

200 PROCESS AND CONTROL

Surface Coating
Operations
Metal Parts
and Products

204 COATING SYSTEMS

The majority of emissions from the coating of Metal Parts and Products originate from the release of VOC from the coating as it dries to form a solid film. Basically, coatings consist of solvents (including diluents and some additives) and solids (resins, pigments, extenders, and some additives).

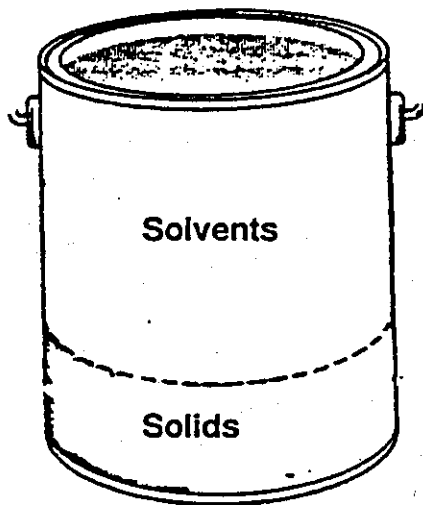


Figure 204.1 Can Of Coating

Solvents lower the viscosity (reduce or thin), act as a carrier for the solids, and dissolve the solid resin. Solvents evaporate from the coating before, during and after application. Solvents include VOC, water, and exempt solvents. **Resins** (or binders) are polymeric materials which form the bulk of the dried film and give the film its physical properties such as hardness, flexibility, and chemical resistance. **Pigments** are small particles which give the film color, hiding power and other properties. **Extenders** are inexpensive thickening agents. **Additives** are chemicals added to achieve very specialized effects, such as dryers, flating agents, flowing agents, etc.

Solvents

Conventional organic solvent borne coatings generally contain about 70% VOC, which evaporates as the coating dries. Of the VOC emissions from coating operations, 50 to 90% emanate from the paint spray booth and the immediate flash-off areas. In most cases, more than 90% of the VOC emissions occur within one hour of the coating application.

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During a rule development feasibility study, several low solvent coating types were identified and targeted as a technology forcing control technique. These coatings included high solids coatings, waterborne coatings, and powder coatings. Additional coating systems currently in use will also be discussed here.

204.1 HIGH SOLIDS COATINGS

High solids coatings, as the name implies, contain a greater proportion of film producing solids per liter than do conventional coatings. For the purpose of this manual, we will consider high solids coatings as those which contain greater than 62% (69% for baked coatings) by weight of solids. In addition to the lower solvent content per liter of coating, solvent emissions are also reduced by the increased solids content of the coating. Because more solids are contained in one liter of coating, the liter will cover a greater surface area than a liter of conventional coating (assuming the same dried film thickness). Thus, the total amount of coating required for application is reduced. The resin systems listed as being used in high solids systems can also be used in conventional coatings. Keep in mind that the solids content can vary greatly and that coatings labeled as high solids may not be complying coatings.

High solids coatings are single or multi-component systems. Single component packages include air dried alkyds and acrylics; baked alkyds, polyesters, acrylics, and single component polyurethanes (including moisture-cure polyurethanes). Multi-component systems involve mixing of the coating and a catalyst (and occasionally a binder and/or reducer) prior to application. Oven baking is usually not required due to the quick polymerization of the coating and of added catalyst. Multi-component coatings have a limited "pot-life", that is, after mixing, the polymerization reaction proceeds until the coating hardens. This can lead to excess coating curing within the equipment and to increased waste disposal. Multi-component coatings can be applied by equipment which mixes the coating at the spray gun, thereby reducing waste. Multi-component systems include air dried polyurethanes and epoxies. Often high solid coatings are used with heated spray systems. The heating in the range of 100 - 150 degrees F reduces the viscosity without adding additional solvents. However, in low usage applications circulation of the coating

Pot-life

may be needed to avoid curing the coating in the spray system.

High solids coatings offer advantages, particularly in the short term, over other emission reduction systems. First, one-component systems have manufacturing characteristics similar to those of the conventional high solvent coatings, thus manufacturers do not have technical production difficulties. The lower solvent content does, however, increase production costs. Second, the one-component systems have application characteristics very similar to the conventional high solvent coatings. Sources are rarely required to alter current practices since the one component coating adapts readily to their existing applicators and ovens. High solids coatings do have limitations, including a high viscosity which makes them harder to spray and may increase "orange peel", gloss differences, and greater film thicknesses. Also, the overspray may remain "tacky" making clean-up harder, and they are more difficult to use as dip coating because they tend to become thicker at the bottom of the tank.

204.2 WATER BORNE COATINGS

Water borne coatings are those where water is the major solvent or dispersant. Water borne coatings do contain VOC as a co-solvent. The VOC aids in pigment dispersion, viscosity control, and in wetting. The concentration of VOC can range from 5 to 40% by weight of the coating. Water borne coatings exist in three basic forms: water soluble dispersions, water soluble polymers, and emulsions. As a function of particle size, water soluble dispersions are usually transparent coatings, water soluble polymers are translucent and emulsions are opaque. Base polymers for waterborne coatings include: acrylics, polyesters, alkyds, vinyl emulsions, styrene-butadiene latexes, urethanes, epoxides, and modified versions of the resins including epoxy esters, acrylic esters, acrylic urethanes, and other synthetic resins. Properties of waterborne coatings vary widely as a function of base resin chemistry, curing properties, and polymer film cross-link density.

Advantages to water borne coatings include: reduced fire hazard, lower toxicity, reduced VOC emissions from coating, and reduced VOC emissions from clean-up (water used instead of VOC). Water borne coatings can be applied with almost all types of application equipment. However, water borne coatings require greater temperature and humidity control

VOC Co-Solvents

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during curing, greater energy and time for cure, and better surface preparation. Application equipment usually require stainless-steel parts due to compatibility problems and special precautions must be taken when using electrostatic equipment with water borne coatings. Water will conduct the electrical charge through the metal application equipment, so grounded isolation stands and areas are required to reduce electrical shock hazards.

204.3 POWDER COATINGS

Powder coatings are composed of fine, dry particles of paint solids and usually contain less than 4% VOC. These particles are applied to the substrate using electrostatic attraction and are then baked to fuse the particles into a smooth continuous film. The resins used in powder coatings are quite different from those used in liquid coatings. Liquid coatings require low viscosity and low molecular weight resins which are soluble or miscible with organic solvents or water. Powder coatings require resins which are solid at room temperature, to facilitate application, and melt during the baking process. The most common resins used in powder coatings to achieve industrial finishes consist of epoxies and polyesters. Commercially available powder coatings have been found to offer better physical properties and chemical and abrasion resistance properties than conventional coatings. Lower air flow is needed for powder spray booths. Additionally, the oversprayed powder can be recovered and reused, a part can be touched-up easily prior to baking, and excess powder can currently be easily disposed. Factors which limit the use of powder coatings include: the system's high capital costs including powder reclamation booths; the high baking temperature required to form the film; and the production down-time during color changes. Powder coatings cannot be mixed and you need to remove all of the initial powder to avoid a spotted finish.

