initially

◆ **Training**

Finally, train employees to operate processes properly and to fully understand their responsibilities in the workplace. Train employees on safe handling of materials and wastes and encourage continuous improvement. Training familiarizes workers with their responsibilities, which reduces spills and accidents.

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Section 8

Chapter Summary

Surface preparation is essential to good organic finishing results. Surface preparation removes old coating materials, dirt, oil, or other contaminants leaving a clean, even surface for the new coating material. Performing proper surface preparation techniques also reduces pollution in the long run by ensuring that parts have good coating characteristics, eliminating the need to rework parts and waste more materials, time, and energy. Summarized in Table 3-2 is the six surface preparation methods discussed in this chapter. Each provides sufficient cleaning of a workpiece prior to coating material application. Virtually any contaminant can be treated and removed from various substrates to ensure good coating characteristics.

The environmental impacts of each surface preparation method must be considered with their use. While all provide adequate preparation of the substrate, the amount of waste generated varies widely. Large volumes of waste material and liquids may be generated with any one system. With careful operation and procedures, these impacts can be reduced or contained to minimize waste and risk.

Table 3-2: Summary of Surface Preparation Methods.

SURFACE PREPARATION METHOD...	REMOVES...	WHILE CREATING...
Chemical Coatings Removal	Old coatings	Air emissions, hazardous waste, wastewater
Mechanical Coatings Removal	Old coatings, surface dirt	Dust, wastewater, solid waste
Carbon Dioxide Blasting	Old coatings, dirt, grease	No harmful by-products
Organic Solvent Cleaning	Dirt, grease	Air emissions, hazardous wastes, wastewater
Aqueous Cleaning	Dirt, grease, rust, scale	Wastewater, sludge
Drying	Excess solvents, water	Heat, air emissions

CHAPTER FOUR

APPLICATION METHODS

Coating application is the second process in organic finishing systems. The coating materials are applied to the workpiece in a variety of ways. Coatings materials can be sprayed over the part, or the part can be dipped into a tank of coating material. Other methods include showering parts with coatings or rolling parts between large barrels to spread on the coating. Transfer of coating materials can be enhanced with the use of electrical potential between the coating and the part.

Several variables dictate the choice of application method. Part geometry, appearance of the coating finish, and production rate all influence the type of application method. A part with recesses and rounded areas that requires a high-gloss finish will be coated by a different system than a flat sheet which needs a protective primer coating. Facility constraints will also determine the choice of application method. The configuration of the application equipment is dependent on space or climate. Systems can be manually or automatically controlled. Other systems may require extra equipment, such as holding tanks or outside air supply to operate properly.

Similar application systems may operate at widely varying parameters. The viscosity of the coating material, the desired thickness of the final coating, and the complexity of the part will determine the best operating parameters for the application method. Thus, part temperatures, dip times, number of coats, or the amount of current used will be different. These operating parameters are carefully monitored by plant engineers to ensure the quality of the coating meets specifications.

One factor that is important to all application methods is the transfer efficiency of coating material onto the part. Transfer efficiency is the percentage of solid coating material used that actually deposit on the surface of the part. The higher the transfer efficiency, the better, as more coating material adheres to the part and less is wasted. Transfer

efficiency ranges from 25% to 40% for conventional spray systems to almost 100% for dip and powder coating methods. Much of the pollution and waste created from organic finishing operations can be minimized or eliminated by improving the transfer efficiency of the application system. If the transfer efficiency cannot be improved, pollution control technology and waste handling measures must be employed.

The environmental issues associated with organic finishing application methods mostly stem from the type of coating material used. More issues arise with the use of solvent-borne coatings than with waterborne or powder coating materials. However, the application processes create pollution and waste that can cause violations but that can be prevented.

This chapter discusses six common application technologies for organic finishing:

- ◆ Spraying,
- ◆ Electrostatic Spraying,
- ◆ Electrocoating,
- ◆ Roll and Coil Coating,
- ◆ Dip, Flow, and Curtain Coating, and
- ◆ Powder Coating.

Each section provides a description of the technology and any specific environmental considerations. The final section discusses the regulatory requirements, common causes of violation, sources of pollution, and pollution prevention alternatives for the application methods.

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Section 1

Spraying

Spray application is the most common technology for applying organic coatings to metals. With spraying, coating materials are forced through a small orifice with or without mixing with air. The change in pressure, and any mixing with air, causes the liquid paint to be atomized into small particles. Additional jets of compressed air can be used to shape the collection of particles and move them in the right direction. When the small droplets contact the workpiece, they flow together to form a film that covers the material. The method is relatively quick, simple, and provides good coating characteristics.

The main equipment in spray applications includes a spray gun, air supply system, fluid supply system and connectors. Spray guns control the volume and direction of the fluid and any air streams. The fluid and air streams are released when the trigger on the gun is squeezed. Different nozzles can be attached to the guns to change the exit area and thus the spray pattern. The air supply system consists of a combination of air compressors, filters, heaters and supply hoses. The fluid supply system can vary widely in complexity. A canister of coating material can be attached to the spray gun with gravity forcing the material through the gun. Other systems have mixing containers at remote locations and use pumps and hoses to carry the fluid to the gun. Spray systems can be operated manually or run by automated robots.

Four types of spray systems commonly found in metal finishing operations include air-atomized spraying, airless spraying, air-assisted airless spraying and high-volume, low-pressure spraying. Each provides good coverage of simple to complex parts rather quickly. The main difference between the technologies is in the use of compressed air to promote atomization of the liquid coating.

♦ Air-Atomized Spraying

Conventional air-atomized spraying is the most widely used technique to apply industrial coatings. Both coating materials and compressed air are

fed to the spray gun. The fluid and air mix when they exit the gun forming a fog of very small coating particles. Additional jets of air are directed into the atomized stream to form smaller droplets and an elliptical or fan spray pattern. Conventional systems use air pressured around 60 pounds per square inch (psi).

Conventional spray painting is very versatile. It can spray coating materials with high viscosity and allows substantial control over the spray pattern. Patterns ranging from a large spray to a fine dot can be obtained by using the controls on the gun to alter air and paint flow. The main disadvantage of air-atomized spraying is the low transfer efficiency. Usually, less than half of the paint discharged from the gun actually reaches the surface to be painted.

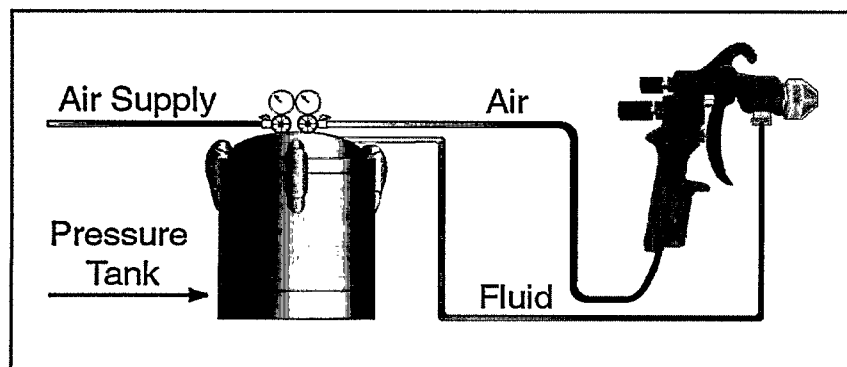


Figure 4-1: Air-Atomized Spraying System.

♦ Airless Spraying

Airless spray systems offer some improvements over air-atomized systems. Airless systems do not directly use compressed air to create the mist of paint. Instead, hydraulic pressure atomizes the paint by pumping it at high pressures (between 500-4500 psi) through a small orifice at the spray nozzle tip. As the fluid is released to the air, the change in pressure separates it into small droplets forming a finely atomized spray. The high discharge velocity reduces the particle size and propels the minute particles to the work surface.

Airless spraying requires careful operation to achieve a good coating. Air is not used to guide the spray, therefore, the operator has less control over the spray pattern. In addition, paint exits the nozzle at a high rate of speed. If the spray movement is paused over the surface, a build up of paint will occur resulting in runs or sags. Also, the coating particle size in airless spraying systems is coarser than that of air-atomized systems, so an even finish may be difficult to achieve. However, airless systems

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apply paint at a faster rate than traditional systems, so the same area can be covered in a shorter time. Airless systems are typically used for broad surface areas such as ship hulls or rail cars. Transfer efficiencies of airless systems are approximately 20% to 50%.

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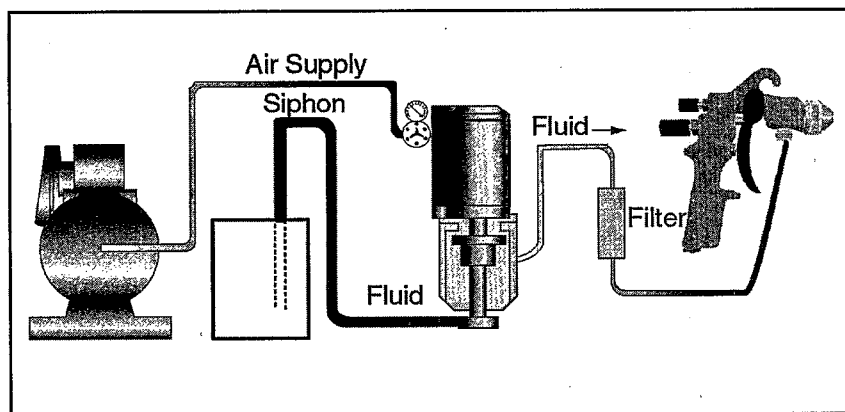


Figure 4-2: Airless Spraying System.

♦ Air-Assisted Airless Spraying

Another spray coating technology is air-assisted airless spraying which combines the mechanics of airless and air-atomized spray techniques. Like an airless system, the fluid stream is partially atomized by forcing the liquid stream at a high pressure (between 200-800 psi) through a small fluid nozzle tip. Complete atomization is achieved from compressed air jets from the face and horns around the nozzle, as done in air-atomized systems.

This method provides the finely atomized spray pattern seen with airless systems but results in a finer finish like traditional spray methods. The spray pattern is easier to control because the fluid stream exits the gun at a slower rate and because air-jets help guide the atomized particles. Transfer efficiency is improved to around 30% to 60 %.

♦ High-Volume, Low-Pressure Spraying

High-volume, low-pressure (HVLP) spraying techniques are a more efficient application method than the other spray methods. Like air-atomized systems, compressed air is mixed with the liquid paint in the spray gun creating the spray and moving it toward the workpiece. Some HVLP systems use standard compressed air, which has its pressure restricted in the gun. Other HVLP systems use an externally fed turbine

to create the high-volume, low-pressure air. The air is often heated which helps reduce the viscosity of some paints. HVLP systems operate at air pressures around 10 psi. Some systems are portable which adds to their versatility.

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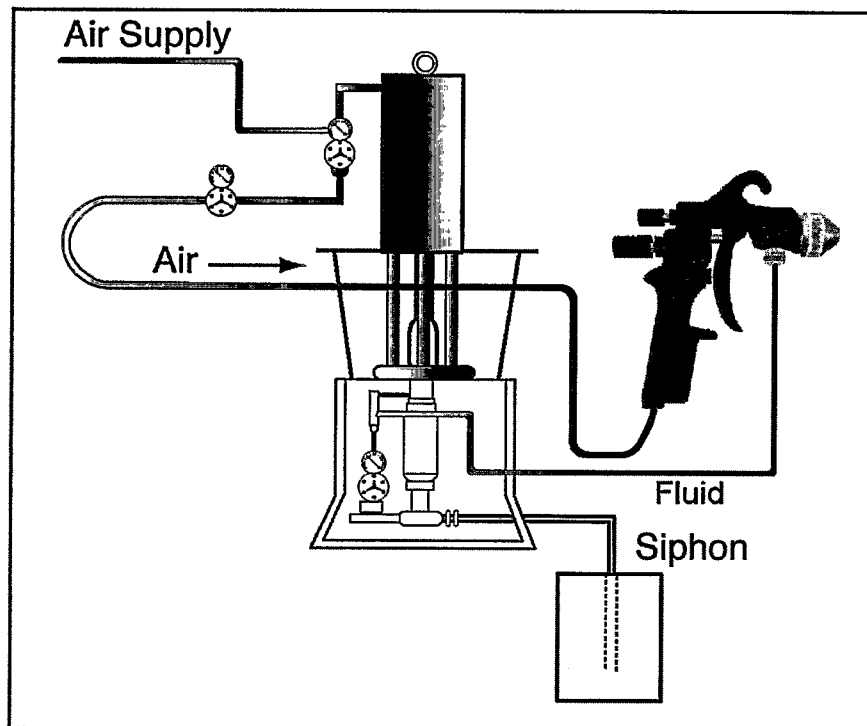


Figure 4-3: Air-Assisted Airless Spraying System.

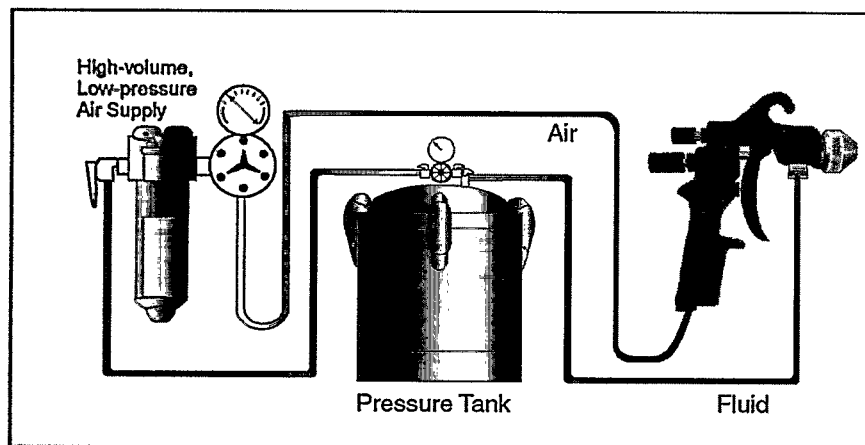


Figure 4-4: High-Volume, Low-Pressure Spraying System.

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HVLP systems produce a soft spray that penetrates recesses and cavities of complex workpieces. The resulting spray is not as fine as air-atomized systems, however, so the final coat may not be as smooth. Extra equipment to create the proper airflow is required and an adequate supply of clean, dry air must be available in the facility. The transfer efficiency of HVLP spraying reaches 65% to 75%.

In many cases, spray painting occurs in enclosures to help confine the paint material that does not deposit on the workpiece. Spray booths have equipment designed to control airflow. An exhaust system pulls paint-laden air through a filtration device that captures excess atomized particles. Additional equipment may be required to control the release of emissions from the organic solvents in the coating material. Spray booths can allow movement of parts by conveyor or trolley if necessary. Two types of spray booths use dry filters or waterwashes.

◆ Dry Filter Spray Booths

Dry filter booths are most common. These booths have cloth or polymer mesh filters to capture coating materials in the exhaust air. Often, a series of progressively tighter filters are used to remove larger, then smaller atomized particles. Filters must be replaced when clogged with coatings, and may be classified as a hazardous waste depending on the type of coating material used.

◆ Waterwash Spray Booths

In a waterwash booth, the rear of the enclosure has a curtain of water or water sprayed from nozzles. As the exhaust system draws air through the water, coating particles are trapped in the water while clean air exits. The water and coatings fall to the bottom of the booth and are collected. Some coating materials can be separated from the water allowing both to be recycled and reused.

Spraying methods can be used to apply most liquid coatings including solvent-based, high-solids or waterborne materials. Consideration must be given to the viscosity of the coating material and the operating parameters of the spray system when determining if a certain material can be used. Viscosity can be reduced by adding solvents or water to

thin the coating material, or by adding heat. Heat gives a more consistent flow and faster curing, but reduces the freshness quality or "pot life" of the paint. Pot life refers to the time from when a container of paint is first opened to the time the paint expires, or loses important coating characteristics.

Spray methods cover large areas very quickly and coat complex parts easily. However, transfer efficiency is typically low compared to other coating methods because much of the atomized coating material does not reach the surface to be painted. In general, as atomization increases, the size of the paint particle decreases. The smaller particles are less influenced by their velocity from the gun and are more likely to miss the target, as shown in the following figure. Some atomized particles are blown away by surrounding air currents or simply fall to the ground due to gravity before reaching the part. This is called fallout. Some coating particles will rebound off the part rather than adhering. The biggest waste in coating materials is usually due to overspray. Overspray is the coating material that misses the part at the edges.

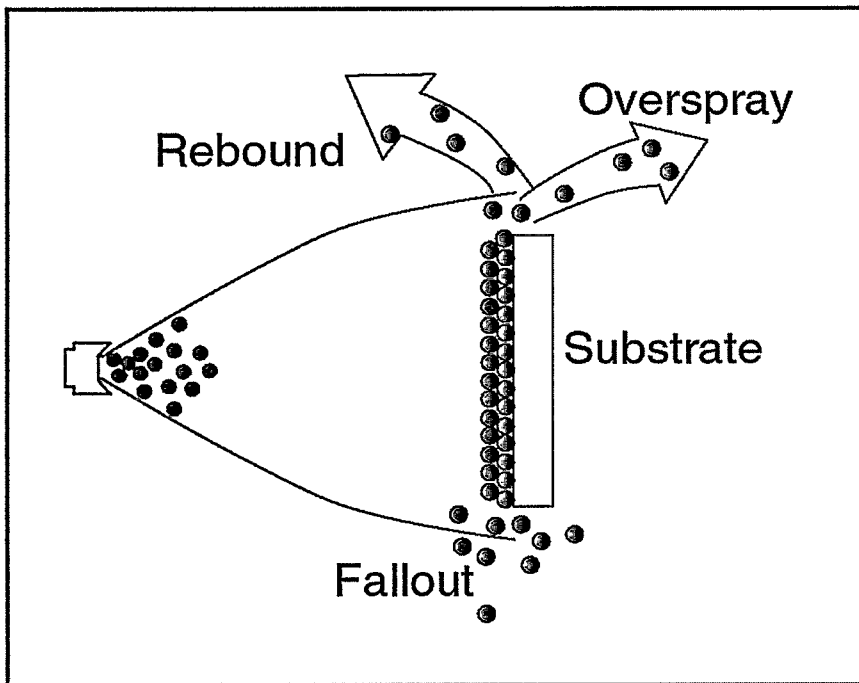


Figure 4-5: Waste Coating Materials from Spray Application Techniques.

Operator technique of manual spray application technologies is critical to proper coating. The operator controls the distance from the gun to the surface, speed of each stroke, pattern overlap, spray gun angle, and

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timing of triggering. All of these parameters contribute to successful application of the coating materials and how much coating material is wasted. Automated systems with fixed guns mounted on reciprocators or guns mounted on movable robots alleviate some of the inconsistency in applying coatings with spray technologies.

Cleaning spray equipment is relatively simple. Compressed air, water or solvents replace the coating material in the fluid supply and the spray gun is triggered. The air, water or solvents flush the unused paint through the system, clearing all fluid supply lines and the gun. Air and water flushes help reduce the amount of solvents required, but are often followed by solvent flushes to completely clean the systems. Cleaning must be done thoroughly to ensure no paint remains and clogs any lines. Additional hand cleaning of the gun may require dismantling of the gun components, such as the nozzle tip.

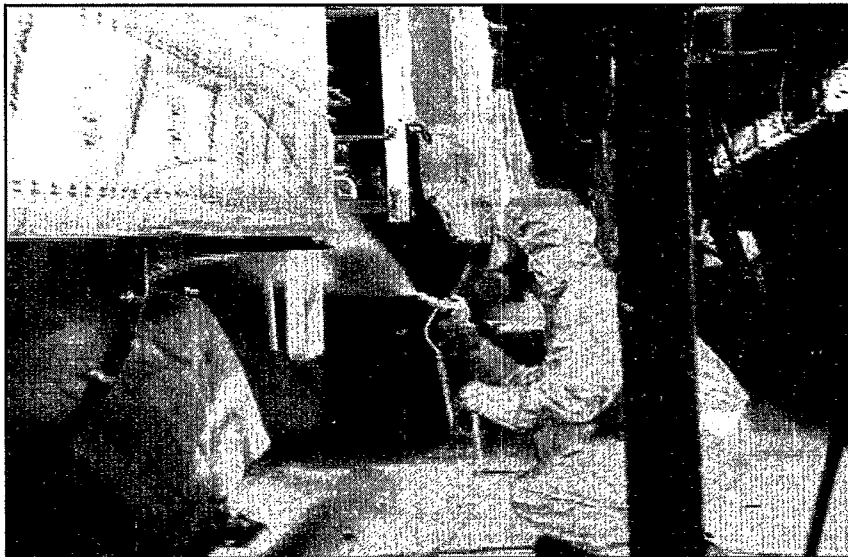


Figure 4-6: Spraying Application.

Facilities utilizing spray application systems must consider several environmental issues. Spray systems atomize the solvents contained in the coating material, which increases their evaporation. This increased evaporation rate creates more air pollution burdens than other application methods. Spray systems are specifically regulated under 40 CFR Part 63 Subpart GG - National Emission Standards for Aerospace Manufacturing and Rework Facilities. Aerospace facilities may use application methods or equipment that have demonstrated reduced HAP and VOC emissions that achieve emissions reductions equivalent to HVLP or electrostatic spraying methods.

The major source of pollution from spraying applications is wasted coating material due to poor transfer efficiency. For most spray systems, only about half of the coating material used actually ends up on the workpiece. A significant amount of coating material is wasted during these processes. Since the coating material then falls on filters, masking materials, clothing or elsewhere, additional waste is created when these items are disposed or cleaned.

Pollution prevention can be achieved from spray systems by taking measures to improve the transfer efficiency of the system. Equipment changes from air-atomized spray systems to airless, air-assisted airless, or high-volume low-pressure spray systems, which have less atomization, improve transfer efficiency of coating materials. Adding electrostatics to the spray system can also improve transfer efficiency by increasing the attraction between coating particles and the work piece.

Proper operation of the equipment can also improve transfer efficiency and reduce waste. Reducing the pressure of compressed air leaving the gun reduces the forward velocity of the particles so they are less likely to rebound off the part. Lower air pressure also reduces energy demand for the compression system. Adjusting the air current velocity in spray areas, especially with automated spray systems where worker safety is not an issue, will prevent atomized coating particles from straying from the workpiece. Spacing parts closer together on conveyors also helps eliminate overspray coating particles. Most importantly, training operators to manipulate spray equipment properly can provide much improvement. Spray gun movement must be compatible with the fluid spray rate. The spray gun should be held about twelve inches from the part and perpendicular to the work piece surface. The spray pattern should be adjusted to be slightly smaller than the part profile. The spray gun should be triggered at the correct time on leading and trailing edges.

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Section 2

Electrostatic Spraying

Electrostatic spraying improves on traditional spray technology by adding electrical forces to improve deposition of coating materials on the workpiece. An electrode imparts a negative charge on the coating material. The negatively charged particle is now pulled toward the workpiece by electrostatic forces as well as directed toward it from the velocity of the spray. As the coating droplet deposits on the part, the charge dissipates.

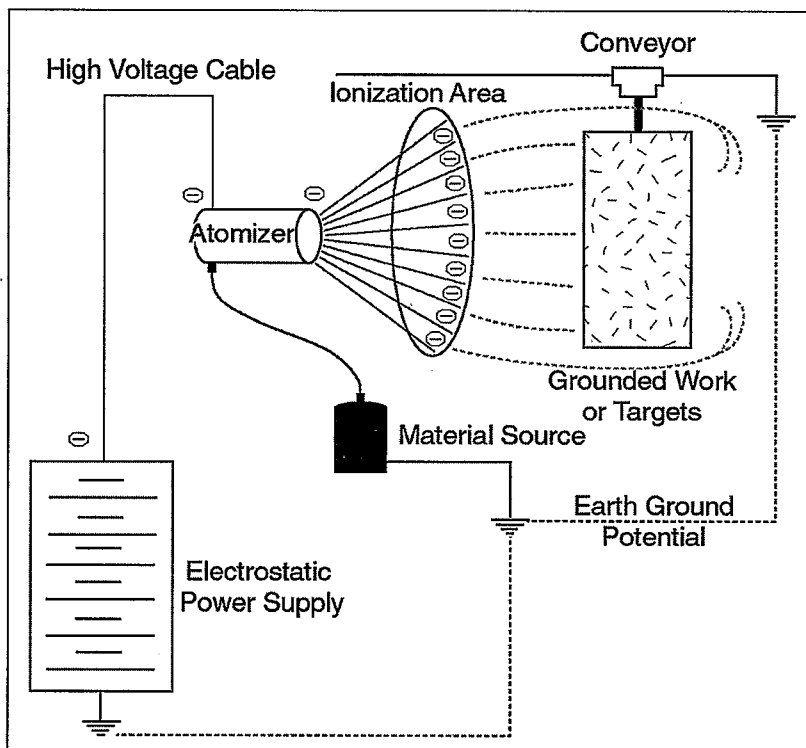


Figure 4-7: Electrostatic Spraying System.

Electrostatic spraying can be completed with methods similar to traditional spray technologies. Like traditional spray technologies,

electrostatic spraying systems combine fluid and air streams to create a mist of atomized coating particles. But electrostatic systems also incorporate a power supply to create the different charges between the coating material and workpiece. Common electrostatic spray systems include air-atomized spraying, airless spraying, air-assisted airless spraying, and bell or disk rotary spraying systems.

♦ **Air-Atomized Electrostatic Spraying**

Air-atomized electrostatic systems mix fluid and compressed air streams at the gun tip to atomize the coating materials into a fine spray. An electrode located at the gun tip imparts an electrical charge to the spray particles on exiting the gun. Additional air jets may be used to further define and control the spray pattern. Transfer efficiency is between 40% and 80%.

♦ **Airless Electrostatic Spraying**

Airless electrostatic systems force fluids at very high pressures through a very small orifice at the gun tip. When the fluid is exposed to the air, the coating material becomes atomized and charged by an electrode. The size and shape of the spray pattern is controlled by the orifice size. Airless systems apply paint at a very fast rate, so operator control is essential for a smooth, uniform finish. Transfer efficiency can range between 40% to 70%.

♦ **Air-Assisted Airless Electrostatic Spraying**

Air-assisted airless systems can also be used with electrostatics. These systems utilize the principles of airless systems by forcing the fluid at high pressure through a small orifice to be atomized. The atomization is assisted by additional air jets to reduce pattern tailing and to shape the spray pattern, as is done in air-atomized electrostatic spraying. Coating flow can be high to medium and coating materials with low or high viscosity can be used. Transfer efficiency for air-assisted electrostatic systems is typically between 50% and 85%.

♦ Bell and Disk Rotary Electrostatic Spraying

Rotary electrostatic systems use different principles to charge and atomize coating materials. Rotary systems consist of quickly spinning bell- or disk-shaped components. Coating materials flow onto the center of the component and the centrifugal force from rotation draws the material to the edge. At the same time, the bell or disk component is charged and transfers this charge to the coating materials. The coating is then released as a spray and propelled toward the workpiece.

Bell rotary systems have cup-shaped components mounted horizontally. The resulting spray of coating materials covers a wide area, so compressed air is often used to help direct the particles toward the part. Bells are often placed on reciprocators that oscillate up and down to ensure thorough coverage of parts. Bell systems offer superior transfer efficiency in the range of 70% to 95%.

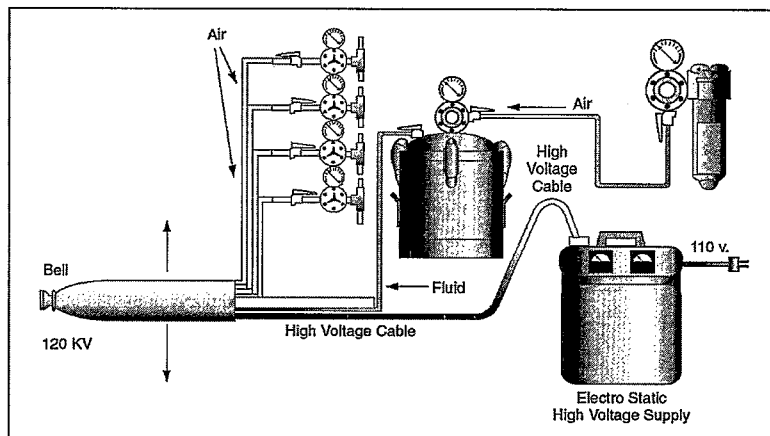
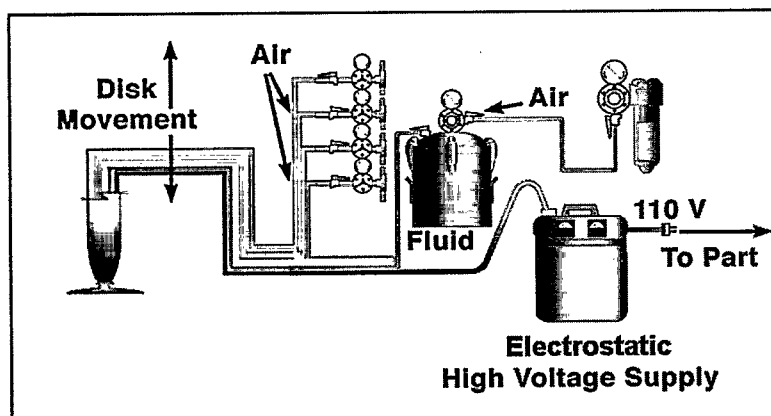


Figure 4-8: Bell Rotary Electrostatic Spraying System.

Disk rotary systems have saucer-shaped components mounted vertically. The resulting spray pattern is a narrow band of coating materials. Less compressed air is used because the paint leaves the disk in a more forward motion. Disk rotary systems are typically used on thin parts with omega-shaped conveyor systems. The parts enter the booth and follow a circular path around the disk and exit after making almost a complete circle. Transfer efficiency of disk systems ranges between 80% to 95%.



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Figure 4-9: Disk Rotary Electrostatic Spraying System.

Although electrostatic spraying systems work regardless of the type of coating material used, adjustments must be made based on the conductivity of the paint. Solvent-based and high-solids coating materials have a low conductive nature. These coatings accept the charge at the point of contact with the electrode, as the fluid is atomized into small particles. The charge does not pass between particles or into the fluid stream. Waterborne coatings, however, are highly conductive. As the charge is imparted to the atomized particles, it easily passes between particles and can be carried down the fluid stream. As such, the paint receptacle must be isolated from the electric potential so that charges applied to waterborne paints are not carried away to a ground.

Electrostatic spraying methods have increased transfer efficiency, while still maintaining the versatility and flexibility of traditional spraying methods. The improved transfer efficiency is due to the electrostatic force on the coating particles influencing the path they follow. The attraction between the negatively charged coating materials and the grounded workpiece causes more of the atomized material to hit and coat the work surface. The influence of the electrostatic force depends on the size and speed of the coating particle, and the air environment in the spray booth. Smaller and slower particles are more likely to be directly attracted to the part. Larger particles with high speeds have high momentum and are less receptive to the electrostatic forces; these particles are beneficial in coating corners and crevices where charged particles tend to miss. Overspray particles are attracted to the back of the workpiece further increasing transfer efficiency and reducing wasted paint.

Operator technique of manual electrostatic spray application technologies is critical to proper coating. The operator controls the

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distance from the gun to the surface, speed of each stroke, pattern overlap, spray gun angle, and timing of triggering. All of these parameters contribute to successful application of the coating materials and how much coating material is wasted. Automated systems with fixed guns mounted on reciprocators or guns mounted on movable robots alleviate some of the inconsistency in applying coatings with spray technologies:

Like traditional spray application, electrostatic spraying occurs in enclosures to help confine the coating material that does not deposit on the workpiece. Spray booths have equipment designed to control airflow. An exhaust system pulls paint-laden air through a filtration device that captures excess atomized particles. Dry filter booths are most common. These booths have cloth or polymer mesh filters to capture coating materials in the exhaust air. Often, a series of progressively tighter filters are used to remove larger, then smaller atomized particles. Filters must be replaced when clogged with coatings, and may be classified as a hazardous waste depending on the type of coating material used. Additional equipment may be required to control the release of emissions from the organic solvents in the coating material. Spray booths can allow movement of parts by conveyor or trolley if necessary.

All equipment used in an electrostatic spray system, such as conveyors, air and fluid lines, and most importantly, the operator, must be grounded to prevent a build up of excess electrical charge. While these components should not be grounded *better* than the parts to be painted, the grounding is necessary to prevent a static discharge and a spark that can cause a fire or explosion.

To clean electrostatic systems, the fluid coating materials are exchanged with solvent or water. The electrode is disconnected from the power source and the gun is triggered to flush coatings from the system. Coating must also be removed from other grounded equipment such as hooks or hangers, conveyors, and booths. Excess coating materials on these surfaces will prevent a ground from being maintained.

Electrostatic spray systems offer an improvement over traditional spray systems. The electric potential between the coating material and parts increases the amount of material that deposits on the part. Much less paint is wasted during their use. However, electrostatic spray systems atomize the solvents contained in the coating material, which increases their evaporation. This increased evaporation rate creates more air pollution burdens than other application methods. Electrostatic spraying systems are not specifically regulated, although they are recommended for meeting some air pollutant restrictions (40 CFR Part 63 Subpart GG).

The major source of pollution from electrostatic spraying applications is due to poor transfer efficiency. For most electrostatic spray systems, only about two-thirds of the coating material used actually ends up coating the workpiece. A significant amount of coating material is wasted during these processes. Since the coating material then falls on filters, masking materials, clothing or elsewhere, additional waste is created when these items are disposed or cleaned.

Electrostatic spray systems are considered a pollution prevention opportunity for organic finishing facilities. Electrostatic spray systems improve on the transfer efficiency of traditional spray systems, making them more desirable. Additional pollution prevention can be achieved from electrostatic spray systems by taking measures to improve the transfer efficiency of the system. Equipment changes from air-atomized spray systems to airless, air-assisted airless, or rotary spray systems, which have less atomization, improve transfer efficiency of coating materials.

Proper operation of electrostatic spray equipment can also improve transfer efficiency and reduce waste. Reducing the pressure of compressed air leaving the gun reduces the forward velocity of the particles so they are less likely to rebound off the part. Lower air pressure also reduces energy demand for the compression system. Adjusting the air current velocity in spray areas, especially if automated spray systems are used, will prevent atomized coating particles from straying from the workpiece. Spacing parts closer together on conveyors helps stray coating particles deposit on parts. Finally, training operators to manipulate spray equipment properly can provide much improvement. Spray gun movement must be compatible with the fluid spray rate. The spray gun should be held about twelve inches from the part and perpendicular to the work piece surface. The spray pattern should be adjusted to be slightly smaller than the part profile. The spray gun should be triggered at the correct time on leading and trailing edges.

NOTES

Section 3

Electrocoating

Electrocoating (also known as electrodeposition, electrophoretic deposition or electropainting) is an organic finishing process in which waterborne coatings are applied to metallic substrates with the use of an electric current. An electric potential is applied between the part and the liquid coating which attracts the paint onto the surface of the workpiece.

Two methods of electrocoating are available: anodic and cathodic. In anodic electrocoating, the ions of the coating materials are negatively charged. In cathodic electrocoating, the coating ions are positively charged. Most industries currently use the cathodic method for several reasons. During coating application, a metallic cathode will not dissolve into the coating solution, and the coating material more easily adheres to contaminated areas of the workpiece. Also, the resulting finish from cathodic electrocoating is more corrosion resistant, and the color of welded areas is more consistent with the rest of the part.

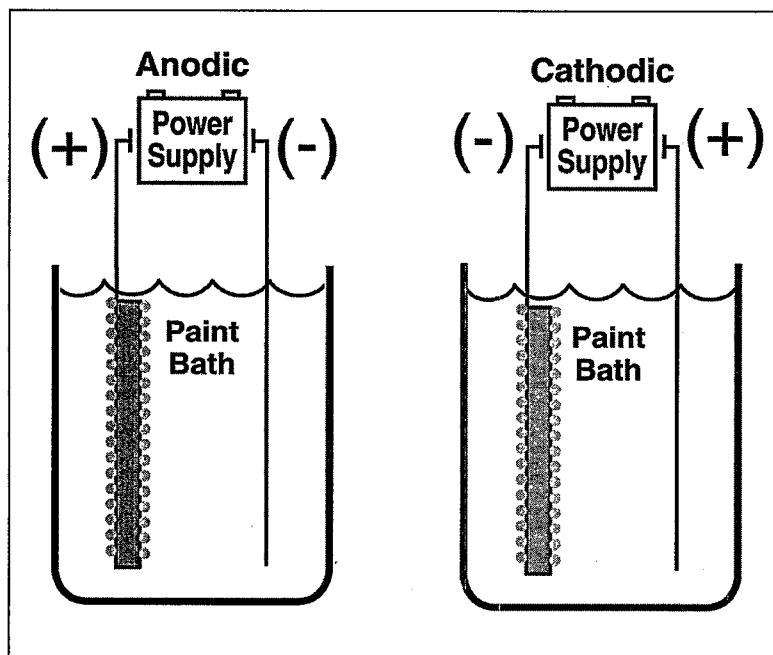


Figure 4-10: Anodic and Cathodic Electrocoating

Parts used in the process are first cleaned and pretreated to improve the adhesion of the electrocoating finish. Then, the workpiece is immersed for a few minutes in the coating material that is heated between 60° and 90° F. Actual operating times and temperatures are dependent on the desired coating thickness. The coating bath is agitated to keep a uniform concentration of coating materials throughout the bath.