204.4 EXEMPT SOLVENT BORNE COATINGS

Exempt solvent borne coatings are those where the major solvent is an exempt solvent which is usually inhibited 1,1,1 trichloroethane (1,1,1 TCA or Methyl Chloroform). Inhibited 1,1,1 TCA includes 3 to 5% by weight of VOC to ensure solvent stability. The VOC added are classified as acid acceptors which neutralize any hydrochloric acid formed, and metal stabilizers to inhibit exposure to reactive metals such as aluminum.

Inhibited

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Additionally, Methylene Chloride and Perchloroethylene may be used in various specialty coatings and maskant coatings. Additionally, VOC is used as a co-solvent to modify the evaporation rate of the solvent blend and reduce orange peel effects. The VOC must be subtracted during the calculation of the VOC content of the coating. Factors which limit the use of exempt solvent borne coatings include: the incompatibility of equipment and surfaces especially with components made of aluminum, the exposure of workers to halogenated solvents, the generation of hydrochloric acid upon exposure to heated surfaces such as ovens and solvent stills, and the incompatibility of other applied coatings.

Aluminum
Incompatibility

204.5 ELECTRO/AUTO DEPOSITION

These coating systems and associated dip application methods are somewhat analogous to electroplating of metals. They result in the surface deposition of a paint film from a water solution or dispersion which contains very low concentrations of VOC.

204.5.1 Electrodeposition

Electrodeposition, or electrophoresis, is a coating system and application process where the paint solids are given an electrical charge and the part is given an opposite electrical orientation. As current flows across the electrodeposition tank, the paint particles deposit on the part. The process can be either anodic or cathodic electrodeposition. If the part has a negative charge, it serves as an electrolyte and anodic electrodeposition occurs. The paint particles are solubilized through the introduction of a base, which results in a resin carboxyl group reaction and forms a water soluble salt. The negatively charged resin and pigment particles are attracted to the anode (substrate) and the pigment particles are deposited smoothly on the surface as an insoluble film. The film continues to build on the surface of the substrate until enough electrical resistance is created to stop the flow of current. The film thickness is a function of voltage supplied. The advantages of electrodeposition include: reduced VOC emissions, better quality control, complete coating coverage, better corrosion protection, reduced fire hazard, reduced waste, reduced ventilation requirements, and a net energy savings. Electrodeposition is usually limited to one color and is used by automobile manufacturing plants.

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204.5.2 Autodeposition

Autodeposition, or Autophoresis, is a coating system and application method similar to electrodeposition except that an electrical current is not used. It is a water borne coating process which depends on chemical reactions to plate out the coating film in a very specialized dipping system. The process uses an acidic bath to release iron cations from the steel surface. The cations react with negatively charged latex polymer and pigment particles and precipitate onto the surface. The system has been used as a primer or corrosion resistant coating where no decorative finish is needed.

204.6 RADIATION CURE

The next three systems can also be grouped as accelerated cure methods because they each involve the use of specific forms of radiation to accelerate the curing process. They are included as coating systems because they often require very specialized coatings. Additional radiation cure methods are being investigated at this time.

204.6.1 Ultraviolet Light

Ultraviolet light (UV) is a type of radiation which activates an initiator in the specialty formulated coating to start a free-radical polymerization reaction. The photoinitiators are catalysts which absorb UV light, and cleave to generate the free radicals which start the chain reaction. Viscosity of the coatings is achieved with reactive (double bond containing) diluents rather than solvents. These reactive diluents are low molecular weight monomers which react with the polymer chain to become part of the finished chain. The UV radiation is usually supplied by a mercury vapor lamp positioned close to the coated surface. Advantages to UV cured coatings include very low VOC content, low cure temperatures, low space requirements, and low exhaust requirements. Curing is difficult for thick films due to low energy of radiation, for pigmented films, and for non-flat surfaces. Additionally, ozone is directly emitted during the process, creating a worker exposure hazard along with an air pollution problem.

204.6.2 Electron Beam

Electron Beams, also known as beta rays, are an energy source which cures special coatings with high energy electrons to cause a crosslinking reaction. The advantages include a quick cure time with very little heat-up of the part. Disadvantages include the exposure to radiation, the generation of ozone, and the high capital costs. The method does require very specialized paints and curing is difficult on non-flat surfaces.

204.6.3 Infrared Radiation

Infrared radiation (IR) is absorbed by many coating systems causing frictional (vibrational) heating of the coating molecules and initiating solvent evaporation or film crosslinking. Advantages of the use of IR cured coatings include the ability to rapidly heat the film without heating the surrounding air, the ability to focus the heating, and the wide availability of coating systems. However, heat transmission is slow through thick coatings, and the method works best on flat surfaces.

205 APPLICATION EQUIPMENT

Coatings may be applied in a several ways. Most Metal Parts and Products operations use spray techniques to apply the coatings onto the substrate. Spraying moves very small particles or droplets from a hand held applicator (spray gun) using a liquid pump system or solid fluidizing system for powder coatings. The nozzle of the spray gun aspirates the liquid stream to achieve proper coverage on the surface of the part. On the part, the droplets flow together to form a wet film which upon curing becomes the dried paint film. In some cases, the facility may use other application techniques such as dip or flow coating. The following sections outline the most common coating application methods used and describe both low and high transfer efficiency methods. Transfer efficiency is dependent upon the type of application equipment used. However, the operation of the equipment will greatly affect the transfer efficiency achieved.

Application equipment can be separated into manual and automated systems. Manual systems are usually hand held spray guns. Transfer effi-

Transfer
Efficiency

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Good Spray Techniques

ciencies are very dependent on human factors including: the training, experience, and ability of the painter; the speed and care of application; and maintenance and cleaning of the equipment. Good spray gun techniques which can improve efficiency include: holding the gun perpendicular to the work; keeping a constant distance from the work; coating the surface following a regular sequence; using a proper fan size and shape; using pattern overlap efficiently; and pulling the gun trigger at the proper time while spraying.

Automatic operations can increase transfer efficiency. They reduce "waving" of the spray stream back and forth in coating the part, so fewer particles miss the target. Parts can also be spun on their axis as they pass through the spray stream. This allows the entire part exterior to be coated in one application. Human error is minimized because the spray gun is held steady and is usually turned on and off by a photoelectric eye as the part passes by. Automated systems can also be used with robotics which mimic a human painter.

205.1 AIR ATOMIZED SPRAY

High Air Pressure

Air atomized spray, commonly known as air spray or conventional spray, involves the dispersion of a paint stream by forced air. Compressed air is supplied to the spray gun at pressures up to 60 psi and to the paint container (pressure pot) at fluid pressures from 10 to 30 psi.

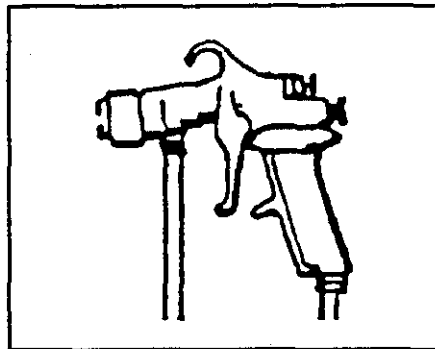


Figure 205.1 Air Atomized Spray Gun
(Source: Schneberger)

As the coating stream enters the application mechanism (spray gun), the high pressure air mixes with the coating, forcing the stream to break up

into small droplets and hurling the droplets in a turbulent mist towards the part to be coated.

The main reason for the lower transfer efficiency is that the air spray causes some initial VOC evaporation. Some of the coating solids dry, or congeal, fall from the stream before reaching the target or bounce off the target. Since air spray causes a wide dispersion pattern, the coating has more of an opportunity to pass by the target. Air spray has been the most widely accepted application method for several years. The painter can adjust the air, the fluid, and the fan pattern to achieve a very fine finish appearance.

205.2 AIRLESS SPRAY

Airless spray uses hydraulic atomization instead of air atomization. The coating is supplied to the gun under high fluid pressure between 1500 to 3000 psi and the coating is then forced through a small orifice. As the coating stream exits the tip into the air, it is atomized by the sudden decrease in pressure. Since air is not added to the spray, VOC evaporation is slightly reduced causing fewer particles to air dry before reaching the target. The droplet size range is larger and the turbulence is decreased so there is less overspray and the transfer efficiency is increased over air atomization. Airless spray can efficiently apply coatings to large surfaces. Disadvantages include: the high fluid pressure causes paint bounce back, increases fluid tip wear, and decreases the life of the pump. Often the finish appearance is coarse.

High Fluid
Pressure

205.3 AIR-ASSISTED AIRLESS SPRAY

Air-assisted airless spray combines air and airless features. An airless type fluid tip atomizes the paint and shapes the fan pattern at fluid pressures around 800 to 1000 psi. Lower pressure air from 10 to 30 psi combines at the spray cap to adjust the fan shape to eliminate heavy edges (tails). Air-assisted airless spray provides for greater pattern adjustment than airless spray and often gives a much greater finish quality. The lower air pressure reduces the surface turbulence and reduces paint bounce back more when compared to air atomization. The transfer efficiency can be greater with this method; however, the air pressure can often be adjusted to a level where the efficiency decreases.

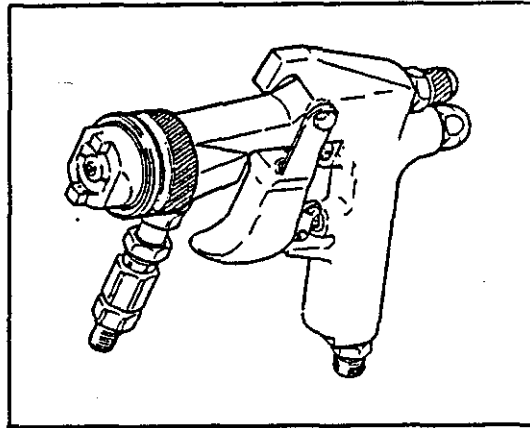


Figure 205.2 Air-Assisted Airless Spray Gun

205.4 HIGH VOLUME, LOW PRESSURE SPRAY

These newer types of spray equipment use a high volume of low pressure air to atomize and carry the coating. The air pressure is around 4 to 6 psi and passes through a relatively large atomizing hole in a more laminar air flow. This effect reduces turbulence and paint bounce back. The high volume low pressure air is produced by a turbine which increases the temperature of the atomizing air. The fluid delivery pressure is also kept low, at around 10 psi, which helps to reduce bounce back. Other advantages, in addition to increased transfer efficiency, include less fluid wear on parts, reduced fogging, the heated air increases the coating viscosity without solvents, and many spray parameters can be adjusted to give greater operator control. Disadvantages include the current expense of the equipment and the relative unfamiliarity of operators with the new technology.

205.5 ELECTROSTATIC SPRAY

Electrostatic attraction is the attractive electrical force between two dissimilarly charged particles. In electrostatic spray operations, the object to be coated is grounded while the paint is given an induced negative charge at the spray applicator. The negatively charged resin and pigment particles are electrostatically attracted to the grounded substrate

Low Air and
Fluid Pressure

and the pigment particles are deposited much in the same manner as in normal air spray. The advantage of electrostatic spray is reduced paint overspray because the coating is forcibly attracted by the substrate, therefore fewer particles miss the target. Operators often encounter an effect called "wrap around" where oversprayed coating which has passed by the target is attracted to the backside by the electrostatic force. Advantages to electrostatic spray include: reduced VOC emissions, better quality control, and reduced waste. One problem often encountered with electrostatic spray is the Faraday cage effect, in which interior corners and deep crevices cause an electrostatic repulsion and force the paint particles away from the area. In most cases, the operator will simply turn off the power to the electrostatic system while coating these hard to reach portions of a part. Other considerations include the potential for electrical shock, especially when using water borne coatings, and the potential for increased fire hazards. The wrap around effect can also be a problem when attempting to coat only one side of the part.