After being removed from the coating tank, the part is rinsed one to four times to remove excess coating material. The part is sprayed or immersed in tanks with either deionized water, or a permeate rinse solution consisting of water, solvents, and salts. The rinse solutions are constantly filtered to remove contaminants and increase bath life. An ultrafilter is used to separate the coating material from the solvent or water. The coating materials are recycled to the electrocoating tank and the permeate and water is reused in the rinse cycles.

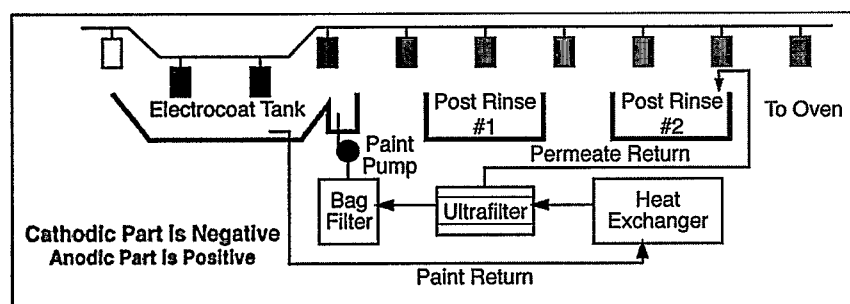


Figure 4-11: Electrocoating System with Rinse Solution Recycling.

The coating applied with this method is very uniform, and the coating thickness can be closely controlled by adjusting the operating parameters. Because the paint completely surrounds the part and is attracted to all charged surfaces, this method is appropriate for parts with complex geometry and hard-to-reach areas. Electrocoating is often used to apply a primer coat to the workpiece.

Because of the elaborate equipment that is required, electrocoating is generally suited only for large-volume finishing. It is not suited for small and medium sized companies that do not have sufficient throughput of material to justify the process, or that manufacture workpieces with several different sizes and shapes. Color change for most installations is very slow, so 95% of electrocoat installations paint only one color. Despite these restrictions, electrocoating is a popular metal finishing method. Because the rinse solutions can be processed to recover coating solids, the transfer efficiency of electrocoating applications approaches 90%.

NOTES

Electrocoating systems are a pollution prevention opportunity for organic finishing facilities and provide several advantages over spray systems in terms of environmental impact. Electrocoating is an acceptable method of applying organic finishes for most industries due to the high transfer efficiency. No regulations target electrocoating, although the composition of the coating material must be considered. Electrocoating systems essentially eliminate pollution and waste because they are often closed-loop processes. Residual coatings and rinses are captured and recycled, so overall transfer efficiency is high and wasted coating material low. In addition, the coating material in electrocoating systems is not atomized which reduces the evaporation of organic solvents and reduces air emissions.

NOTES

Section 4

Roll and Coil Coating

Roll and coil coating are application methods for continuous, flat parts processed at high speeds. Large sheets of metal pass between circular drums which apply the coating material; these sheets, then, are formed into cans, drums, or other simple structures.

The basic coating application operation for roll and coil consists of two or more rollers. The feed roller will receive the coating material either from an internal source, a reservoir underneath the roller, or a stream from above the roller. The feed roller passes the coating material through a series of rollers or directly to the applicator roller. As the coating material is passed between rollers, the consistency and thickness is more evenly distributed across the roller surface. The applicator roller then contacts the workpiece and coats the part. Coating thickness is controlled by the distance and pressure between the roller and workpiece. If only one side of the substrate is to be coated, a pressure drum will be placed on the opposite side of the workpiece; if both sides are to be coated, a similar feed roller and application roller configuration will be used on both.

Depending on the rotational direction of the rollers in relation to the movement of the part, the technique is called roll or coil.

♦ Roll Coating

Roll coating, or direct roll coating, is configured with the rollers turning in the same direction as the workpiece. The roller rotates counterclockwise as the workpiece is moved from left to right. As the part comes in contact with the roller, the coating is transferred. Because of the pressure between the roller and the metal, this process can impart a wavy surface to the coating layer that can be controlled by using low viscosity paints.

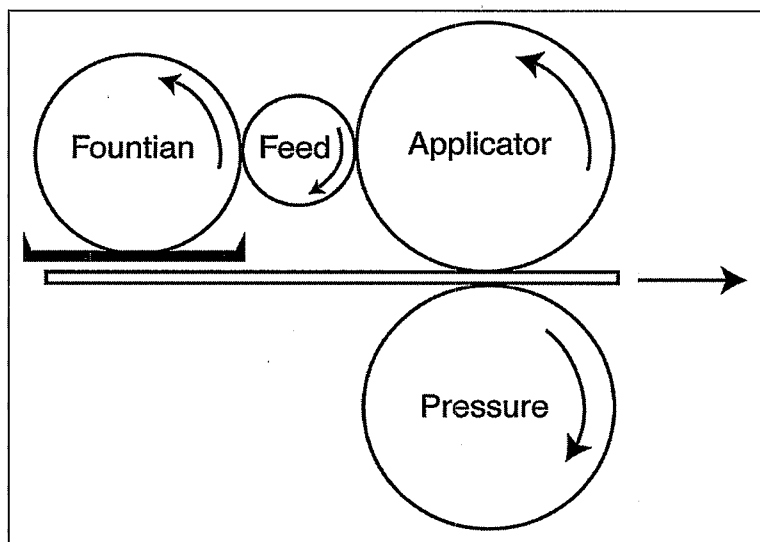


Figure 4-12: Roll Coating System.

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♦ Coil Coating

Coil coating, or reverse roll coating, is configured with the rollers turning in the opposite direction as the workpiece. The application roller rotates in a clockwise direction while the workpiece travels from left to right. As the roller and workpiece meet, the paint is literally scraped off the application roller by the part. The high shear resulting from the transfer helps to smooth out the coating surface. This method is preferred over roll coating for applying topcoats.

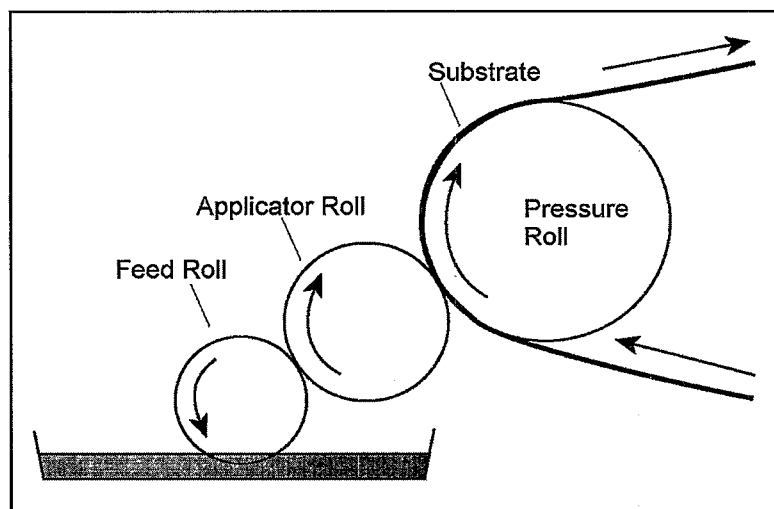


Figure 4-13: Coil Coating System.

NOTES

Roll and coil coating systems typically combine all organic finishing processes together. Pretreatment, primer, primer cure, topcoat application, and final cure are found in a continuous system. The long continuous sheets travel on a conveyor through each stage of the process as a take-up roll at the end captures the finished product. Roll and coil lines operate almost year round due to the continuous feed of metal into the system. Applicator rollers are usually gelatin-rubber or urethane-coated metal. Other rolls are polished steel or chromium-plated steel. Both solvent and waterborne coatings can be used in this process.

Rollers can be damaged easily, which will effect coating quality and require expensive replacement. Part shape is limited to flat continuous sheets or webs. However, the transfer efficiency is near 100% for both methods, as coating materials not applied stays on the roller. No material is wasted except when the equipment is emptied and cleaned.

Roll and coil operators have a few environmental issues to consider. Roll and coil systems use a large volume of coating material in a continuous flow. This creates some concerns with the evaporation of solvents and adverse air emissions. Roll and coil coating operations are specifically regulated under 40 CFR Part 60 Subpart TT - Standards of Performance for Metal Coil Surface Coating, with specific VOC emissions limitations depending upon the use of control devices. For facilities that do not maintain control devices, the VOC emissions must not exceed 0.28 kilograms of VOC per liter (kg/L) of coatings applied for each calendar month; for facilities that continuously use emission control devices, the VOC emissions must not exceed 0.14 kg/L for each calendar month. Alternatively, facilities may show that the VOC emissions of coatings as applied is reduced to less than 10% of their initial amount (a 90% reduction in VOC emissions).

As part of the Clean Water Act, Effluent Guidelines and Standards for Coil Coating (40 CFR Part 465) have been established that limit concentrations of heavy metals, toxic organics, and conventional pollutants in wastewater streams. The regulation is based on the type of metal being coated (e.g., aluminum, steel. etc.) and covers wastewater generated from all processes in the facility. The organic solvents often contained in liquid coatings used with roll and coil coating application methods may be classified as toxic organics. These materials can enter the wastewater when cleaning coatings from containers or equipment. Other wastewater may be generated during cleaning or surface activation stages prior to applying the coating material. Actual limits for effluent constituents are dependent on the size of the operation and the amount of wastewater generated from the facility.

NOTES

Overall, roll and coil coating applications create very little pollution and offer pollution prevention over traditional spray systems. Roll and coil systems are typically closed-loop systems and run continuously without needing to be adjusted or cleaned. Coating materials are recirculated, leading to high transfer efficiency and little waste.

Section 5

Dip, Flow, and Curtain Coating

Dip, flow, and curtain coating processes apply liquid organic coatings to parts in high throughput operations. Coating materials can be applied quickly to a workpiece by dipping or showering it as moves through the process. Control of operating parameters including temperature, conveyor speed, and viscosity ensure proper coating properties and film thickness.

♦ Dip Coating

In dip coating, parts are suspended from a conveyor. The parts are immersed in a bath filled with liquid coating material. When the part is removed from the bath, surface tension pulls off excess coating material that keeps the coating thickness uniform and reduces drain-off time. The conveyor system carries the part over a drainboard to catch excess coating that drips from the part. This material drains back into the bath reducing waste. The tanks, which hold the liquid coating, typically have agitation devices to keep the coating material consistent throughout the bath. When not in use, lids cover the tanks, which help reduce evaporation of solvent.

This process is most effective at coating simple geometric parts that do not have "cupped" areas. Cupped or recessed areas facing down will trap air when lowered into the tank, leaving the inside surface uncoated. Cupped areas facing up will hold coating material while the part is being removed from the bath. Frequent color changing is difficult and costly because separate coating tanks or holding tanks are required. However, this process has a transfer efficiency of approximately 95%. Parts are thoroughly coated with one dip and excess coating material drains back into the tank.

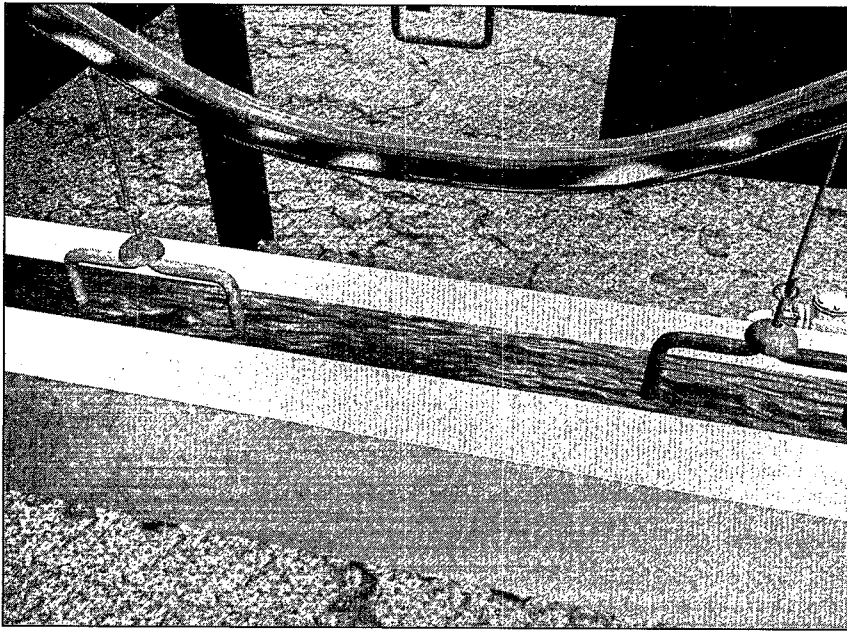


Figure 4-14: Dip Coating System.

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◆ Flow Coating

Flow coating involves pumping liquid coating materials around moving parts without atomizing the coating stream. In an enclosed area, coating material is pumped from a reservoir through nozzles stationed at various distances, heights, and angles. The paint is showered into the center of the enclosure where the parts move while suspended from a conveyor. Excess material that misses a part or drips off a part is collected at the bottom of the enclosure and circulated back into the system for reuse.

Part complexity is not an issue with flow coating as the nozzles can be configured to reach all sides of a moving part. This process can limit coating application to either exterior or interior surfaces depending on the timing and locations of the nozzle spray. However, the part should be positioned so that coating material is not trapped in recesses, but can flow downward to be recovered. Transfer efficiency for flow coating processes can reach 95%.

◆ Curtain Coating

Curtain coating is a specialized flow coating process. Instead of a random showering of coating material, a continuous falling sheet of liquid material is used to coat parts. The part, typically a flat panel with

no recesses, is held in a horizontal position while passed under the curtain on a conveyor. To create the curtain, organic coating is pumped from a supply reservoir through a filter to a coating head over the conveyor. When the head is full and reaches the overflow level, it flows over the length of one side as a curtain. A basin collects and returns any excess material back to the reservoir tank.

Control of the pumping process is necessary to prevent breaks in the curtain that would result in uncoated part sections. For high quality coating characteristics, solvent-based coatings are preferred. This process has fast throughput rates, and is flexible enough to apply multiple layers. Two or more coating layers can be applied in one pass. However, the mixing of coating materials in the collection basin may prevent recovery and reuse. Transfer efficiency can reach above 90% with this method if coating materials are collected and reused.

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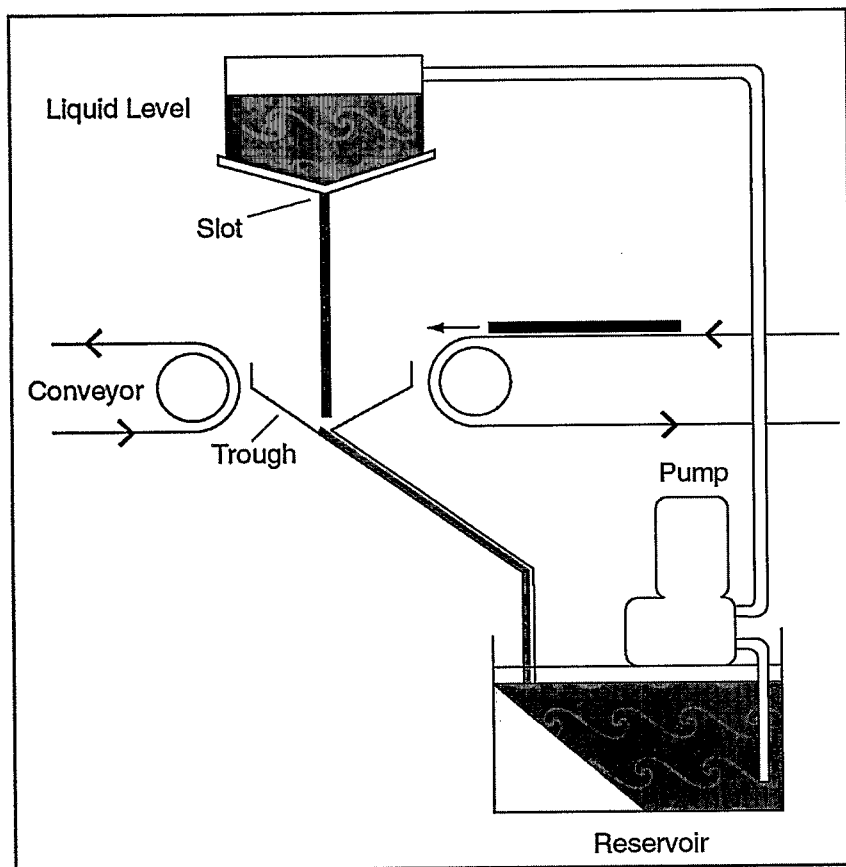


Figure 4-15: Curtain Coating System.

Overall, dip, flow, and curtain coating methods offer several advantages over other coating application methods. Most types of coating materials, including high-solids coatings, can be used either with dip, flow, or curtain coating methods. Coating thickness is more uniform and controlled since the methods depend on timing of conveyor speed and paint flow rate rather than operator ability. The equipment does not require excessive maintenance, although color changes require separate holding tanks. Most importantly, these methods have superior transfer efficiencies as compared to traditional spraying application methods.

Dip, flow, and curtain coating offer facilities a pollution prevention opportunity. Dip, flow, and curtain coating systems are often closed-loop processes that essentially eliminate pollution and waste. Coatings that do not adhere to parts are collected in catch basins and recirculated for future use, so overall transfer efficiency is high and wasted coating material low. The motion of the coating materials through the systems may increase the volatilization of solvents within the coating material, but the rate is much less than that of spray systems.

Pollution prevention tactics can be used when using dip, flow, or curtain systems. Additional waste reduction is achieved by increasing the drain time and area for the parts after they have been coated. This allows excess material to return to the collection basin. If multiple coatings are used in a single system, steps should be taken to prevent coatings from mixing together. Increasing the distance between the streams and having separate catch basins for each will keep the different coating materials separate and allow them to be recirculated.

NOTES

Section 6

Powder Coating Methods

Powder coating materials have their own class of application methods. Because they are in dry form and not liquid, powder coating materials cannot be applied with traditional coatings methods and equipment. However, powder coating application methods are designed to provide high transfer efficiency and achieve good coating coverage. Powder coating techniques include electrostatic powder spraying, flame spraying, powder flocking, fluidized bed coating, and electrostatic fluidized bed coating.

♦ Electrostatic Powder Spraying

Electrostatic powder spraying is similar to traditional electrostatic spraying of liquid coatings. Powder coating materials are pumped from a hopper through hoses to a modified spray gun. An electrode imparts a negative charge to the coating particles as they exit the gun that helps to attract them to the grounded workpiece.