Wrap Around

Faraday Cage
Effect

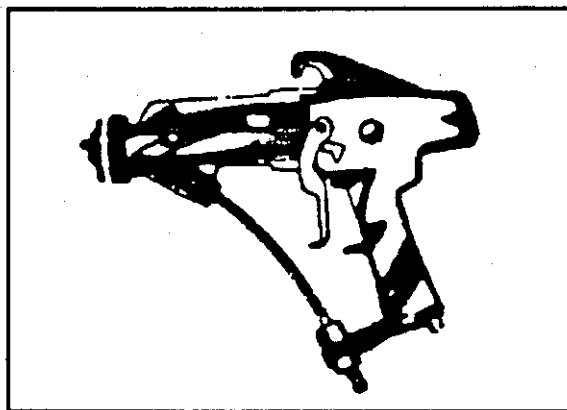


Figure 205.3 Electrostatic Air-Assisted Airless Spray Gun

Air atomized, airless, and air-assisted airless spray equipment in both manual and automatic spray operations have been designed to include electrostatic attraction. Additionally, rotational methods of atomizing the coating including electrostatic turbo-discs and turbo-bells are in use. These methods have achieved greater transfer efficiency because the atomization is produced by rotational energy at a lower delivery pressure. The coating is delivered to a rotating bell or disc which rotates at speeds up to 30,000 rpm atomizing the coating. Low pressure air is used to shape the fan pattern.

Flow Coating

205.6 FLOW, DIP, ROLL, AND HAND APPLICATION

Flow coating involves conveying the metal part or product over a closed sink and allowing a pumped stream of coating to gently 'flow' over the surface of the part. Excess coating drains into the sink, is filtered and then pumped back to a holding tank for re-use. Solvents evaporate over time, so additional solvents are occasionally added to the holding tank to control the coating viscosity. Pumping, filtering, temperature, and viscosity control are important parameters in flow coating operations.

Dip Coating

Dip coating is the immersion of pieces into a tank of coating. After withdrawal, the parts are held over the tank and excess coating is allowed to drip back into the tank. Very often the parts are dipped into the tank on hangers or trays. These hangers must later be scraped clean or subjected to extreme heat in order to remove the coating deposits. Parts can be dipped in batches or by conveyor line. The equipment is simple to use and allows for the coating of many shapes with high transfer efficiency provided the waste collects back into the tank. Circulation, filtering, temperature, and viscosity control of the coatings are important. Often reducing solvents are added to the dip tanks to replace evaporated solvents. Electro/Auto deposition systems are very specialized dip coating operations.

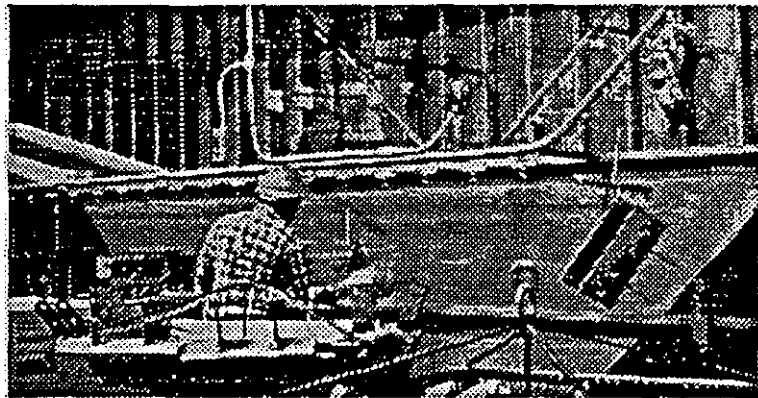


Figure 205.4 Conveyorized Dip Coating Line

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Roll coating is the application of a coating from a paint trough to a flat surface by a mechanical series of rollers. It is often used in the coating of metal coils and sheets, in the coating of paper, film and fabrics, and in graphic arts coating operations. Advantages include high transfer efficiencies and high rates of application and automation. Roll coating is usually limited to flat surfaces and is subject to high capital costs.

Roll Coating

Hand application methods involves the manual application of the coating using brushes and rollers. Many touch up operations and applications where overspray cannot be tolerated use some form of brush coating. Disadvantages include high labor costs and increased time necessary to coat a given surface area.

Brush Coating

206 ADD-ON CONTROL EQUIPMENT

Add-on control equipment consists of an abatement device, such as an incinerator, and an emission collection system consisting of hoods, ducting and fans. The abatement device is designed to destruct or recover the VOC it receives. Collection systems should vent all of the drying oven exhaust and spray booth exhaust, and vent the appropriate hoods which collect the fugitive emissions. Both the abatement device and the collection system must be properly sized, designed, operated, and maintained to reduce the emissions from the coating operation.

Add-on control equipment or abatement devices are technically feasible for the control of VOC emissions from coating application lines. In general, the capital and operating cost of such devices has been high compared with the use of general purpose low solvent coatings. Coating application lines need to be designed and positioned in such a way as to maximize VOC collection efficiency. This means that retrofitting existing facilities with control devices may be difficult and expensive. Finally, the volumes of exhaust air are very high and the concentrations of VOC are very low. This is due in part to worker safety and fire safety concerns. The combined effect is to increase the size and operating cost of add-on control equipment. However, reformulation costs for many speciality coatings have increased to levels where add-on control equipment may be cost effective.

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Abatement Device Efficiency

Collection Efficiency

The effectiveness of add-on control equipment is dependent on both the abatement device (destruction) efficiency and the collection (capture) efficiency. The abatement device efficiency is the ratio between the outlet and the inlet VOC concentrations of the device during operation as measured by adopted source test methods. Collection efficiency is the ratio of the emissions which enter the abatement device to the emissions from the uncontrolled operation. In practice the collection efficiency is very difficult to measure and the efficiency will vary significantly due to numerous parameters which the inspectors may not be able to quantify. Due to the difficulty in collecting emissions from actual coating lines, the applications for which add-on control equipment has been used was to control emissions from large baking ovens. However, facilities are now installing enclosed negative pressure rooms that ensure high capture efficiency. Computers are used to monitor the lower explosive limit to determine the volume of make-up air required to maintain safety. The following section discusses the two main types of VOC control devices and the promising technologies currently being investigated.

206.1 INCINERATION

Incinerators (afterburners) destroy VOC through thermal oxidation to water vapor and carbon dioxide. This combustion process usually requires the addition of auxiliary fuel, such as natural gas. Incineration is dependent on the three "T's" of combustion: time, temperature and turbulence. The time the VOC is within the high temperature zone (residence time) must be long enough for all the VOC to combust. The temperature of the incinerator must be high enough to completely oxidize the VOC. Finally, turbulence ensures adequate mixing of combustion air, auxiliary fuel, and the VOC. Incineration has previously been accomplished through two different types of equipment: direct flame incinerators and catalytic incinerators. Both types of incinerators have been used in California to reduce VOC emissions from large baking ovens.

Direct Flame Incinerator

Direct flame incinerators depend on flame contact and high temperatures in the range of 1200 to 1500 degrees F to complete oxidation of the VOC. Direct flame incinerators usually consist of refractory lined chambers, burners, controllers, safety equipment, and heat recovery equipment.

Catalytic incinerators require a catalyst to promote the oxidation of the VOC at a lower temperature. The catalyst is often a platinum series metal deposited in a porous form onto a structure, such as a honeycomb, or on pellets. The VOC is preheated up to 650 to 900 degrees F and then enters the catalyst area. There the oxidation of the VOC continues to produce an increase in temperature across the catalyst bed. Catalytic systems have advantages over direct flame systems in that fuel savings are possible due to lower temperatures. However, catalysts have a limited life span and must be replaced, often every 3 to 5 years. Catalysts are subject to fouling (poisoning) from chemicals and particulate which would quickly reduce the effectiveness of the incinerator.

Catalytic Incinerators

Poisoning

General limitations with incineration include: 1) high capital costs, 2) ongoing costs of incinerator fuel to facilitate the thermal destruction of the VOC, 3) fouling of the catalysts resulting in reduced destruction efficiencies, and 4) emission of gaseous pollutants including oxides of nitrogen and carbon monoxide.

206.2 CARBON ADSORPTION

Carbon adsorption units adsorb VOC from the gaseous stream onto the surface of activated carbon. Activated carbon has a very large surface area due to the large number of pores throughout the carbon. VOC diffuse into these pores and are retained on the surface of the carbon due to chemical and physical forces. The capacity of the carbon to adsorb is a function of: 1) amount of carbon; 2) the characteristics of the carbon; 3) the gas stream temperature and humidity; 4) the VOC concentration; and 5) the chemical characteristics of the VOC itself. Generally, high molecular weight compounds are retained more effectively and also require more energy to desorb from the carbon.

Carbon adsorption units are typically either fixed beds or fluidized beds of carbon. VOC-laden air is pretreated to remove solids, liquids, and the longer chain high boiling organic compounds which would coat the carbon. The exhaust stream then passes through the adsorbing bed where the VOC collects on the surface of the carbon. A concentration gradient develops and a band of carbon becomes saturated with VOC. Over time the entire bed becomes saturated with VOC and its capacity to adsorb is reduced. When the bed is saturated it reaches its breakthrough point and

Adsorption

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Desorbtion

VOC vents out of the unit. The bed must then be regenerated. In other words, the VOC must be stripped (desorbed) from the bed. Usually steam or high temperature nitrogen is used for regeneration. The stripped VOC is either recovered, sold for reclaiming, or properly disposed of.

The use of carbon adsorption is technically feasible for use in controlling VOC emissions from coating operations, provided temperatures of the gaseous stream are low, contaminants (solids, liquids, etc.) are removed, and humidity is adjusted. Additional limitations to the use of adsorption include 1) high capital costs, 2) high operation cost including desorbing energy and carbon replacement, and 3) periodic desorbing of carbon bed results in reclaimed solvent which, for many solvent blends found in paints, may need to be properly disposed of.

206.3 OTHER ADD-ON CONTROL EQUIPMENT

Condensation

Condensation and absorption control devices could potentially be used at Metal Parts and Products coating operations; however, neither technology is used to a large extent. Condensers reduce the temperature of the VOC stream to a temperature at which the VOC condenses out into a liquid. Absorbers usually pass a VOC containing air countercurrent to a liquid stream, so that the liquid absorbs the VOC. The VOC must then be removed from the liquid.

Absorption

Several other promising technologies are currently being evaluated as add-on control devices at metal parts and products coating operations. These include fluidized-bed catalytic incinerators using non-precious metal catalysts; regenerative incineration; carbon adsorption concentration systems coupled with catalytic incineration; "comb-changer" regenerative oxidation systems; polymer adsorption material fluidized bed system; super-critical fluid oxidation; UV destruction; ozone destruction; molten salt oxidation; infrared incineration; silica and alumina bead adsorption; membrane vapor separation (similar to reverse osmosis membrane separations in water system); and other hybrid combination systems. In addition to these technologies, flow modification techniques are being investigated. These techniques are designed to reduce the volume of air flow from the application area to be treated.

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207 SPRAY ENCLOSURES

Spray coating operations produce emissions of VOC and particulate matter. The spraying of coatings and other materials is often performed inside a booth or enclosure which uses a draft fan to provide ventilation. These enclosures are commonly referred to as paint spray booths. Paint spray booths are designed and operated to: remove overspray from the work area; provide a work area which is protected from ambient conditions; protect the painter from harmful vapors, particulates, and explosions; and vent the VOC and particulates through the filter/hood/ducting system to the ambient air.

Paint spray booths are usually sized to handle the largest object to be painted; however, in practice the parts painted on any day are usually much smaller. Ventilation velocities vary from 2.8 to 4.3 meters per minute per square meter of booth opening. Safety and insurance requirements usually will require that the VOC concentration of the exhaust stream be maintained at lower than 25% (or approximately 2,500 ppm) of the lower explosive limit (LEL). The majority of paint spray booths will operate with much lower exhaust concentrations of VOC.

Spray booths can be grouped as side-draft or down-draft booths. The majority of booths are side-draft booths. Air entering the booth passes through filters to remove dust from the incoming air, and then is drawn past the application area and into the filter/collection system which is usually located along the opposite wall of the booth. Down-draft booths draw the air down through a filter/collection system which is located in the floor of the booth. Down-draft booths are often used for painting large objects.

Both filter/collection systems include filtering area, collection ducting which often includes flame arrestors, and an exhaust stack with fan. The particulate matter consists of entrained coating material which does not stick onto the part or to the inside of the enclosure. Paint spray booths are designed for the removal of the particulates through baffle plates, dry filters, or water spray curtains. Keep in mind that spray booth filters are not designed for the capture of VOC.

Side-draft

Down-draft

207.1 DRY FILTERS

Dry baffle spray booths use baffle plates to force the air to change direction and to provide a surface for the particulate to adhere to. Particulate removal efficiencies are comparatively low and depend on the particle size and how tacky the overspray is. Lacquers which dry rapidly will not be collected well on dry baffles. Dry baffles require frequent cleaning.

Dry filter spray booths use filter pads, usually of a woven mesh, through which the air flow passes. The particulate is trapped on the filters. When the filters become loaded with paint, the pressure drop across the filters increases and the air flow through the filters decreases. Unless the filters are changed, the visibility in the work area will decrease. Generally, a maximum pressure drop of 0.25 inches of water prior to changing of the filters is recommended. However, this can vary from booth to booth. Manometers enable the operator to determine the pressure drop provided they are filled with fluid, zero'd, and are properly installed and operated. Filters which contain activated carbon are also being used. Additionally, powder spray booths often contain a special filter and reclaiming system to prevent the powder from settling on nearby surfaces where they can flow and set up on a hot day.