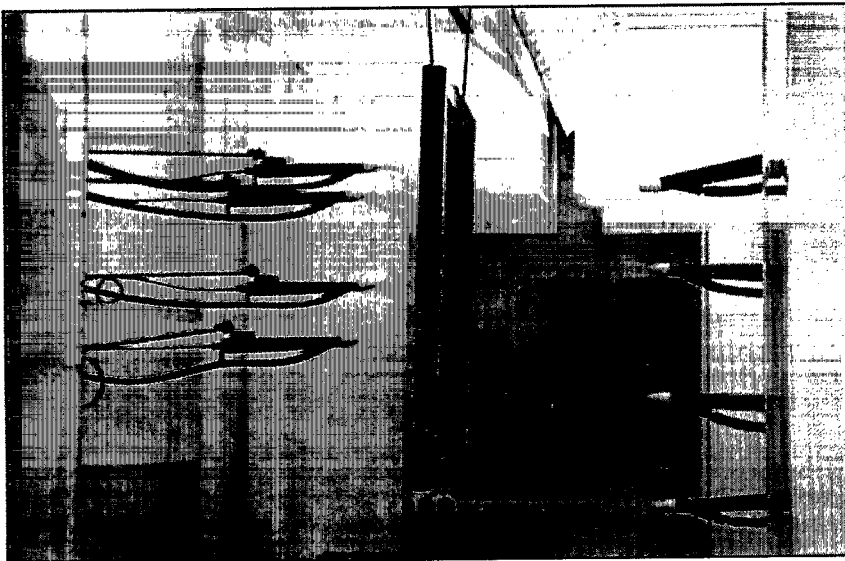


Figure 4-16: Electrostatic Powder Spraying System.

♦ **Flame Spraying**

Flame spraying techniques are similar to electrostatic powder spraying systems, but heat, instead of an electric charge, is supplied at the gun tip. The powder is blown through a flame where it is partially melted and projected towards a preheated substrate. The melted particles adhere to the part and begin to form a film immediately.

♦ **Flocking**

Flocking application methods are similar in theory to flow coating of liquid materials. Powder coatings are mixed with compressed air and pumped through guns. The powder coating flow is distributed around the preheated workpiece. When the powder coating particles contact the heated surface of the part, they begin to melt and adhere.

♦ **Fluidized Beds**

In fluidized beds, powder coating materials are placed in an open container. Air flows into the container through a ceramic filter at the bottom, suspending the dry particles in the container. Parts are heated slightly and dipped into the container. The particles that touch the part are partially melted, coating the surface of the workpiece. Coating thickness is difficult to control because particles touch and melt in random locations.

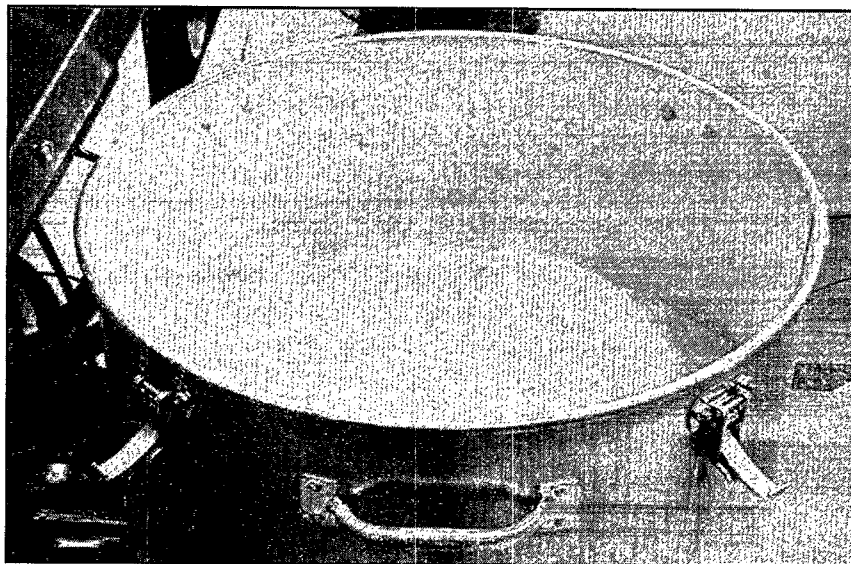


Figure 4-17: Powder Coating Fluidized Bed System.

♦ **Electrostatic Fluidized Beds**

Fluidized beds can also incorporate electrostatics to assist in coating. An electric charge is applied to the coating materials as they pass above the ceramic filter. This method does not require the part to be preheated, and coating thickness is more controllable by the amount of charge given to the particles.

One major advantage of powder coating application methods is the high transfer efficiency. Unmelted powder coating materials that do not adhere to the part can be collected and reused. Electrostatic powder spraying and flocking are typically performed in enclosed booths with vacuum systems to capture powder that does not adhere to the part. The powder is returned to the hopper for reuse. Fluidized beds retain the powder materials within the system much like dip tanks used with liquid coating materials. Melted powder coating materials from flame spraying methods cannot be reused. Overall, transfer efficiencies for powder coating spray applications approach 95% to 100%. In addition to the low material waste, the extremely low volatile organic content of powder coating materials virtually eliminates any air emissions during their application. Care must be taken to avoid mixing different powder coating types if applied using the same equipment or in sequential systems. Mixed powder coatings materials usually cannot be reused.

Section 7

Environmental Considerations for Application Methods

Application methods for organic finishing share common environmental issues. Regulatory violations and sources of pollution among the various technologies are found to be very similar. Pollution prevention tactics can be followed by organic finishing facilities regardless of the application method used. Many environmentally related problems stem from the type of coating material used and its solvent content, rather than from the specific type of application method being used. Environmental issues concerning the coating materials are discussed here briefly.

Regulatory Requirements

Except as noted in the previous sections, application methods have few direct restrictions from environmental regulations. Facilities should be aware of a few general regulations under the main environmental acts.

♦ Air

The Clean Air Act regulates the emission of volatile organic compounds (VOCs) (40 CFR Part 60) and hazardous air pollutants (HAPs) (40 CFR Part 61 and 40 CFR Part 63). 40 CFR Part 60 covers organic finishing for metal furniture, automobiles and light duty trucks, large appliances, coil coating, and beverage can industries. 40 CFR Part 63 restricts HAP from the aerospace and shipbuilding and ship repair industries. Depending on the solvent content and the volume of coating material used, solvents can evaporate and produce sufficient VOC and HAP emissions to subject an operator to major source requirements and Title V permitting requirements. If VOC emissions cannot be eliminated completely, they must be controlled. Air pollution control equipment, such as recovery or incineration units, is often found with the ventilation associated with application equipment. These units capture VOCs prior to their release into the atmosphere.

♦ Water

As part of the Clean Water Act, Effluent Guidelines and Standards for Metal Finishing (40 CFR Part 433) have been established that limit concentrations of toxic organics in wastewater streams. The organic solvents often contained in liquid coatings used with various application methods may be classified as toxic organics. These materials can enter the wastewater from liquids (water or solvents) used to clean containers, equipment, or work areas. Actual limits for effluent constituents depend on the size of the operation and the amount of wastewater generated from the facility. If the facility discharges directly to receiving waters, these limits will be established through the facility's National Pollutant Discharge Elimination System (NPDES) permit (40 CFR Part 122). Facilities which are indirect dischargers releasing to a publicly owned treatment works (POTW) must meet limits in the POTW's discharge agreement. Wastewater streams with concentrations exceeding permit limits will require pretreatment prior to discharge to receiving waters or to a POTW. Pretreatment may include separation of liquid wastes to remove solvents, and settling or precipitation of solid materials.

♦ Solid and Hazardous Waste

Under the Resource Conservation and Recovery Act (RCRA), organic finishing facilities are required to manage listed and characteristic hazardous wastes (40 CFR Part 261). Depending on their formulation, coating materials may contain constituents listed or characterized as hazardous wastes. Materials contaminated with the coatings, such as spray booth air filters, masking materials for fixtures and floors, and rags or containers used when cleaning, may require treatment as hazardous waste. Hazardous waste management (40 CFR Part 262) includes obtaining permits for the facility in order to generate wastes, meeting accumulation limits for waste storage areas, and manifesting waste containers for off-site disposal. Responsibilities will vary according to the amount of hazardous waste material generated; facilities generating at least 100 kilograms of hazardous waste per month must comply. Each state and/or region is primarily responsible for the regulation of non-hazardous solid wastes (those not governed by the hazardous waste provisions of RCRA). Check with state environmental agencies for specific information or guidance.

Common Causes of Violation

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The air emission regulations may be violated if evaporated solvents classified as volatile organic compounds and/or hazardous air pollutants are allowed to accumulate above limits allowed by the Clean Air Act. Ventilation and exhaust systems must operate properly to ensure the vapors are removed from the application area. Adequate fresh air volumes must circulate and any particulate filtration devices must not be clogged. Air pollution control equipment should be attached to exhaust systems to recover or destroy volatile organic compounds instead of releasing them to the air.

Wastewater can easily become contaminated with coating materials or cleaning solvents. This may occur with the use of waterwash spray booths, disposal of materials, or accidental spills of coating material or wash solutions. Contaminated water streams may contain pollutants in concentrations exceeding limits established by facility NPDES permits or POTW discharge requirements. As a result, effluent, may not be directly released to water systems or to POTWs without pretreatment.

Materials that contact coating waste or cleaning solution must be handled accordingly. If the materials are classified as hazardous, they must be properly stored, manifested and disposed according to RCRA standards for hazardous waste (40 CFR Part 262).

Sources of Pollution

Specific sources of pollution have been covered in more detail in each section previously. With all types of application, pollution is created from two main areas - wasted coating materials and cleaning processes. Coating material that is not used to coat parts and cannot be captured and reused is the major source of waste. Spray applications with the lowest transfer efficiency create the most wasted coating material. The other methods allow excess material to be collected and reused on other parts. Cleaning must be done periodically to all equipment and work areas. Cleaning solutions and tools such as brushes or rags must be discarded. Again, higher volumes of cleaning waste is associated with spray systems that must be cleaned more frequently and thoroughly. Continuous application systems, such as dip, electrocoating, and roll coating, do not require as much cleaning and therefore produce less waste.

Pollution Prevention Alternatives

NOTES

Numerous pollution prevention alternatives are available for application processes to reduce waste. The most effective is to change to an application method with higher transfer efficiency. Switching from traditional spray systems to dip, flow, or powder methods greatly reduces the amount of pollution and waste created. This is not always feasible due to part constraints, facility restrictions, or personnel requirements, not to mention the associated capital costs. Several actions can still be taken without changing equipment that will reduce facility pollution and waste.

♦ Material Substitution

First, facilities should evaluate the coating material currently used and its solvent content. Lowering or eliminating solvent in the coating material will greatly reduce air pollution, wastewater problems, and solid waste restrictions. Solvent thinners can be reduced by using heat to lower the viscosity of coating materials.

♦ Materials and Waste Handling and Storage

If the type of coating material cannot be changed, proper handling of the materials will help reduce waste. Large containers of the material, such as dip tanks or collection basins, should be covered whenever possible to reduce evaporation of solvents and prevent contamination by dirt and other debris. Non-hazardous coating solids and water should be segregated from hazardous solvents and thinners, and containers labeled to prevent mixing. Separation of the materials reduces the amount of hazardous waste that is produced. Coating material solids can be dried and treated as a solid waste for disposal in a landfill.

♦ Operations and Procedures

Next, operational changes can reduce waste. Schedule paint jobs to minimize changing colors in equipment. If several colors are required, use a different set of equipment for each individual color rather than cleaning equipment with solvents each time a new color is used. If extra equipment is not an option, schedule painting with light colors first, then darker ones; lighter coating does not need to be completely removed from the equipment, but can blend into the darker coating. Pre-inspect parts to eliminate rejects prior to painting. Orient parts properly to minimize recessed areas that would hold excess coating material.

♦ **Maintenance and Housekeeping**

Facilities should perform regular maintenance and housekeeping. Regular inspection and maintenance of equipment will assure that valves, regulators, gauges, and other monitoring devices are working properly and providing consistent coating. Keeping painting areas clean will allow improper coating techniques and equipment leaks to be observed and fixed quickly. Accidents can also be prevented. Regular cleaning is also essential to pollution prevention. Cleaning will remove coating materials from equipment to prevent drying and clogging of hoses, valves, and pipes. Water should be used for cleaning when possible to reduce the amount of organic solvents used and amount of hazardous waste generated. Perform the initial flush of application equipment with used solvent, saving fresh solvents for final cleaning stages. When cleaning, point spray guns and drain tank residues into an enclosed area, such as a barrel or can, to capture coating materials, and solvents.

♦ **Training**

Finally, properly trained employees are essential to any pollution prevention plans. Train employees on the correct operating procedures for application methods. This will reduce reject parts, wasted coating materials, and damage to equipment. Train employees on safe handling of materials and wastes and encourage continuous improvement. Training familiarizes workers with their responsibilities, which reduces spills and accidents.

NOTES

Section 8

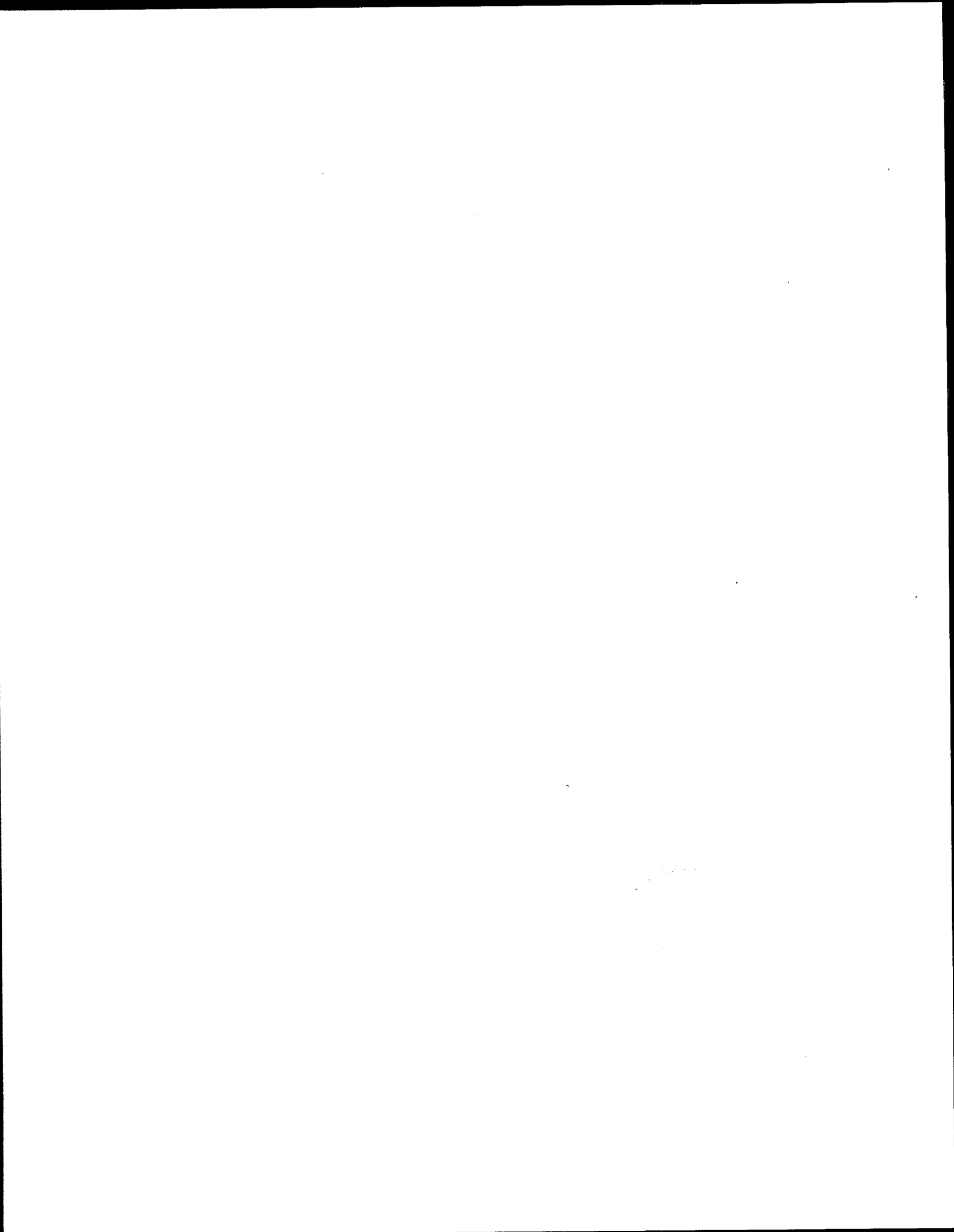
Chapter Summary

The application technologies discussed in the chapter are summarized in Table 4-1. These six methods are quite common in the organic finishing industry although new methods are being developed. Methods such as supercritical fluid spraying or autodeposition increase transfer efficiency while maintaining good coating characteristics. The table also provides the coating materials and part geometries typically used with each application. The combination of coating material, part geometry, and production variables must be considered when developing an application system. Ranges of transfer efficiency are also provided in the table to give a quick comparison of the different methods.

The application process is essential to providing the proper coating on a workpiece, but it also contributes a good amount to the environmental concerns of an organic finishing facility. Air pollution from volatile organic compounds is the main issue for facilities. VOC emissions can be reduced in two ways: use coating materials with fewer VOCs or use less coating material. Some application methods restrict the type of coating materials that can be used, so lowering VOCs in the coating material may not be possible. But the technologies can be used to increase transfer of the material to the parts with less waste. The application methods discussed here cover a wide range of transfer efficiencies.

NOTES**Table 4-1: Typical Organic Finishing Application Methods.**

APPLICATION METHOD	TRANSFER EFFICIENCY	COATINGS USED	PART GEOMETRY
Spraying		For each:	For each:
Air-atomized	15%-40%	Solvent-based	Simple to complex
Airless	20%-50%	High-solids	Large areas to small parts
Air-assisted Airless	30%-60%	Waterborne	
HVLP	30%-75%		
Electrostatic Spraying		For each:	For each:
Air-atomized	40%-80%	Solvent-based	Simple to complex
Airless	40%-70%	High-solids	Large areas to small parts
Air-assisted Airless	50%-85%	Waterborne	
Rotary	70%-95%		
Electrocoating	90%-98%	Waterborne	Simple to complex Medium to small parts
Dip, Flow, and Curtain	90%-100%	Solvent-based High-solids Waterborne	Flat panels or simple Medium to small parts
Roll and Coil	95%-100%	Solvent-based High-solids Waterborne	Flat continuous sheets
Powder Coat Methods	95%-100%	Powder	Simple to complex Large to small



CHAPTER FIVE

CURING METHODS

Curing is the final stage of the organic finishing process. Curing has two stages. The first is the removal of the solvent or diluent through evaporation so that the coating is no longer wet to the touch. This is often called drying. The second stage is the actual curing, during which the resins or binders in the coating material are undergoing a chemical reaction. The reaction causes crosslinking between the resin molecules and renders the coating film relatively inert to the environment. In the curing of powder coating materials, because no solvent or diluent is there to be removed, only the second stage occurs.