Pressure Drop

Manometers

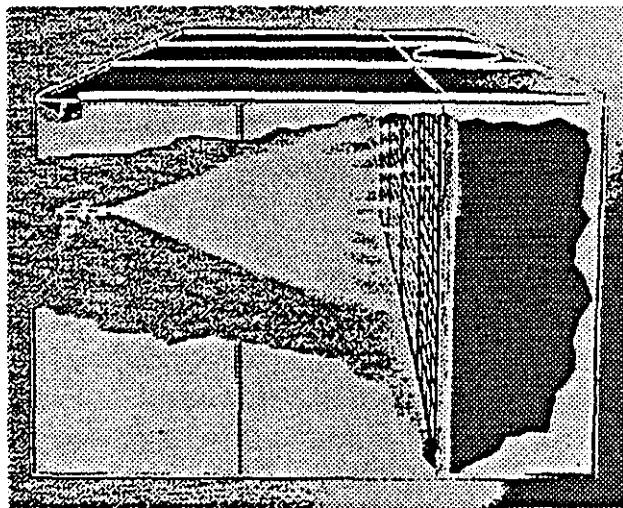


Figure 207.1 Dry Filter Spray Booth

207.2 WATER WASH

Water-wash spray booths may include wet curtains and spray nozzles. Water (or occasionally oil) flows down a baffle plate which enhances the capture of particles and the flow washes the particulates down to a circulating tank. Additionally, spray nozzles are often used to knock down the particulate. Greater particulate removal efficiencies can be achieved without the need to purchase filters. However, surface active agents are added to the water to aid in the removal of the paint from the tank. The proper maintenance of the booth and of the chemical additives are very important to ensure adequate removal efficiencies. Additionally, sludge is generated from water-wash booths. Health services and water control agencies have additional requirements for the discharge of wastewater and for the disposal of the sludge.

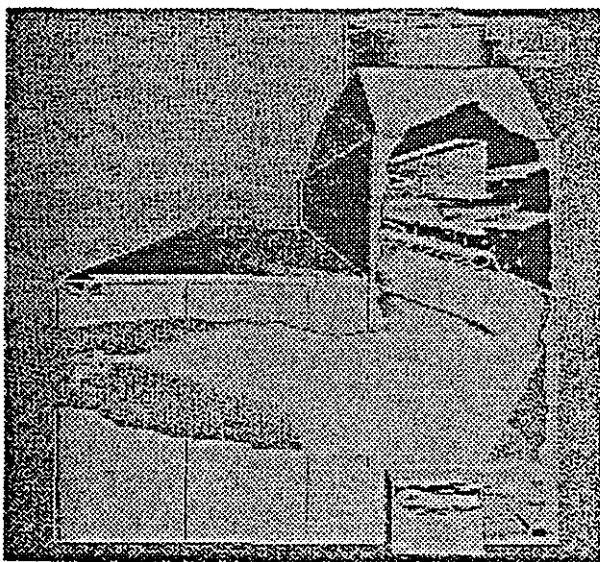


Figure 207.2 Water Wash Spray Booth

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COATING TERM GLOSSARY

Acrylics - Binder (Resin) based on polymer comprised of short chain esters of acrylic and methacrylic acid, acrylonitrile, and their copolymers. (Thermoplastic) Also used as powder coating.

Active Solvents - A liquid which can dissolve the binder when used alone.

Additives - Any substance added in small quantities to another substance, usually to improve properties. Examples are plasticizers, fungicides, dryers, etc.

Adhesives - Adhesives are any coatings which are applied to bond one surface to another surface (See Coatings and Mastic). Any surface may be bonded to the metal surface, however some rules limit "adhesives" to the bonding of one metal surface to another metal surface.

Aerosol Can Spray Coatings - Aerosol can spray coatings are coatings which are sold in hand-held pressurized containers and which are expelled from the container in a finely divided spray when a valve on the container is depressed.

Aerospace Vehicles or Components - The fabricated part, assembly of parts or completed unit of any aircraft, helicopter, missile or space vehicle. The definition is usually found in the specific aerospace coating rules.

Air Dried Coatings - Air dried coatings are coatings which are not heated above 194F for curing or drying. In the SCAQMD, curing must be done below (rather than at or below) 194F to qualify as air dried. These also include forced-air dried coatings.

Airless Spray - Paint spray application system using high fluid pressure to atomize paint without compressed air.

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.

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

Aliphatic Solvent - VOC primarily comprised of straight chain hydrocarbons. Included mineral spirits, kerosene, and hexane.

Alkyd - Binder based on resins formed by the condensation of polyhydric alcohols with polybasic acids. (Thermoset)

Appurtenances - Accessories to an architectural structure, including, but not limited to: hand railing, cabinets, bathrooms and kitchen fixtures, fences, rain-gutters and down-spouts, window screens, lamp-posts, heating and air conditioning equipment, large fixed stationary tools and mechanical equipment, and concrete forms.

Architectural Coatings or Prefabricated Architectural Component Coatings - Any coatings applied to stationary structures and their appurtenances, to mobile homes, to pavement, or to curbs. This definition is usually located in the specific district architectural coating rule. Districts usually allow an exemption in the Metal Parts and Products rules for the use of air dried coatings on architectural structures and their appurtenances provided the coating meets the requirements of the applicable architectural coating limit. Baked coatings of components or appurtenances are usually subject to the Metal Parts and Products limits. Problems have been encountered in the field with respect to determining what constitutes an architectural appurtenance. The SCAQMD definition for prefabricated architectural component coatings states that they are coatings applied to components which are to be used as an architectural structure which subjects items such as door frames, handrails, decorative trim, etc., to the metal parts and products rules.

Aromatic Solvents - VOC which contain an unsaturated ring of carbon atoms, including benzene, naphthalene, anthracene and their derivatives. Toluene (toluol) and xylene (xylol) are commonly used aromatics.

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

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Autodeposition - Dip coating application method which depends on a chemical reaction to plate out the coating film.

Baked Coatings - Baked coatings are coatings which are cured or dried, usually in an oven, at an oven air temperature above 194F (90 degrees C) or are cured at a temperature at or above 194F.

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

Bituminous Coating Materials - Black or brownish coating materials, soluble in carbon disulfide, consisting mainly of hydrocarbons and which are obtained from natural deposits, or as residues from the distillation of crude petroleum oils, or of low grades of coal. (Asphaltics)

Bleeding - Defect which occurs when colorants from a lower surface diffuse into a surface coat and cause discoloration.

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

Blooming - Powder-like deposit forming on the surface of the film often resulting from partial dissolving and redepositing of pigment by a solvent component.