Regardless of the type of technology used, curing equipment generates thermal energy that is absorbed by the coating and part. The curing stage elevates the workpiece and coating to a particular temperature and holds that temperature for a set period of time. The combination of temperature and time serves to evaporate solvents and set the coating. Temperature and exposure times are carefully monitored to ensure proper curing and drying. Extended baking or exposure to heat sources may impair the coating characteristics.

If ambient air conditions permit, curing of low-solvent coatings can be completed in open areas. No heat is generated or supplied to the area, but air circulation may be enhanced by blowers and fans. Open air curing is often done during the warmer summer months.

The type of curing method employed is often dictated by the coatings materials used. Air dried coatings are defined by the EPA as those that cure at room temperatures, while those that cure at temperatures up to 194° F are classified as forced-air dried. Baked coatings require a curing stage at temperatures above 250° F. Others coatings are classified as radiation curable. The curing occurs when the part and coating are exposed to infrared, ultraviolet, microwave, or other radiation.

Two common curing technologies are convection ovens and infrared radiation systems. Both provide consistent curing of many different coatings. This chapter describes each of these systems and their environmental issues.

Section 1

Convection Oven Curing

Convection ovens are used in organic finishing for curing and drying. Some solvent-based paints require heated drying and curing, while most waterborne and powder coatings demand it. Industrial convection ovens are designed to move heated air around an enclosed area. The heat accelerates the release of vapors and the formation of chemical bonds to create the final coating surface.

Convection ovens consist of large metal, brick, or ceramic housing structures where heated air circulates. The heat can be generated by electricity, gas, or other energy sources. Typical temperatures for ovens used in metal finishing processes range from around 100° to 500° F and baking times range from a few minutes to an hour.



Figure 5-1: Convection Oven Curing System.

Air from the oven is continually recirculated to the heater unit or exhausted. The exhaust system removes excess volatile organic compounds released from the paints and eliminates any smoke build up

inside the oven shell. Additional equipment may be needed with the exhaust system to capture harmful vapors before they enter the atmosphere.

Convection ovens can be a batch system where parts remain stationary and are placed in and removed from the chamber at various times. Ovens can also be continuous systems where parts move through the heated area on a conveyor or overhead trolley.

Two types of gas convection ovens are direct-fired and indirect-fired. In a direct-fired oven, the heated air and combustion products pass over the parts. If the combustion products would adversely effect the coating characteristics, an indirect-fired oven must be used. In indirect-fired ovens, the combustion products do not directly come in contact with the parts. Instead, air in the heating chamber is passed through a heat exchanger to heat the oven area where the parts are contained. Indirect-fired ovens can require a third more energy than direct-fired systems.

Using convection ovens for curing is not restricted by part geometry. Because the entire mass of the part is heated to the required temperature, the paint is cured on all surfaces. Larger or more complex parts, however, may need to remain in the oven for a longer period of time than smaller, simpler parts. Cooling may be required after a part leaves an oven before it can be handled or be processed further.

Convection ovens, depending on their design, are not as energy efficient as radiation systems. Heat is easily lost through the doors (i.e., where parts enter and exit) and oven walls, when heated parts exit, and through exhausted air.

NOTES

Section 2

Infrared Radiation Curing

Radiation systems cure organic coatings by supplying heat in the form of wavelengths. Infrared (IR) radiation is the most prevalent form of radiation curing, although ultraviolet light, microwaves or radio waves are also used. The transfer of heat energy from the emitter to the target is precise and rapid, making radiation curing popular in organic finishing systems.

In infrared systems, different wavelengths correspond to different temperatures. Long wavelengths produce temperatures up to 500°F, while short wavelengths can emit temperatures up to 4000°F. As the IR waves are directed at a coated part, the thermal energy is absorbed by the coating or substrate to accelerate the curing and drying of the coating materials.

Depending on the wavelength of infrared radiation emitted, different components of the target absorb the energy. Long wavelengths are absorbed slowly by the coating at the surface; the rate of absorption is the same as that in a convection oven. These long wavelengths will eventually heat the whole mass. Medium length IR radiation heats the coating from the center with some losses by conduction to the metal substrate or the air. Use of medium wavelengths is most efficient because the coating receives the most thermal energy. Short wavelength radiation will penetrate the coating and heat the substrate directly, which will eventually heat the coating by conduction. Coatings that may be adversely effected by heat should be cured with short wave radiation to avoid surface defects, such as bubbling or blistering.

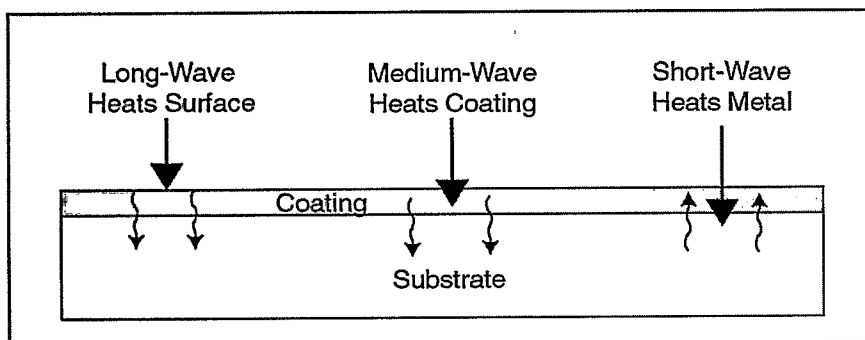


Figure 5-2: Absorbtion of Infrared Radiation by Coating Materials.

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The choice of wavelength is based on the polymer or resin and the pigment color. The infrared wavelength should be set in a range that will be absorbed by the resin so that crosslinking and bonding of the molecules will occur. At the same time, the infrared wavelength must also be absorbed by the color of the coating instead of scattered. Typically, wavelengths greater than 5.5 nanometers are effective. Some coating materials have been specially formulated to cure with IR radiation; however, conventional coatings can be used with infrared heaters once the optimal wavelength for absorption has been determined.

The design of infrared heaters varies based on the wavelength and intensity of the radiation emitted. Short waves with high intensity are created with quartz tubes. External reflectors of gold or ceramic direct the waves toward the product. Medium length waves with medium intensity can be formed with wide, flat type coils covered with quartz or ceramic. Alternatively, metal rods or quartz tubes, with or without reflectors, can be used. This configuration allows rays to be directed precisely or packed closely in smaller, controllable zones. Long wavelengths at low intensity are emitted from electric metal-faced or fiberglass panels, or ceramic cylinders on reflectors. For long wavelengths, another option is gas heaters that chemically catalyze the gas on a surface instead of burning it; this typically creates a combination of convection and low intensity IR radiation.

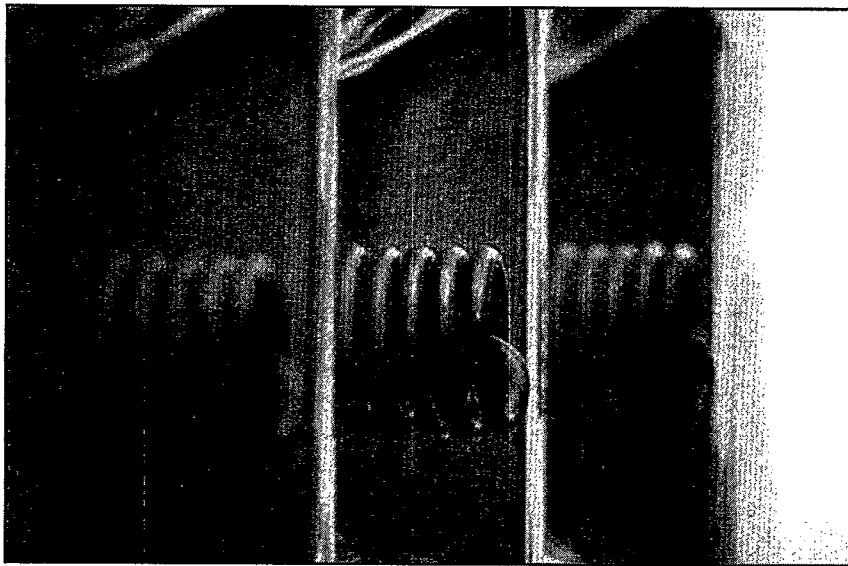


Figure 5-3: Infrared Radiation Coils.

To achieve good results, infrared curing systems must be properly designed and the operating parameters optimized. In addition to the

choice of wavelength and time, the infrared ray emitters and the part must be arranged properly. Infrared curing is a line-of-sight process, so heat only reaches areas where the radiation is directed. Parts in sheets or simple forms work well with IR curing. Bends, corners, and recesses of complex parts may be missed by the wavelengths. Careful configuration of the emitters and orientation of the part can reduce areas in shadows and allow complete curing. One benefit of this attribute is that if only a portion of a part is coated, only that section needs to be exposed to the IR rays.

Infrared curing is more efficient than conventional convection oven curing due to several reasons. First, the transfer of heat energy to a part is much faster with IR rays than with heated air. Second, when using infrared systems, specific layers of the workpiece are heated to focus the energy on the proper target, as compared to convection ovens where both the coating films and workpiece substrates must be heated to achieve thorough curing. Third, infrared systems must only heat the coating layer to the curing temperature; but in convection ovens, the entire part must reach the curing temperature to ensure good coating results.

Often, infrared curing is used in conjunction with convection oven curing. The IR system is used to bring the workpiece up to the curing temperature very quickly. Then, the part enters a convection oven where the heated air ensures that all surfaces, especially on complex parts, are fully cured and dried. This dual system allows for simple configuration of the IR heater.

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Section 3

Environmental Considerations for Curing Methods

Curing methods typically do not contribute significant environmental burdens to organic finishing facilities. Most concern is from the type of coating material used. Excess solvents in the coating material that evaporate during the curing stage must be captured to prevent air pollution. Curing systems do require large energy inputs, so consumption of electricity or natural gas is an issue.

Regulatory Requirements

♦ Air

The Clean Air Act regulates the emission of volatile organic compounds (VOCs) (40 CFR Part 60) and hazardous air pollutants (HAPs) (40 CFR Part 61 and 40 CFR Part 63), and provides specific standards of performance to control emissions from various types of coating operations (40 CFR Part 60). Depending on the solvent content of the coating material applied, sufficient VOC and HAP emissions could develop during curing operations to subject an operator to major source requirements and Title V permitting requirements. The Act also regulates the formation of nitrogen oxides (NO_x) from combustion sources; however, emissions of NO_x are often well below compliance levels for small operations.

Controlling VOC emissions can be accomplished in two ways. A coating material with a lower VOC content can be used. Otherwise, air pollution control equipment is required on curing exhaust systems to recover or incinerate the VOCs and HAPs before they are released from the facility. Controlling NO_x emissions can be achieved by adding oxidation systems, scrubbers or adsorbers to the exhaust system if necessary.

Common Causes of Violation

Emission of volatile organic compounds or hazardous air pollutants from heating structures may occur and exceed limits allowed by Clean Air Act

Title V permits. The quantity of VOCs or HAPs released from the curing depends on the amount of organic solvent in the coating formulation. These emissions in the exhaust air stream can be captured and treated to prevent their release to the atmosphere. Common air pollution control tactics include solvent recovery, solvent incineration, and solvent concentration.

Emission of nitrogen oxides (NOx) may occur and exceed limits allowed by Clean Air Act Title V permits. The quantity of NOx formed depends on the amount of combustion products and evaporated diluent that combine and come in contact with a direct flame.

Sources of Pollution

The biggest source of pollution from curing systems is air pollutants. Volatile organic compounds and hazardous air pollutants may be released from the coating material, depending on the formulation. Emissions of nitrogen oxides (NOx) may be produced when products of combustion and curing contact a direct flame. A major concern is inefficiency in curing systems. Heat loss through oven doors, heated work pieces, poorly insulated walls, and improperly sealed panels uses additional energy. Finally, poor circulation of heated air and improper alignment of infrared heaters can result in unacceptable finish on the parts. The parts become waste, or must be reworked.

Pollution Prevention Opportunities

A few pollution prevention opportunities are available to improve curing system operations. Volatile organic compound and hazardous air pollutant emissions can be reduced by using powder coating or waterborne coating formulations where possible, rather than solvent-based coating materials. Nitrogen oxide (NOx) emissions can be reduced by introducing fresh air into the combustion chamber. Fresh air will lower the flame temperature and prevent NOx formation. Heat loss can be reduced by improving insulation of the structure, and sealing panel joints. Proper curing can be achieved consistently by monitoring airflow circulation systems for accurate operation in convection heaters. In radiation systems, proper curing can be achieved by optimizing the wavelength, exposure period, and part arrangement. Curing can also be improved by introducing air into the system to distribute latent heat more evenly across part surfaces.

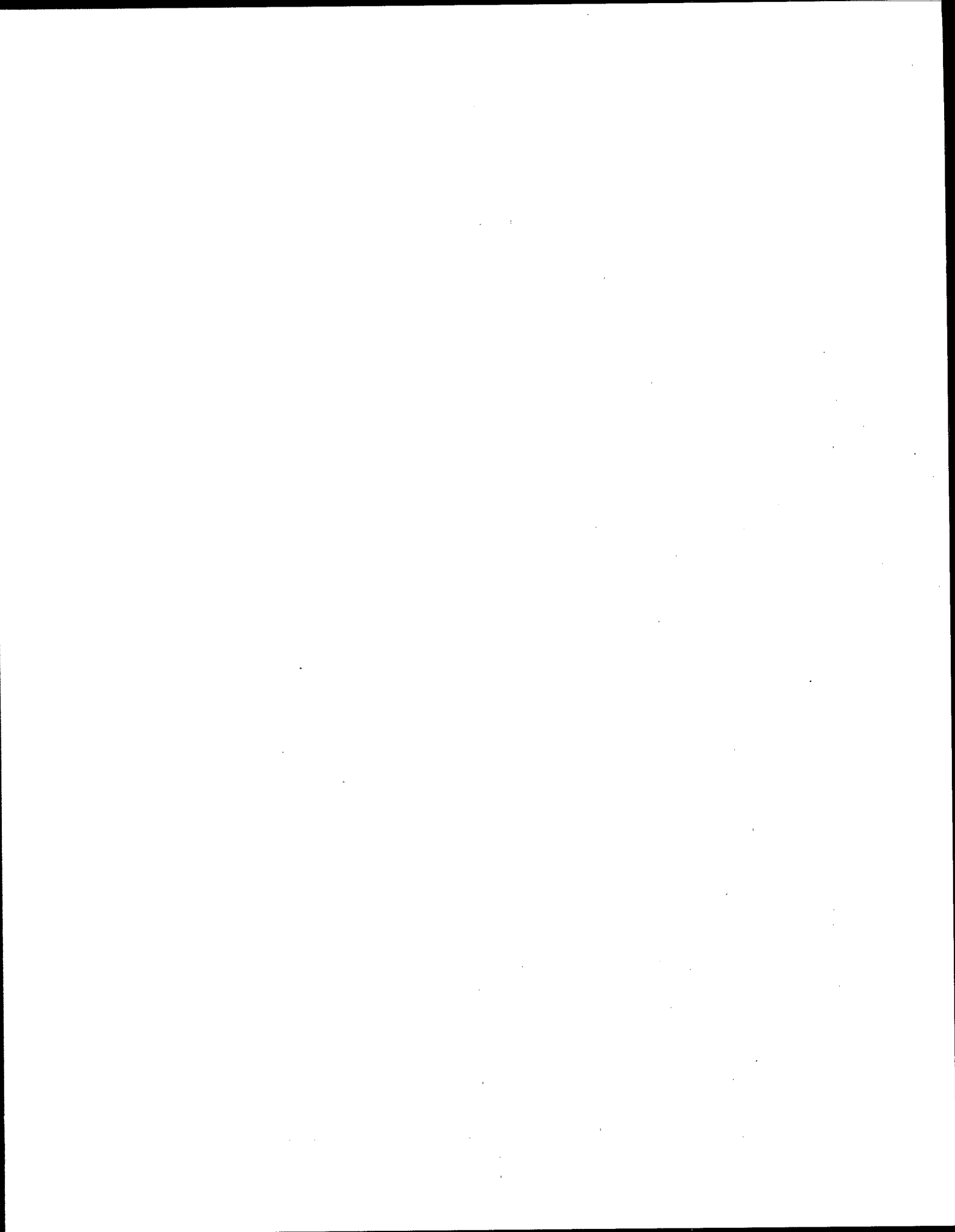
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Section 4

Chapter Summary

Curing systems complete the process for manufacturing workpieces with an organic finish. The heated cycle dries the coating material by promoting the evaporation of any liquid solvents or water. It also provides the thermal energy necessary for the binders in the coating material to form bonds and adhere to the part surface. Typical curing systems include convection ovens and radiation heaters. Convection ovens heat the air surrounding parts to cure the coating. Radiation heaters, such as infrared radiation systems, use energy at different wavelengths that are absorbed by the coating material to cause the curing.

Curing systems themselves create a minimal amount of environmental burdens for organic finishing facilities. All systems require a large energy input, and thus consume natural resources. Convection ovens using natural gas may create nitrous oxide emissions. The biggest source of pollution is from the coating material used. High solvent coatings will evaporate during the curing stage. These air pollutants must be captured for recovery or incineration instead of being release to the atmosphere.



CHAPTER SIX

SELF-AUDIT PREPARATION GUIDE

This chapter provides information to assist organic coating facilities in preparing for an environmental audit and is divided into several sections based on the type of pollution or waste. Each section has a list of records to review, such as plans, monitoring data, and inventory lists. Specific areas that should be inspected are also listed. Actions required by management, supervisors, and operators are presented. Items that relate directly to organic finishing are also listed. Prior to conducting an audit, facilities should identify all of the applicable environmental regulatory requirements, including federal, state, and local requirements.

The information in this chapter provides general guidance on what facilities need to do to prepare for an environmental audit. EPA encourages conducting internal audits as a way for individual facilities to identify and address environmental issues. More specific information on EPA's self-audit and small business policies are presented below:

Audit Policy:

- ◆ EPA's final policy on incentives for self-evaluation and self-disclosure of violations was published in the *Federal Register* on December 22, 1996 (60 FR 66706). It took effect on January 22, 1996.
- ◆ It represents a refinement of the March, 1995 Voluntary Environmental Self-Policing and Self-Disclosure Interim Policy Statement, which offered regulated entities powerful new incentives to discover, disclose, and correct violations of environmental law.

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- ◆ The goal of the voluntary self-disclosure policy is to provide an incentive for regulated entities to self-audit, disclose, and correct environmental violations.
- ◆ Under the final policy, the Agency will protect public health and the environment by reducing civil penalties and by not recommending criminal prosecution for regulated entities that voluntarily discover, disclose, and correct violations.
- ◆ The final policy applies to violations under all of the environmental laws that EPA administers, and will be applied uniformly across EPA's enforcement programs and Regions.
- ◆ EPA will study the results of the policy within three years of the effective date and make that study available to the public.