Blushing - Whitish, milky area which develops on the film and may be caused by the absorption of water vapor by the drying film.

Brittleness - Tendency of a coating film to crack.

Brush Coating - Manual application of coatings using brushes and rollers.

Catalyst - Chemical used to change the rate of the chemical reaction. Catalysts are not chemically consumed during the reaction while curing agents are consumed. Catalysts may be accelerators which increase the rate of reaction, or inhibitors which decrease the reaction rate.

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Camouflage Coating - Camouflage coatings are applied on military equipment to conceal such equipment from detection. However, care should be used to sufficiently limit the qualification as a camouflage coating and to require the source to demonstrate that complying coatings are not available.

Cathode Coatings - Cathode coatings are coatings which have as their primary purpose the coating of electrical cathodes. The term may also be used in an electrodeposition process.

Chalking - The degradation of a paint film by gradual erosion of the binder.¹

Checking - Paint film cracking which starts at the surface as a V-shaped crack that is narrower at the bottom. If the substrate surface is exposed, it is called cracking.

Chemical Milling Maskants - These are coatings which are applied to a component to protect an area when performing chemical milling, anodizing, aging, bonding, plating, etching, and/or other chemical surface operations on the component.

Chipping - The breaking away of small portions of the paint film due to its inability to flex under impact or with thermal expansion and contraction of the substrate.¹

Chlorinated Rubber - Resin formed by the reaction of rubber with chlorine.²

Chlorinated Solvents - Organic solvents which contain chlorine. Includes 1,1,1 trichloroethane and methylene chloride.

Coating - A liquid, liquefiable or mastic composition which is converted to a solid protective, decorative, or functional adherent film after application as a thin layer.³ SCAQMD has defined coatings as materials which are applied to a surface and which form a continuous film in order to beautify and/or protect the surface.

Coating Line - Coating lines are all operations involved in the applica-

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tion, drying and/or curing of surface coatings. However, this definition may not give enough specific guidance to delineate between what constitutes separate coating lines in a source, especially when a single oven may cure parts from multiple spray booths. This definition may not be necessary for most rules when the exemption level of the rule is not related to the volume of coating applied per coating line.

Corrosion - The deterioration of metal or of concrete by chemical or electrochemical reaction resulting from exposure to weathering, moisture, chemicals, or other agents in the environment in which it is placed.²

Cobwebbing - The tendency of spray paint to form strands rather than droplets as it leaves the spray gun. This may be caused by too volatile a solvent or too little air pressure.¹

Cracking - The splitting of the paint film. This includes: hair-cracking, checking, cracking, crazing, and alligatoring (crocodiling).

Cratering - Small round depressions in a paint film which may or may not expose the underlying surface.¹

Crawling - Defect in which wet paint or varnish film recede from small areas of the surface, leaving them apparently uncoated.² May be caused by an incompatible film on the surface.

Crazing - The formation of surface cracks, often as a fine network, which do not penetrate to the underlying surface.¹

Cure - To change the properties of a polymeric system into a final, more stable, usable condition by the use of heat, radiation, or reaction with chemical additives.³ For liquid coatings, it is the process by which the liquid is converted into a solid film.

Density - Measure of mass per unit of volume, ie. grams per liter and pounds per gallon. One pound per gallon approximately equals 119.8 grams per liter.

Diluent - Diluents are liquids which increase the capacity of a solvent for the binder. Diluents cannot dissolve the binder themselves. They are

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usually used to control viscosity, flash time, or cost.¹

Dip Coating - The process in which a substrate is immersed in a solution (or dispersion) containing the coating material and withdrawn.³

Dispersion Coating - A type of coating in which the binder molecules are present as colloidal particles.¹

Drier - An additive which accelerates the drying of coatings.

Drying Oil - An oil which possesses to a marked degree the property of readily taking up oxygen from the air and changing to a relatively hard, tough, elastic substance when exposed in a thin film to the air.³

Dry Spray - Spray particles which become partially dried before reaching the surface which may result in a reduced gloss finish or a sand finish.

Electric Insulating Varnish - These are non-convertible-type coatings applied to electric motors or components of electric motors. These coatings are often applied at electric motor rewind shops through a dip coating process.

Electrodeposition - Dip coating application method where the paint solids are given an electrical charge which is then attracted to the part.

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

Emulsion - 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).²

Emulsion Paint - Paint, the vehicle of which is an emulsion of binder in water. Not to be confused with a latex paint in which the vehicle is a latex, however, latex and emulsion are often used synonymously in the paint industry.

Enamels - Topcoat which is characterized by its ability to form a smooth

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surface; originally associated with a high gloss, but may also include a lower degree of gloss.² Also are a class of substances having similar composition to glass with the addition of stannic oxide, or other infusible substances to render the enamel opaque.² Can be used to describe a coating which forms a film through chemical union of its component molecules during cure and in shop terminology can be used to describe any paint which is not a lacquer.¹

Epoxies - Binder based on epoxy resins. Epoxy crosslinking is based on the reaction of the epoxide groups with other materials such as amines, alcohols, phenols, carboxylic acids, and unsaturated compounds. Also a thermoset powder coating.

Etching - Use of chemical solution to remove a layer of base metal to prepare the surface for coating or binding.

Etching Filler - Coatings that contain less than 23 percent solids by weight and at least 1/2 percent acid by weight, and are used instead of applying a pretreatment coating followed by a primer.

Exempt Compounds - Most district rules excludes these compounds within the definition of "volatile organic compound". These compounds are: 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). SCAQMD specifies a separate definition for exempt compounds in the text of the prohibitory rule. Other districts may use the terms non-precursor or non-reactive organic compounds. During the calculation of the VOC content of the coating, these exempt compounds and water are excluded and are not considered to be part of the coating. As a note, many of these compounds which are listed as exempt compounds may contribute to upper atmosphere ozone destruction. Other exempt compounds are being investigated as possible toxic air contaminants. Finally, carbon dioxide is considered to be a "Greenhouse gas" which may contribute to global warming, and carbon monoxide is a primary pollutant.

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Explosive Limits - Range of vapor concentrations that will burn in air. A flame will not be sustained at a vapor concentration below the lower explosive limit (LEL) or above the upper explosive limit (UEL).

Extender (Pigments) - White powders intended to give body to the coating rather than color.*

Extreme Performance Coatings - Coatings which during intended use are exposed to industrial grade detergents, cleaners, and scouring agents. District rules usually contain a catch-all provision which basically states that a coating may qualify as an extreme performance coating if it is intended for exposure to similar harsh environmental conditions as approved by the APCO. Interpretation problems can occur because the definitions do not quantify exposure conditions. The rules employ terms such as, "intended for exposure", "chronically exposed to", "designed for exposure to", "extreme environmental conditions", and "unprotected shipboard conditions".