Incentives for Due Diligence, Disclosure, and Correction:

- ◆ Under the final policy, where violations are found through voluntary environmental audits or efforts that reflect a regulated entity's due diligence (i.e., systematic efforts to prevent, detect and correct violations, as defined in the policy), and all of the policy's conditions are met (see discussion of safeguards), EPA will not seek gravity-based penalties and generally will not recommend criminal prosecution against the company if the violation results from the unauthorized criminal conduct of an employee.
- ◆ Where violations are discovered by means other than environmental audits or due diligence efforts, but are promptly disclosed and expeditiously corrected, EPA will reduce gravity-based penalties by 75% provided that all of the other conditions of the policy are met.
- ◆ EPA retains its discretion to recover economic benefit gained as a result of noncompliance, so that companies will not be able to obtain an economic advantage over their competitors by delaying their investment in compliance.
- ◆ The final policy also restates EPA's practice of not routinely requesting environmental audit reports.

Safeguards to Protect the Public:

- ◆ In addition to prompt disclosure and correction, the policy requires companies to prevent recurrence of the violation and to remedy any environmental harm.
- ◆ Repeated violations, or those which may have presented an imminent and substantial endangerment or resulted in serious actual harm, are excluded from the policy's coverage.
- ◆ Corporations remain criminally liable for violations resulting from conscious disregard of their legal duties, and individuals remain liable for criminal wrongdoing.
- ◆ The policy contains two provisions ensuring public access to information. First, EPA may require as a condition of penalty mitigation that a description of the regulated entity's due diligence efforts be made publicly available. Second, where EPA requires that a regulated entity enter into a written agreement, administrative consent order, or judicial consent decree to satisfy the policy's conditions, those agreements will be made publicly available..

Information regarding this policy may be obtained at the following website: <http://www.es.epa.gov/oeca/auditpol.html>.

Small Business Policy:

EPA's *Small Business Policy* is intended to promote environmental compliance by providing incentives like penalty waivers and penalty mitigation to conduct environmental audits and participate in on-site compliance assistance programs to discover, disclose and correct violations. The policy applies to a person, corporation, partnership, or other entity that employs 100 or fewer individuals and is specifically tailored to small businesses. In particular, the policy:

- ◆ Is written in plain, simple English and is concise and easily understandable
- ◆ Allows small businesses who have the expertise to conduct an environmental audit and permits those who do not to obtain government-sponsored compliance assistance to get credit under the policy
- ◆ Provides an extended compliance period for companies who employ pollution prevention fixes to correct their violations

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- ◆ Anticipates that penalties for economic benefit will be collected infrequently, so small businesses are more likely to get 100% penalty mitigation
- ◆ Allows small businesses to get anonymous compliance assistance and still get credit under the policy if they disclose their violations to an appropriate regulatory official.

The policy also provides guidance for State and local governments to offer these incentives. A copy of the policy may be obtained at the following website: <http://www.es.epa.gov/oeca/smbusi.html>.

Section 1

Air Emissions

A. Records To Review

- ◆ State and local air pollution control regulations
- ◆ Emissions inventory
- ◆ All air pollution source permits
- ◆ Plans and procedures applicable to air pollution control
- ◆ Emission monitoring records
- ◆ Opacity records
- ◆ Notices of violation (NOVs) from regulatory authorities
- ◆ Instrument calibration and maintenance records
- ◆ Reports/complaints concerning air quality
- ◆ Air Emergency Episode Plan
- ◆ State and/or federal regulatory inspections
- ◆ Regulatory inspection reports
- ◆ Documentation of preventive measure or action
- ◆ Results of air sampling
- ◆ Pollution prevention management plan
- ◆ Ozone depleting chemical (ODC) inventory

B. Physical Features To Inspect

- ◆ All air pollution sources (fuel burners, VOC sources, etc.)
- ◆ Air pollution monitoring and control devices
- ◆ Air emission stacks
- ◆ Air intake vents

C. Responsibilities of Supervisors and Managers

Supervisors and managers should...

- ☐ Sign all permits and compliance statements for facility operations unless multi-facility permits are to be signed by a higher authority.
- ☐ Sign applications for permits related to demolition, pre-construction, and construction phases of projects unless

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multi-installation permit applications are to be signed by a higher authority

- ☐ Sign applications and pay related fees associated with operations permits
- ☐ Budget sufficient resources to maintain and demonstrate compliance, including all routine air monitoring and scheduled sampling or testing. Notify state and local authorities of all instances of noncompliance, to conform with permit requirements
- ☐ Update air emission inventories and maintain current records of physical, operational, and emission characteristics of air sources
- ☐ Survey emission sources to identify potential reductions
- ☐ Ensure the development of air episode plans as required, and provide copies to the Regional Environmental Coordinator. Cooperate with the EPA, and state and local air pollution control authorities in the execution of air episode plans while in episode areas
- ☐ Ensure training is provided as required by the Clean Air Act.

D. Supervisor's and Manager's Air Checklist

Regional Concerns

- ☐ What is the attainment status of the region we are located in? What is the probability of restrictions on air emissions limiting our ability to accommodate new products, structure changes, or changes in operations?
- ☐ Do we have a current air pollution emission inventory? Has it been provided to the regulatory agency? What percentage of the regional emissions do we account for?
- ☐ Do we maintain records and reports on Emission Reduction Credits (ERCs)?
- ☐ Are we required to have an air pollution episode plan? Is it current? How many times have we had to activate it in the last five years?

Stationary Sources

- ☐ How many permitted sources do we have? Have we received any Notices of Violations or other enforcement actions?
- ☐ Do we have a program for periodic inspection of air emission sources to assure that they are properly operated and maintained?
- ☐ Do we have a requirement in our activity environmental instruction to ensure everyone reports to the environmental staff before obtaining, building, or modifying equipment or processes?

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What are the emission limits and testing requirements on our...

- ☐ Boilers and other fuel burning systems?
- ☐ Maintenance and other industrial shops?

Do we have the required emissions controls on our...

- ☐ Solvent degreasers?
- ☐ Painting operations?
- ☐ Ovens?

Personnel

- ☐ Are there any requirements for licensing or certification of operators of air emissions sources? If yes, what sources? Do our personnel have the required certification?
- ☐ Do we have a program for training operating personnel?

E. Organic Finishing Facility Checklist

- ☐ What is the VOC content of coating materials? Do the VOC emissions fall below levels required for my particular industry as noted in 40 CFR Parts 60 and 63?
- ☐ Do liquid coatings come in contact with exhaust air streams? If so, do concentrations of VOCs exceed the limits established by facility air permits? Are air emissions from organic solvent cleaning processes properly controlled and in compliance?
- ☐ Do powder coatings come in contact with exhaust air streams? Do dry residual coatings and blast media come in contact with exhaust air streams? If so, do concentrations of particulate matter exceed the limits established by facility air permits?
- ☐ Do exhaust air streams have air pollution control equipment attached? Is that air pollution control equipment working properly? Does final exhaust air have concentrations of pollutants below required levels?
- ☐ What is the transfer efficiency of the coating application system? Does it meet requirements, if any, for the particular industry to prevent air emissions?

Section 2

Wastewater Management

A. Records To Review

- ◆ NPDES Permits
- ◆ NPDES Permit applications (new or RENEWAL)
- ◆ Discharge monitoring reports for the past year
- ◆ Laboratory records and procedures and USEPA QA results
- ◆ Monthly operating reports for wastewater treatment facilities
- ◆ Flow monitoring calibration certification and supporting records
- ◆ Special reports, certifications, etc., required by NPDES permit
- ◆ Spill Prevention Control and Countermeasure (SPCC) Plan
- ◆ All records required by SPCC Plan
- ◆ All enforcement actions
- ◆ NPDES state or federal inspection reports
- ◆ Sewer and storm drain layout
- ◆ Local sewer use ordinance
- ◆ Local service use permit
- ◆ Sewer system bypass records
- ◆ Notification to local POTW
- ◆ Old spill reports
- ◆ Repair/Maintenance records for the wastewater treatment system
- ◆ As built drawings
- ◆ Federal facility compliance agreements
- ◆ Stormwater pollution prevention plan
- ◆ Pretreatment permits
- ◆ Design plans for wastewater and industrial waste treatment plants, including treatment basins
- ◆ Utility and general site maps, diagrams, plumbing
- ◆ Pollution Prevention Plan

B. Physical Features To Inspect

- ◆ Discharge outfall pipes
- ◆ Wastewater treatment facilities
- ◆ Industrial treatment facilities
- ◆ Floor and sink drains (especially in industrial areas)

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- ◆ Oil storage tanks
- ◆ Oil/water separators and other pretreatment devices such as sand and grit traps, grease traps, and sand interceptors
- ◆ Wastewater generation points
- ◆ Discharge to POTW
- ◆ Streams, rivers, open waterways
- ◆ Stormwater collection points (especially in industrial and maintenance areas)
- ◆ Non-point source discharge areas
- ◆ Wash areas (centralized facilities and areas in vicinity of maintenance)
- ◆ Catch basins, drop inlets, holding/retention ponds
- ◆ Waste and sump collection points
- ◆ Sludge disposal areas
- ◆ Sewage sludge land application sites
- ◆ Construction sites

C. Responsibilities of Supervisors and Managers

Supervisors and managers should...

- ☐ Develop program to comply with EPA regulations for industrial activity non-point source pollution and stormwater discharge requirements
- ☐ Cooperate with federal, state, local, and regional environmental regulatory officials
- ☐ Reduce or eliminate wastewater treatment needs by eliminating or reducing the volume and pollutants at the source
- ☐ Comply with permit conditions for discharge of treatment plant sludge into navigable waters (incineration of sludge must comply with Clean Air Act and hazardous waste requirements, and land disposal of sludge must comply with applicable CWA and RCRA requirements)
- ☐ Comply with all applicable pretreatment standards and local Publicly Owned Treatment Works limits and permit requirements
- ☐ Train all personnel involved in operations that result in actual or potential pollution of surface or groundwater.
- ☐ Provide the resources for operation performance monitoring, sampling, and testing, as well as for maintaining and demonstrating compliance with permit and pretreatment requirements and maintain records of all monitoring information
- ☐ Identify and submit environmental compliance projects required to bring wastewater sources into compliance with applicable requirements

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- ☐ Improve opportunities to recycle and reclaim and reuse wastewater and sludge
- ☐ Develop, implement and maintain current stormwater management plans for the facility, and comply with federal, state and local regulations and permit conditions
- ☐ Ensure environmental personnel are properly trained and certified, if required.

D. Supervisor's and Manager's Clean Water Checklist

NPDES Discharge Permits

- ☐ How many discharge permits do we have? How many discharge points? Have we ensured that raw wastewater cannot bypass our treatment facility/facilities?
- ☐ Are we covered by some type of stormwater discharge permit?
- ☐ Have we completed the Stormwater Pollution Prevention Plan (SWPPP)? Have all operational best management practices been implemented? Structural best management practices?
- ☐ Do we ensure that a construction stormwater permit covers all construction activities that disturb five acres or more?
- ☐ What are the general limitations and monitoring requirements?
- ☐ How many violations of permit limitations have occurred in the last year?
- ☐ Have we received any Notices of Violations or other enforcement actions? What corrective action has been taken? Has the violation been closed with the regulatory agency?
- ☐ Do we have any problems with recurring violations?

Un-permitted Discharges

- ☐ Are there any other discharges that may require permits, i.e., stormwater outfalls, etc.?
- ☐ Have we identified site requirements for, and have in place, properly designed oil/water separators?
- ☐ Has monitoring of our stormwater discharges indicated elevated levels of any pollutants?
- ☐ Do we have a program to periodically inspect potential sources of stormwater contamination?

Discharges to POTWs

- ☐ Do we have any discharges to Publicly Owned Treatment Works (POTW)?
- ☐ What are the types and volumes of the discharges?
- ☐ What pretreatment is required?
- ☐ Are we required to monitor these discharges?
- ☐ Are we complying with the applicable requirements?
- ☐ Are there any current or anticipated problems with our discharges?
- ☐ If no POTW is available, is one under construction? If yes, what are our plans to connect to it?

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E. Organic Finishing Facility Checklist

- ☐ Do coating materials come in contact with water streams? Do chemical coatings removal solutions, organic solvent cleaning solutions, or aqueous cleaning solutions come in contact with water streams? Do mechanical coatings removal media or residual coatings come in contact with water streams? If so, do concentrations of pollutants exceed limits established by the facility NPDES permit or POTW discharge agreement?
- ☐ Does waste from equipment cleaning processes, particularly organic solvent waste, contact wastewater streams? If so, do concentrations of pollutants exceed limits established by the facility NPDES permit or POTW discharge agreement?

Section 3

Hazardous Materials/Waste Management

A. Records To Review

- ◆ Hazardous Substance Spill Control and Contingency Plan
- ◆ Spill records
- ◆ Emergency plan documents
- ◆ MSDSs
- ◆ Inventory records
- ◆ Hazardous substance release reports
- ◆ Shipping papers
- ◆ Training records
- ◆ Placarding of hazardous materials
- ◆ Hazardous Communication Plan
- ◆ Chemical Hygiene Plan (labs)
- ◆ Notification (USEPA identification number)
- ◆ Hazardous waste manifests
- ◆ Manifest exception reports
- ◆ Biennial reports
- ◆ Inspection Logs (as applicable)
- ◆ Delistings
- ◆ Land disposal restriction certifications
- ◆ Employee training documentation
- ◆ Contingency plan

B. Physical Features To Inspect

- ◆ Shipping and receiving area
- ◆ Hazardous material storage areas
- ◆ Hazardous material transfer areas
- ◆ Shop activities
- ◆ Hazardous waste generation sites
- ◆ Satellite accumulation points
- ◆ Accumulation points
- ◆ Vehicles used for transport
- ◆ Storage facilities (including drums)
- ◆ Treatment units
- ◆ Recycling sites

- ◆ Disposal sites
- ◆ Surface impoundments

NOTES

C. Responsibilities of Supervisors and Managers

Supervisors and managers should...

- ☐ Establish Pollution Prevention Plans, in accordance with applicable regulations. These plans must address hazardous materials (HM) and hazardous wastes (HW) and encompass all aspects of health and safety of personnel and protection of the environment
- ☐ Comply with applicable HW management requirements. Compliance with all aspects of an EPA-approved state HW management program is considered compliance with federal requirements. If a state has a program that is not approved by EPA, activities shall comply with both the state and federal program requirements
- ☐ Eliminate HW disposal to the maximum possible extent by eliminating the use of HM and by implementing best management practices and best demonstrated available technology.
- ☐ Control and reduce the amounts of HM used and HW generated by HM acquisition, supply, and utilization management
- ☐ Identify HM needed to meet production requirements and, where feasible, substitute less hazardous material. Support decisions to use hazardous material or substitute less hazardous material by an economic analysis appropriate to the magnitude of the decision being made
- ☐ Comply with all federal standards, directives, instructions, and regulations related to hazardous materials and hazardous waste, including applicable state and local regulations
- ☐ Obtain and renew required operating permits for hazardous waste facilities at all activities and complete construction of all required hazardous waste storage and handling facilities
- ☐ Minimize land disposal of hazardous wastes.
- ☐ Develop and use a HW management plan, or HW component of a Pollution Prevention Plan
- ☐ Budget, fund, and manage HW in compliance with applicable substantive and procedural federal, state and local requirements
- ☐ Cooperate with federal, state, and local HW regulatory officials
- ☐ Provide reports and other required data and information to federal, state and local HW regulatory agencies
- ☐ Obtain and maintain applicable HW generator identification number

- ☐ Perform operations under applicable federal, state, and local requirements

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D. Supervisor's and Manager's Hazardous Materials/Waste Management Checklist

Program Status

- ☐ Is our Hazardous Waste Management Plan current?
- ☐ Are our inventories of hazardous materials and wastes current?
- ☐ What is the status of our Hazardous Waste Minimization program?
- ☐ When does our hazardous waste disposal contract expire?
- ☐ Do our procedures for storage and dispensing of hazardous materials and waste comply with applicable requirements?
- ☐ What are the cognizant regulatory agencies and who are our contacts at these agencies?
- ☐ When was the most recent regulatory agency inspection of our hazardous waste management facilities and what were the results?
- ☐ Do we have any RCRA corrective action projects programmed?

Hazardous Waste Management Facilities

- ☐ What types of hazardous waste management facilities do we have?
- ☐ What is their permit status?
- ☐ Do we have written operating procedures and operating logs for each of our facilities?
- ☐ Are we conducting periodic inspections of our facilities?
- ☐ Have all of the operating personnel received appropriate training, including required safety and health training?
- ☐ Do we have closure plans for all of our permitted facilities?

Accumulation Point Management

- ☐ How many hazardous waste accumulation points have been designated? How many satellite accumulation points?
- ☐ Have accumulation point managers been appropriately trained?
- ☐ Are accumulation points inspected regularly to ensure that hazardous wastes are segregated, properly labeled and stored for less than 90 days from the start of accumulation?

Disposal Procedures

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- ☐ Have we initiated procedures to ensure that hazardous wastes shipped from this facility are properly packaged, labeled, manifested, and transported? Do we ensure that we receive and file all our hazardous waste manifests to verify completed disposal actions?
- ☐ Do we have an inspection/certification plan for vehicles involved in transporting hazardous waste?

RCRA Corrective Actions

- ☐ Do we have any sites for which corrective action is required under RCRA? What is the status of the actions at these sites?

E. Organic Finishing Facility Checklist

- ☐ Are coating materials, chemical stripping solutions, and cleaning solutions properly labeled and packaged in accordance with 40 CFR Part 262, Subpart C?
- ☐ Are wastes contaminated with coating materials, organic solvents, or chemical strippers classified as hazardous? If so, are the wastes handled and manifested in accordance with 40 CFR Part 262, Subpart B? Are hazardous wastes segregated from non-hazardous wastes?
- ☐ Are dry wastes contaminated with residual coating from mechanical and carbon dioxide blasting classified as hazardous? If so, are the wastes handled and manifested in accordance with 40 CFR Part 262, Subpart B? Are hazardous wastes segregated from non-hazardous wastes?

Section 4

Solid Waste Management

A. Records To Review

- ◆ Record of current non-hazardous solid waste management practices
- ◆ Estimated generation rates
- ◆ Documentation of locations (map) and descriptions of all non-hazardous waste storage, and disposal sites
- ◆ Records of operational history of all active and inactive disposal sites
- ◆ State and Federal inspection reports
- ◆ Environmental monitoring procedures or plans
- ◆ Records of resource recovery practices, including the sale of materials for the purpose of recycling
- ◆ Solid waste removal contracts and inspection records
- ◆ Regional solid waste management plan
- ◆ Pollution prevention management plan

B. Physical Features To Inspect

- ◆ Resource recovery facilities
- ◆ Incineration and land disposal sites (active and inactive)
- ◆ Areas where non-hazardous waste is disposed
- ◆ Construction debris areas
- ◆ Waste receptacles
- ◆ Solid waste vehicle storage and washing areas
- ◆ Transfer stations
- ◆ Recycling centers

C. Responsibilities of Supervisors and Managers

Supervisors and managers should...

- ☐ Comply with all federal, state, and local requirements regarding solid waste management and disposal
- ☐ Ensure an adequate solid waste disposal capability for all facility activities

NOTES

- ☐ Identify economically recyclable wastes and identify markets for these wastes which requires that scrap metal, high-grade paper, corrugated containers and aluminum cans be segregated for recycling
- ☐ Ensure that all activities have a Solid Waste Management Plan (SWMP)
- ☐ Implement solid waste recycling and source reduction programs to keep pace with national efforts to maximize recycling and recovery of materials from solid waste
- ☐ Minimize the use of packaging materials in the supply system
- ☐ Develop SWMPs including source reduction and recycling programs and resource recovery facilities that incorporate all federal, state and local requirements
- ☐ Cooperate with the personnel/company that provides solid waste collection and disposal services in establishing source reduction and separation programs and affirmative procurement programs
- ☐ If listed in a Standard Metropolitan Statistical Area (SMSA), cooperate with the designated SMSA lead agency

D. Supervisor's and Manager's Solid Waste Management and Resource Recovery Checklist

Site Facilities

- ☐ What types of solid waste facilities are operated by the facility?
- ☐ What is the status of the facility's Solid Waste Management Plan? What is the permit status of these facilities?
- ☐ What monitoring and reporting is required for these facilities?
- ☐ What are our annual operating and disposal costs?

Use of Offsite Facilities

- ☐ Do we use any offsite solid waste disposal facilities?
- ☐ Have we verified that these facilities are appropriately licensed or permitted and that they are in compliance with their permits?
- ☐ What are our annual disposal costs for offsite facilities?

Availability of Regional Facilities

NOTES

- ☐ Are there any regional solid waste management, recycling or resource recovery programs? Is there a state or local household hazardous waste program?
- ☐ Do we participate in these programs? If not, why?

Waste Minimization Programs

- ☐ Have we established a program to reduce the volume of solid waste generated on the facility? If not, why?
- ☐ How successful has it been?

Recycling Programs

- ☐ Do we have a recycling program?
- ☐ Does the program encompass all personnel, including manufacturing areas, office areas, etc.?
- ☐ How successful have they been?

Control of Hazardous Wastes

- ☐ What procedures are used to ensure that hazardous wastes are not inadvertently (or intentionally) mixed with non-hazardous solid wastes?
- ☐ How often are sources of both solid and hazardous wastes inspected to ensure that hazardous wastes are not mixed with non-hazardous solid wastes?

E. Organic Finishing Facility Checklist

- ☐ What process wastes, such as excess coating materials, have been identified as solid wastes? Are these materials segregated from hazardous materials?
- ☐ Are coating materials, rags, filters, coveralls, etc. collected and disposed in an appropriate manner?

Section 5

Community Right-to-Know

A. Records to Review

- ◆ Emergency Response Plans
- ◆ Emergency and Hazardous Chemical Inventory Forms
- ◆ Toxic Chemical Release Forms (EPA Form R)
- ◆ Emergency plan documents
- ◆ MSDSs
- ◆ Inventory records
- ◆ Hazardous substance release reports
- ◆ Hazardous Communication Plan
- ◆ Delistings
- ◆ Contingency plan

B. Physical Features To Inspect

- ◆ Shop activities
- ◆ Hazardous material storage areas
- ◆ Hazardous material transfer areas
- ◆ Storage facilities (including drums)
- ◆ Generation sites
- ◆ Satellite accumulation points
- ◆ Accumulations points
- ◆ Treatment units
- ◆ Recycling sites
- ◆ Disposal sites
- ◆ Surface impoundments

C. Responsibilities of Supervisors and Managers

Supervisors and managers should...

- ☐ Designate an employee to represent you on the local emergency planning committee
- ☐ Account for the types and quantities of hazardous substances used and stored at your facility

NOTES

- ☐ Notify the local emergency planning committees and state emergency response commissions if you exceed a Threshold Planning Quantities (TPQ) for an extremely hazardous substance
- ☐ Annually submit Emergency and Hazardous Chemical Inventory Forms and Toxic Chemical Release Forms (EPA Form R) for all chemicals exceeding prescribed thresholds to the appropriate agencies
- ☐ Sign each EPCRA Form R as the validating official
- ☐ Prepare an activity plan to handle chemical emergencies similar to the plan prepared by the local emergency planning committee
- ☐ Use data provided from EPCRA reporting to develop a comprehensive Pollution Prevention Plan for the facility
- ☐ Reduce the releases of toxic chemicals as identified in the Pollution Prevention Plan to support a reduction in EPCRA reporting requirements
- ☐ Identify funding needed to the major claimant to support all EPCRA requirements
- ☐ Establish and implement procedures to control, track, and reduce the variety and quantity of hazardous material in use, in storage or stock, or disposed of as hazardous waste, to support reduced EPCRA reporting.

D. Emergency Planning and Community Right-to-Know Checklist

- ☐ Has a contact for local emergency response planning been identified and does the community know who the individual is and how to contact him or her?
- ☐ Does the facility participate in local, regional, or state emergency response planning activities?
- ☐ Have facility response plans been developed and coordinated with local authorities?
- ☐ Have procedures been developed for notifying state and local emergency planning authorities in case a hazardous substance is accidentally released that may harm facility personnel or off-facility residents?
- ☐ If requested, can information concerning types and quantities of hazardous substances used and stored on the facility be provided to local authorities?

E. Organic Finishing Facility Checklist

NOTES

- ☐ Are coating materials, chemical stripping solutions, and cleaning solutions considered hazardous or extremely hazardous materials and subject to reporting and recordkeeping requirements?
- ☐ Are MSDS available for all coating materials, stripping solutions, cleaning solutions, etc.?

Section 6

Pollution Prevention

A. Responsibilities of Supervisors and Managers

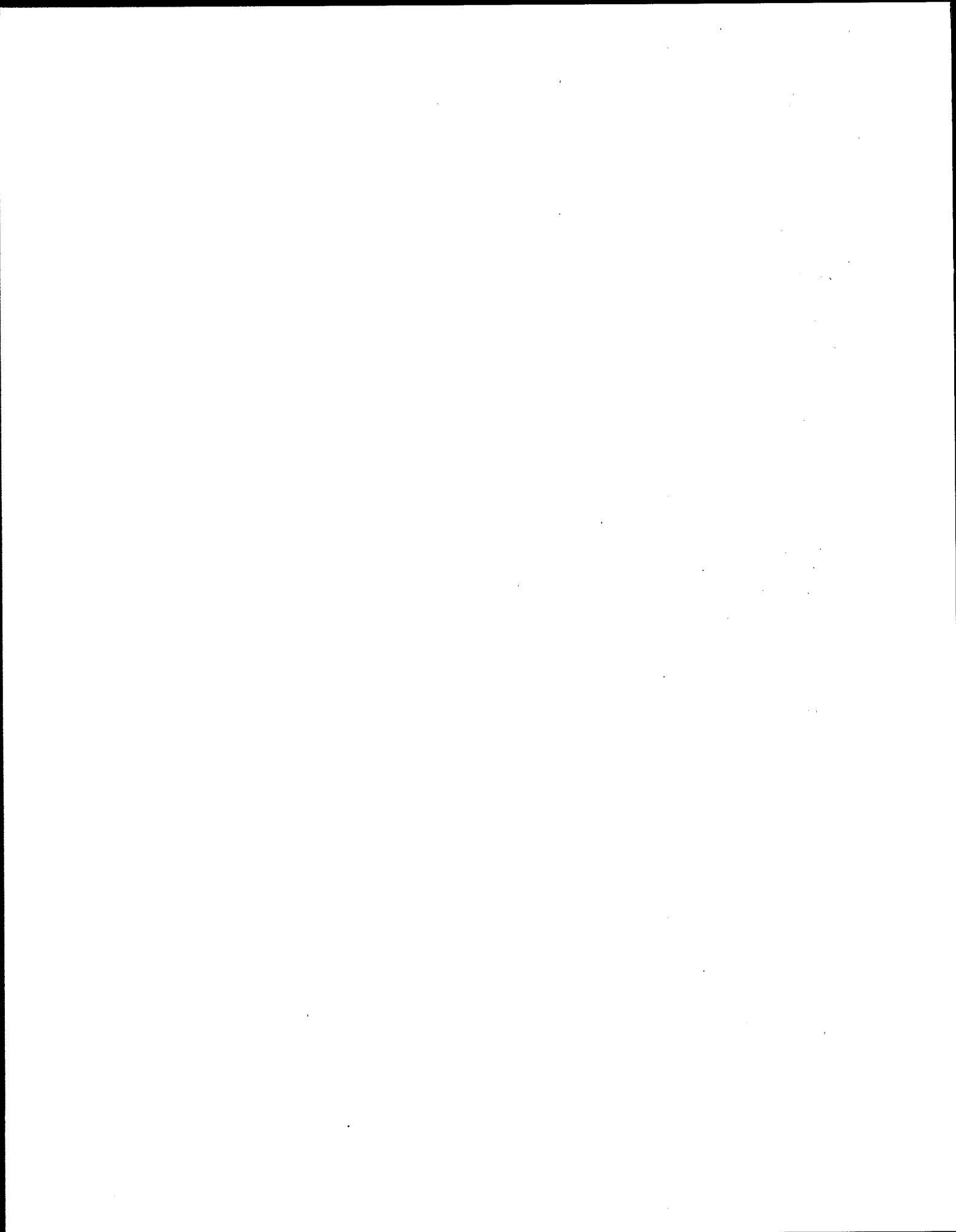
Supervisors and managers should...

- ☐ Reduce the quantity of toxic pollutants disposed or transferred off site through process modification, recycling, reuse, material substitution or equivalent.
- ☐ Reduce the amount of hazardous material (HM) used and hazardous waste (HW) generated by HM control in procurement, supply, and use.
- ☐ Limit the use of hazardous materials. Establish methods of substituting less hazardous materials or non-hazardous material.
- ☐ Develop and incorporate new technology or materials which have a reduced impact on the environment, are safer and healthier for the user, or result in reduced pollutant emissions.
- ☐ Incorporate pollution prevention into the design of new products and modification to current products, support systems, and facilities.
- ☐ Develop and implement a facility pollution prevention program that incorporates the hazardous material control and management and hazard communication requirements of the listed laws and regulations.
- ☐ Implement and annually update the facility Pollution Prevention Plan.
- ☐ Establish and implement procedures to control, track, and reduce the variety and quantities of HM in use, in storage or stock, or disposed of as HW.
- ☐ Develop and implement a facility level HM authorized use list (AUL) using an inventory that identifies and quantifies HM, including whether the material is an extremely hazardous substance, hazardous substance, or toxic chemical as defined under EPCRA
- ☐ Ensure facility level supply functions establish and implement a local shelf life control and management program.

NOTES

B. Supervisor's and Manager's Pollution Prevention Checklist

- ☐ Do we have a Pollution Prevention (P2) Plan?
- ☐ Do we have an active P2 program? Has a P2 committee been established?
- ☐ Have we established procedures to control, track, and reduce the variety and quantities of HM in use, in storage or stock, or disposed of as HW?
- ☐ Do we have procedures for tracking toxic chemicals to assist with EPCRA reporting?
- ☐ Do we have any challenging potential or actual pollution problems? Are they addressed in our P2 Plan?
- ☐ What accomplishments in P2 have been attained to date?
- ☐ What are the ongoing programs to enhance P2 or recycling awareness? Does the program involve all tenants?
- ☐ Do we invite or have any community involvement, activities, or affiliations with civic or environmental organizations?
- ☐ Do we consider our relationship with federal, state, and local agencies, organizations, and academic institutions to be excellent, satisfactory, unsatisfactory, or hostile and why?



GLOSSARY

A

active solvent - A liquid which dissolves a binder.

additives - Any substance added in small quantities to another substance, usually to improve properties. Examples of additives include plasticizers, fungicides, and dryers.

air spray - A paint spray application system using air at high velocity and pressure to atomize the paint.

air-assisted airless spray - Paint spray application system using fluid pressure to atomize the paint and lower pressure air to adjust the shape of the fan pattern.

air pollution control equipment - equipment that removes particulates and/or volatile organic compounds from exhaust air of facilities.

air-dried coatings - Coatings which are not heated above 194 F (90 C) for coating or drying. In the South Coast Air Quality Management District, curing also must be done below (rather than at or below) 194 F (90 C) to qualify as air-dried. Air-dried coatings also include forced-air-dried coatings.

airless spray - Paint spray application system using high fluid pressure to atomize paint by forcing it through a small orifice.

aliphatic solvent - A solvent comprised primarily of straight chain hydrocarbons, including mineral spirits, kerosene, and hexane. These solvents are characterized as volatile organic compounds.

anode - The electrode at which chemical oxidation takes place. In electrodeposition (E-coating) the anode is indicated on diagrams by the positive (+) marking.

applied coating solids - The volume of dried or cured coating solids which is deposited and remains on the surface of the part.

aromatic solvents - Hydrocarbon solvents which contain an unsaturated ring of carbon atoms, including benzene, naphthalene, anthracene and their derivatives. Toluene (toluol) and xylene (xylol) are commonly used aromatics. These solvents are characterized as volatile organic compounds.

atomization - The formation of tiny liquid droplets during the spraying of coatings.

B

bake oven - A device that uses heat to dry or cure coatings.

baked coatings - Coatings that are cured or dried at or above an oven air temperature of 194 F (90 C).

bells - A rotating head that is shaped to deliver paint forward in a circular pattern. The bell may be directed at any angle and be moved on robots or reciprocators.

binder - The solid (non-volatile) material in a coating that binds the pigment and additive particles together to form a film. In general, binders are resins.

blistering - The formation of hollow bubbles in the paint film caused by air, moisture, or solvents trapped under the film.

C

CAA - Clean Air Act

carbon dioxide - CO₂, is a non-toxic material used in solid form to remove coatings. Carbon dioxide is considered to be a "greenhouse gas" which may contribute to global warming.

cathode - The cathode is defined as the electrode at which chemical reduction takes place. In electrocoating, the cathode is indicated on diagrams by the negative (-) marking.

CD-ROM - Compact Disk-Read Only Memory

CERCLA - Comprehensive Environmental Response Compensation and Liability Act

CFC - Chlorofluorocarbons (CFCs) are compounds made from combinations of carbon, chlorine, and fluorine typically used as propellants, cleaners, or cooling agents. CFCs are non-toxic to workers, and are non-flammable. The compounds are very stable in the lower atmosphere and can persist for at least 100 years. When the molecules reach the upper atmosphere, they deplete the ozone layer. Manufacturing of CFCs has been banned in the US, and their use has been extremely restricted.

CFR - Code of Federal Regulations

chipping - Total or partial removal of a dried paint film in flakes by accidental damage or wear during service.

chlorinated solvents - Powerful organic solvents that contain chlorine. Examples include 1,1,1-trichloroethane and methylene chloride. These solvents are characterized as volatile organic compounds.

coating - A liquid composition which is converted to a solid protective, decorative, or functional adherent film after application as a thin layer.

conventional pollutants - Conventional pollutants, as defined by the Clean Water Act, include biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil, and grease, which have been present in wastewater streams for many years.

cosolvents - Water-miscible organic solvents. Waterborne paints frequently require

cosolvents in addition to water for easier manufacture and improved application properties.

cracking - The splitting of a dry paint film, usually the result of aging. This includes: hair cracking, checking, crazing, and alligatoring (crocodiling).

criteria pollutants - Under the National Ambient Air Quality Standards (NAAQS) regulations, the following compounds are considered to be criteria pollutants: particulate matter, nitrogen oxides, ozone, sulfur dioxides, carbon monoxide, and lead.

crosslinking - The setting up of chemical links between the molecular chains of a resin to form a three-dimensional network polymer system. Crosslinking generally toughens and stiffens coatings.

cure - Using heat, radiation, or reaction with chemical additives to change the properties of a polymeric system into a final more stable, usable condition. For liquid coatings, it is the process by which the liquid is converted into a solid film.

CWA - Clean Water Act

D

deionized water - Water resulting from the removal of contaminants in the water by a double-bed ion exchanger. Deionized water is equivalent in purity to distilled water but is much less costly to produce.

diluent - Liquids which increase the capacity of a solvent for the binder. Diluents cannot dissolve the binder themselves, but rather are used to control viscosity, flash time, or cost. When added to a prepared paint, a diluent will lower the viscosity just as effectively as a true solvent. However, if too much diluent is added, the resin will separate out of solution and the paint becomes unusable.

dip coating - The process in which a substrate is immersed in a solution (or dispersion) containing the coating material and withdrawn.

disks (discs) - Rotating heads that deliver paint horizontally 360 degrees around the head and use an omega loop conveyer line. A disk is usually mounted horizontally on a vertical reciprocator.

E

Effluent Guidelines and Standards - Effluent guidelines and standards are the basis for controlling the discharge of pollutants, primarily in wastewater, from industrial facilities and publicly owned treatment works (POTWs) to lakes, streams, and other receiving waters, as well as from industrial facilities to POTWs. The EPA developed the industry-specific, technology-based standards to cover facilities performing similar operations which would use similar processes for pretreatment. Individual states developed additional standards which would protect water quality in their regions.

electrocoating - A dip coating application method where the paint solids are given an electrical charge which is then attracted to the part. In a method closely paralleling electroplating, paint is deposited using direct electrical current. The electrochemical reactions that occur cause water-soluble resins to become insolubilized onto parts that are electrodes in the E-coating paint tank. Subsequent resin curing is required.

electrostatic spray - Methods of spray application of coating where an electrostatic potential is created between the part to be coated and the paint particles.

emulsion - A two-phase liquid system in which small droplets of one liquid (the internal phase) are immiscible in, and are dispersed uniformly throughout, a second

continuous liquid phase (the external phase). This contrasts with a latex, which consists of solids dispersed in a liquid.

EPA - United States Environmental Protection Agency

EPCRA - Emergency Planning and Community Right-to-know Act

F

film - One or more layers of coating covering an object or surface.

flash-off area - The portion of a surface coating operation between the coating application area and bake oven.

flash point - The lowest temperature of a liquid at which it gives off sufficient vapor to form an ignitable mixture when mixed with air and brought in contact with an open flame or spark.

flow coating - A coating application system where paint flows over the part and the excess coating drains back into a collection system.

fluidized bed - Finely divided powders can be made into a fluid-like state by passing air through a porous plate bottom of a powder hopper. This permits the fluidized bed of powder particles to be used in dip tanks and to be transported in a manner similar to liquids.

G

ground (electrical ground) - An object so massive that it can lose or gain overwhelmingly large numbers of electrons without becoming perceptibly charged.

H

halogenated solvents - Formed by substituting one of the halogen elements (chlorine, bromine, or fluorine) into a chemical compound to change both the

physical and chemical natures of the compound.

Hazardous Air Pollutants - Hazardous air pollutants (HAP), also referred to as "air toxics," pose a significant threat to human health and the environment. Common HAPs include benzene, toluene, formaldehyde, mercury, and polyaromatic hydrocarbons. They are emitted from a wide variety of sources, such as combustion sources and compounds found in organic solvents. EPA originally listed 189 HAPs and continues to establish National Emission Standards for Hazardous Air Pollutants (NESHAP) for various industrial sources.

HAP - Hazardous Air Pollutant

HCFC - Hydrochlorofluorocarbons (HCFC) are compounds made from carbon, chlorine, fluorine, and hydrogen commonly used as replacements for chlorofluorocarbons (CFC). While the compounds provide similar propellant, cleaning, and cooling capabilities as CFCs, they are slightly less damaging to the ozone layer.

heavy metals - Heavy metals include mercury, lead, cadmium, and zinc. These materials may be found in some coating material formulations, surface preparation solutions, or as part of substrates. Concentrations of these materials are limited in wastewater by the National Pollutant Discharge Emissions Standards. The metals may enter wastewater discharges as a result of phosphatizing rinses or from wet blasting of coatings materials.

High-volume low-pressure spray - Spray equipment used to apply coating by means of a gun which operates between 0.1 and 10.0 psi air pressure. The high volume of air is produced by a turbine.

high-solids - Solvent-based coatings that contain greater than 50 percent solids by

volume or greater than 62 percent (69 percent for baked coatings) solids by weight.

HVLP - High-volume, Low-pressure

hydrocarbon solvent - An organic compound consisting exclusively of the elements carbon and hydrogen. They are principally derived from petroleum and coal tar, and include aliphatic, aromatic, and napthenic solvent.

I

Infrared (IR) - Wavelengths of light energy that produce thermal energy, used to heat coatings and substrates to cure coating materials.

L

listed and characteristic hazardous wastes - Characteristic hazardous wastes are materials that exhibit toxicity, reactivity, ignitability, and/or corrosivity. Materials with these characteristics have been found to cause or contribute to an increase in mortality or serious illness, or pose a hazard to human health or the environment when improperly treated, stored, transported, disposed or otherwise managed. Listed hazardous wastes are materials specifically identified as hazardous because they have exhibited characteristics of hazardous wastes, have been found to be fatal to humans or to test animals, or contain toxic, carcinogenic, mutagenic, or teratogenic constituents. Both individual materials and categories of materials are listed as hazardous.

M

Material Safety Data Sheets - Material Safety Data Sheets (MSDS) are informational fact sheets developed for each commercially available chemical, compound, or substance. MSDSs provide general product information,

physical components and characteristics of the product, health risk information, fire and explosion warnings, product reactivity data, spill and disposal procedures, storage and handling issues, and personal protective equipment suggested when working with the material. MSDSs are to be made easily accessible to employees working with chemical substances and to surrounding communities.

MEC - Methylene chloride

MEK - Methyl ethyl ketone

molten salt bath - A mixture of inorganic salts melted at temperatures between 650 and 900 F. Painted items immersed in these are rapidly stripped by combustion of the paint in the molten salt bath.

MSDS - Material Safety Data Sheet

N

National Ambient Air Quality Standards (NAAQS) - National Ambient Air Quality Standards (NAAQS) establish maximum concentrations for criteria air pollutants in specified geographical areas. These pollutants include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO₂), particulate matter (PM-10), ozone (O₃), and sulfur dioxide (SO₂). To prevent established concentrations from being exceeded, State and local governments may require air pollution controls on existing, new, and modified industrial facilities; tighter standards on emissions from motor vehicles; and the use of alternative fuels.

National Emission Standards for Hazardous Air Pollutants (NESHAP) - National Emission Standards for Hazardous Air Pollutants (NESHAP) establish limits on emissions of hazardous air pollutants.

National Pollutant Discharge Elimination System (NPDES) Permits - National

Pollutant Discharge Elimination System (NPDES) Permits limit discharges of pollutants into water from point sources. Industrial dischargers must obtain permits prior to releasing wastewater into receiving waters.

nitrous oxides NO_x - NO_x are emissions of nitrogen oxides typically created during the combustion of fuels during dry-off and curing stages of organic finishing.

non-conventional pollutants - Non-conventional pollutants under the Clean Water Act are defined as any pollutants not classified as either toxic or conventional pollutants. EPA included this classification to account for developments in industry and the changing characterization of possible water pollutants.

O

omega loop - The conveyor for rotating disk paint applicators that is shaped to produce a circular path around the vertically oriented disk to deliver paint from all 360 degrees of its circumference. The term was derived because the shape of the conveyor resembles the capitalized form of the Greek letter.

organic coating - A coating used in a surface coating operation, including dilution solvents, from which volatile organic compound emissions occur during the application or the curing process. For the purpose of many environmental regulations, powder coatings are not included in this definition.

overbake or overcure - Exposure of the coating to a temperature higher or for a longer period of time, or both, than recommended for optimal curing; the condition may adversely affect the appearance and the properties of the coating.

overspray - Any portion of a spray-applied coating which does not land on a part and

which is deposited on the surrounding surfaces.

ozone-depleting substances - Ozone-depleting substances (ODSs) are chemical compounds that harmfully react with ozone to transform ozone into oxygen. The most common ODSs are chlorofluorocarbons (CFCs). These compounds transform ozone into oxygen while continuously recycling chlorine within the atmosphere. The constant supply of chlorine in the atmosphere supports additional ozone depleting reactions.

P

particulate matter - Particulate matter (PM) is the term used for a mixture of solid particles and liquid droplets found in the air. While individual particles can not be seen with the naked eye, collectively they can appear as black soot, dust clouds, or gray hazes. Particles originate from a variety of sources in organic coating facilities, most often exhaust from drying ovens.

permeate - The output of ultrafiltration, called ultrafiltrate or permeate.

pH - Value taken to represent the acidity or alkalinity of an aqueous solution and defined as the logarithm of the reciprocal of the hydrogen-ion concentration of a solution. The scale ranges from 1 for highly acidic solutions to 13 for highly basic or alkaline solutions. neutral solutions have a pH of 7. Because the scale is logarithmic, the intervals are exponential.

phosphating - A pretreatment for steel or certain other metal surfaces by chemical solutions containing metal phosphates and phosphoric acid as the main ingredients, to form a thin inert adherent, corrosion-inhibiting phosphate layer which serves as a good base for subsequent paint coats.

pigment - Finely ground insoluble particles dispersed in coatings to influence properties such as color, corrosion resistance, mechanical strength, hardness, durability, etc. Particles may be natural or synthetic, and also inorganic or organic.

point source pollutants - Point source pollutants are direct wastewater discharges into national water sources, such as rivers, lakes, and streams. Common discharge sources of point source pollutants are pipes, ditches, channels, and sewer deposits.

polymers - A high molecular weight organic compound, natural or synthetic, with a structure that can be represented by a repeated small unit, or mer.

pot life - The length of time a coating material is useful after the original package is opened or after a catalyst or other ingredient is added.

POTW - Publicly Owned Treatment Works

powder coatings - Any coating applied as a dry (without solvent or other carrier), finely divided solid that adheres to the substrate as a continuous film when melted and fused.

Pretreatment - Pretreatment of wastewater removes oils, dirt, solids, hazardous liquids and adjusts pH before the waste stream is discharged. Pretreatment standards must be met prior to discharge to a publicly owned treatment works (POTWs). Pretreatment requirements are imposed by the POTW upon industrial dischargers to protect POTW equipment and personnel, and to ensure that water leaving the POTW has received adequate treatment.

primers - Coatings that are designed for application to a surface to provide a firm bond between the substrate and subsequent coatings.

priority pollutants - Priority pollutants are hazardous or radioactive organic and inorganic chemicals present in an

environmental setting, such as air, water, or vegetation. These pollutants were identified by EPA as indicators of environmental contamination.

publicly owned treatment works (POTWs)

- Publicly Owned Treatment Works (POTWs) are treatment works owned by a State, unit of local government, or Indian tribe, usually designed to treat domestic wastewaters. POTWs are required to demonstrate that industrial sources of toxic pollutants are in compliance with all of their pretreatment requirements, including local limits.

R

RCRA - Resource Conservation and Recovery Act

rebound - Paint droplets from air-atomized application that rebound or bounce away from the surface due to the blasting effect of the air.

receiving water - any water source into which effluent may be discharged, such as lakes, ponds, oceans, and rivers. Receiving waters must support a balanced population of fish and wildlife, allow for recreation, and show need for protection to maintain these uses.

reciprocator - An automatic device to move a paint-applying tool in alternating directions along a straight or slightly curved horizontal or vertical path.

resin - The polymer (plastic) component of a paint that cures to form a paint film. Also known as binder or vehicle.

roll coating - Process by which a film is applied mechanically to sheet or strip material.

S

sagging - The downward flow of a coating film as a result of the film being applied too heavy or too fluid a wet coat.

solvent - The liquid or blend of liquids used to dissolve or disperse the film forming particles and which evaporate during drying. A true solvent is a single liquid that can dissolve the coating. Solvent is often used to describe terpenes, hydrocarbons, oxygenated, furans, nitroparaffins, and chlorinated solvents.

solvent-based - Coatings in which volatile organic compounds are the major solvent or dispersant.

spray application - A method of applying coatings by atomizing and directing the atomized spray toward the part to be coated.

spray booth - A structure housing automatic or manual spray application equipment where coating is applied to parts. Dry filters or waterwashes are used to remove particulates from the exhaust air.

static electricity (electrostatics) - Electrons temporarily removed from various items can cause static charges. Whatever has excess electrons has a negative charge; the object from which electrons have been taken will be positively charged. Electrons will tend to jump from one object to another if at all possible in order to neutralize all charges.

suspended solids - Suspended solids are small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means, and therefore require specially designed instruments for removal.

T

terpene solvents - Volatile organic compounds obtained from pine trees and are

the oldest solvents used in coatings, includes turpentine, dipentene, and pine oil.

thermoplastic - Resin capable of being repeatedly softened by heat and hardened by cooling. These materials, when heated, undergo a substantially physical rather than chemical change. Thermoplastic resins can be completely dissolved with appropriate solvents.

thermoset - Resin that, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble material. Thermosetting resins will soften but will not dissolve in any solvents.

thinning - The process of adding volatile liquid to a coating to reduce its viscosity. This liquid may be solvent, diluent or mixtures of both. Also may be called reducing or "adding make-up solvent".

Title V permitting - Title V permitting is the mechanism by which EPA integrates all of the federally applicable requirements of the Clean Air Act designed to reduce emissions of air toxics, improve and maintain air quality, meet new source requirements, and control the precursors of acid rain. The operating permit program is administered by states under federally approved programs. A facility's operating permit will indicate the emissions standards and operation limitations that it must follow in order to stay in compliance.

topcoat - The final coating film or multiple layers of the same coating film applied to the surface.

touch-up - The portion of the coating which is incidental to the main coating process but is necessary to cover minor imperfections.

toxic organics - Toxic organic chemicals include a variety of chemicals, such as polychlorinated biphenyls (PCB) and dioxin, that are considered to be severely damaging to human health, wildlife, and aquatic species. The toxic organics are persistent in the

environment, remaining chemically reactive for long periods. The materials can accumulate in animal and fish tissue, be absorbed in sediments, or find their way into drinking water supplies, posing long-term health risks to humans.

toxic pollutants - Toxic pollutants are those priority pollutants identified by EPA that display toxic, hazardous characteristics.

Toxic Release Inventory - The Toxic Release Inventory (TRI) is a compilation of chemical procurement and release data from manufacturing facilities in the US. TRI reports are required for facilities with more than 10 full-time equivalent employees and that use more than 1,000 pounds of a listed substance annually. Facilities are required to report hazardous, toxic, and ozone-depleting chemicals used, and the amount of each released to the air, publicly owned treatment works, receiving waters, landfills, and other disposal facilities. EPA maintains a database of records for public record.

transfer efficiency - The ratio of solids adhering to an object to the total amount of coating solids used in the application process, expressed as a percentage. Non-adhering paint, or overspray, goes onto booth surfaces, hooks, filters, etc.

U

ultrafiltration - Ultrafiltration uses low-pressure membrane filtration to separate small molecules from large molecules and fine particulates. For example, electrocoat rinse water is extracted from the paint bath by ultrafiltration.

UV - Ultraviolet

underbake or undercure - Exposure of the coating to a temperature lower or for a shorter period of time, or both, than recommended for optimal curing; the condition may cause

tackiness, softness, and inferior film durability.

V

varnish - Clear or pigmented coatings formulated with various resins and designed to dry by chemical reaction on exposure to air. These coatings are intended to provide a durable transparent or translucent solid protective film.

vehicle - The liquid portion of a coating in which the pigment is dispersed; it is composed of binder, solvent and diluent.

viscosity - The property of a fluid whereby it tends to resist relative motion within itself. A thick liquid such as syrup has a high viscosity.

VOC - Volatile Organic Compound

VOC content - The proportion of a coating that is volatile organic compounds (VOCs), expressed as kilograms of VOCs per liter of coating solids. In calculating the VOC content of the coating, exempt compounds and water are excluded and are not considered to be part of the coating. Exempt compounds are acetone, ethane, methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, metallic carbonates, ammonium carbonate, methylene chloride, 1,1,1 trichloroethane (methyl chloroform), 1,1,2 trichlorotrifluoroethane (CFC-113), trichlorofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), dichlorotetrafluoroethane (CFC-114), chloropentafluoroethane (CFC-115), trifluoromethane (CFC-23), and

chlorodifluoromethane (CFC-22). Many of these exempt compounds may contribute to upper atmosphere ozone destruction.

VOC emissions - The mass of volatile organic compounds (VOCs), expressed as kilograms of VOCs per liter of applied coating solids, emitted from a surface coating operation.

volatile organic compound (VOC) - Any organic compound not specifically exempted by the U.S. EPA that participates in atmospheric photochemical reactions. VOCs may be emitted during the application and/or drying of coatings.

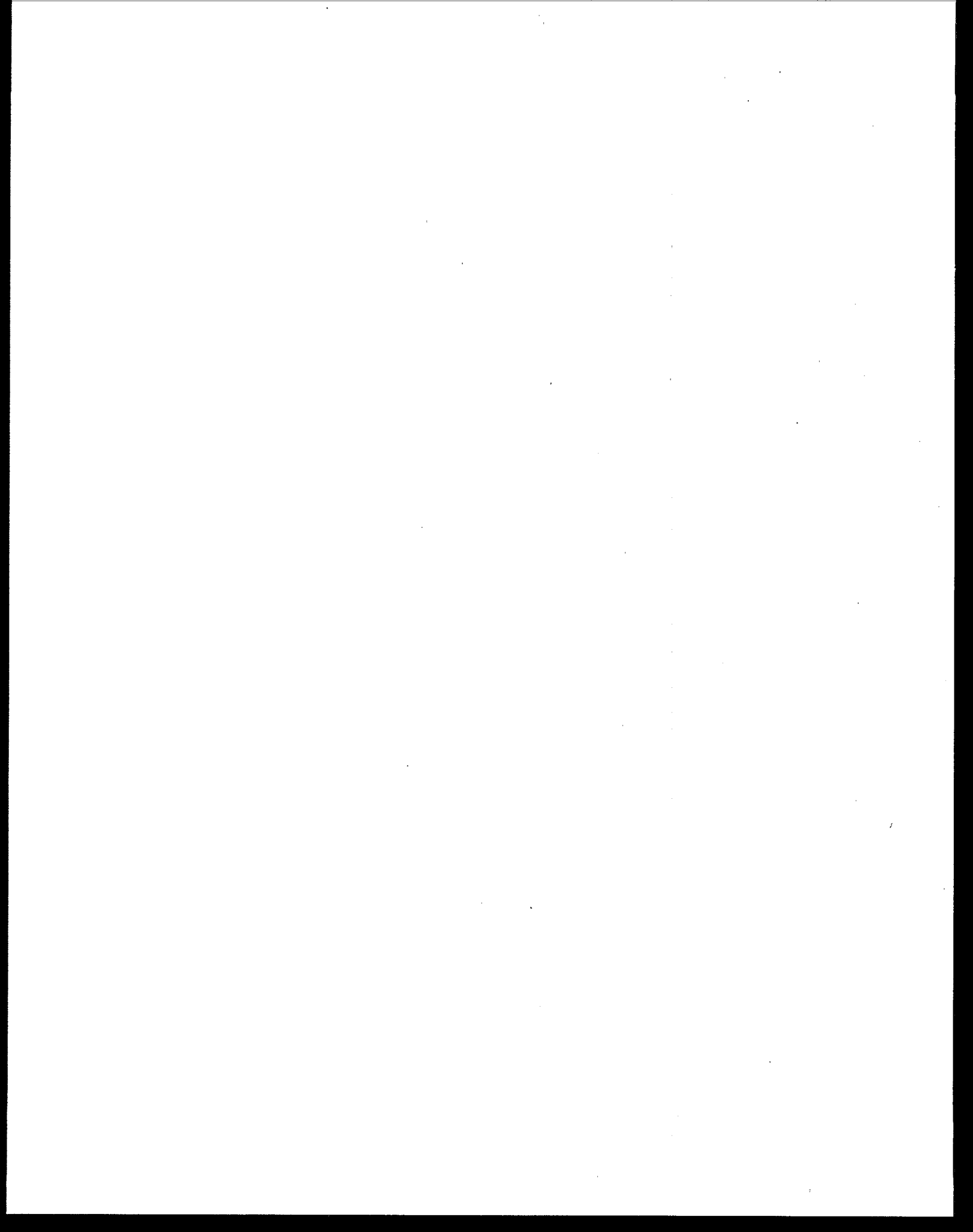
volatility - The tendency of a liquid to evaporate. Liquids with high boiling points have low volatility and vice versa.

voltage - A measure of the potential difference (force or pressure) in electrical systems.

W

waterborne coatings - Coatings in which water is the major solvent or dispersant. Solvents or dispersants include water soluble polymers (water reducible), water soluble colloidal dispersions, and emulsions (including latex).

wrap around - Electrostatic effect where charged coating particles curve around the part and are deposited onto the rear side of the part.



REFERENCES

Metal Finishing magazine is a technical periodical published monthly featuring articles on organic and inorganic metal finishing materials, technologies, and developments. Elsevier Science Publishers.

Products Finishing magazine is a technical periodical published monthly featuring articles on inorganic and organic metal finishing materials, technologies, and developments.

Coating Alternatives Guide (cage.rti.org) and Solvent Alternatives Guide (clean.rti.org). The Coating Alternatives Guide (CAGE) and the Solvent Alternatives Guide (SAGE) are pollution prevention tools utilizing an expert system and information base designed to recommend low-emitting alternative coating or cleaning technologies. The tools were developed by the Pollution Prevention Program and the Surface Cleaning Program at Research Triangle Institute in cooperation with the U.S. EPA Air Pollution Prevention and Control Division.

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