Fading - Loss of the color in a pigmented coating film over time following exposure to light, heat, time, etc.

Faraday Cage Effect - The phenomenon by which charged particles are prevented from entering recessed areas during the electrostatic application of coatings.

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

Film Thickness - The thickness of any applied coating measured either as wet or dry using film thickness gauges. Often described in units of one thousandth of an inch (0.0254 mm) thickness or one mil.

Fisheye - Paint defect resulting in a pattern of small surface depressions or craters in the wet film. May be caused by surface contamination such as oil or silicone materials.

Flash-off Time - Time between applications of successive wet-on-wet coatings or between application and baking where the bulk of the solvents in the coating can rise slowly and evaporate. In baked coatings the flash-

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off time helps to prevent solvent boil off and film blistering.

Flash Point - Temperature at which enough flammable vapors will evaporate from a material to ignite in contact with an open flame or spark.

Flat Coatings - Coatings which register gloss less than 15 on an 85 degree meter or less than five on a 60 degree meter, or which is labeled as a flat coating. Definition is usually found in architectural coating rules.

Flocculation - Formation of loose clusters of pigment particles in the liquid coating.

Flooding, Floating, or Mottle - Tendency of pigment particles to separate and concentrate in an area such as the surface.

Flow Coating - Coating application system where paint flows over the part and the excess coating drains back into collection system.

Fusion - Melting of a powder coating into a solid film.

Gloss - A measure of the amount of light reflected off a surface. The more reflection, the higher the gloss. Gloss can be measured with photoelectric devices which compare the reflected light versus the light originally falling on the surface at a given angle of reflection.

Hardness - Resistance of the film to cutting, indentation or penetration by a hard object.

Heat Resistant Coating - Heat resistant coatings must withstand a temperature of at least 400F during normal use. The SDCAPCD rule stipulates that the coating must withstand temperatures of 400F during normal use as determined by ASTM Method D-2485.

Hiding Power - Ability of film to cover a surface from view.

High Boilers - Solvents with boiling points above 212 degrees F (Tail-end solvents). These solvents usually evaporate during baking.

High Gloss or Extreme High Gloss - Coatings which when tested by

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ASTM D-523, show a reflectance of either 75, or more recently 85, or more on a sixty degree meter.

High Performance Architectural Coating - High performance architectural coatings must be applied to architectural subsections and must meet the requirements of Architectural Aluminum Manufacturers Association publication number AAMA 605.2-1980; a requirement which can be laboratory tested. None of the district rules define the term "architectural subsections."

High Solids Coatings - For the purpose of this manual, high solids coatings are solvent borne coatings which contain greater than 62 percent (69 percent for baked coatings) by weight of solids.

High Temperature Coatings - A coating which is certified to withstand a temperature of 1000 degrees F for 24 hours, or which during normal use must withstand temperatures of at least 1000 degrees F.

High Volume, Low Pressure Spray - Spray equipment used to apply coating by means of a gun which operates between 0.1 and 10.0 psig air pressure. The high volume of air is produced by a turbine.

Humidity Testing - Paint tests which expose dry film to water vapor.

Hydrocarbon Solvent - In coating terminology, VOC that obtained from petroleum and coal tar, and contain only compounds of carbon and hydrogen. Includes aliphatic, aromatic, and naphthenic solvent.

Impact Resistance - Paint test to measure resistance to impact damage (chipping and cracking).

Inhibitor - A chemical added to retard an undesired chemical reaction such as corrosion, oxidation, drying, skinning, etc.

Initiator - A chemical added to help start a chemical reaction such as polymerization.¹

Ink - A fluid or viscous substance used for writing or printing.²

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Inorganic Polymers - Substances whose principal structural features are made up on homopolar interlinkages between multivalent elements other than carbon. This does not preclude the presence of carbon-containing groups in the side branches, or in interlinkages between principal structural members. Examples of such polymers are ethyl and butyl silicates.

Isocyanate Resins - Resins synthesized from isocyanates ($-N=C=O$) and alcohols ($-OH$). The reactants are joined through the formation of the urethane linkage and hence this field of technology is generally known as urethane chemistry.²

Job Shop - A shop which does not manufacture metal parts and products but which applies coatings to such products at their shop under contract with one or more parties that operate at a different location under separate ownership and control. May also be referred to as a contract painter.

Kick-out - Binder comes out of solution as small lumps.

Lacquer - Clear or pigmented coating formulated with nitrocellulose or synthetic resin to dry by evaporation without a chemical reaction and to provide a quick-drying, solid protective film.

Latent Solvent - A liquid which cannot itself dissolve a binder but which increases the tolerance of the coating for a diluent.¹

Latex - Fine dispersion of rubber or resin, natural or synthetic, in water; the synthetic is made by emulsion polymerization. (Strictly speaking after polymerization, a latex is a solid dispersed in water and therefore not an emulsion. Latex and emulsion are often used synonymously in the paint industry).²

Low Boilers - Solvents with low boiling points (less than 122 degrees F) and usually high evaporation rates. May be called front-end solvents.¹

Magnet Wire Coating Operations - The process of applying insulation coatings such as varnish or enamel on magnet wire where the wire is continuously drawn through a coating applicator. As a note, these operations are usually subject to a separate specific regulation and are exempted from the Metal Parts and Products regulations. Operations which apply

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electric insulating varnish to subassemblies such as armatures, rotors, stators, and motor housings are usually subject to the Electric Insulating Varnish Speciality Limits of the Metal Parts and Products rules.

Magnetic Data Storage Disk Coating - Coating used on a flat film or metal disk on which digital information can be stored through the selective magnetization of portions of the flat surface.

Mastic - Adhesive composition, loosely used to describe a plastic filler, stopper, putty or adhesive.²

Material Safety Data Sheets (MSDS) - Informations sheet provided to users by chemical manufacturers providing information concerning the hazards of the materials. The format is specified by the federal Occupational Safety and Health Administration (OSHA) in Title 29, Sections 1915-1917 of the Code of Federal Regulations.

Metal Particles - Metal particles are particles of an elemental pure metal or combination of elemental metals.

Metallic Topcoat - A coating which must contain greater than 5 g/l or 8 g/l metal particles, as applied, to qualify as a metallic topcoat. The BAAQMD rule also stipulates that the particles must be visible in the dried film.

Middle Boilers - Solvents with boiling points in the range of 122 to 212 degrees F (Middle Solvent).

Mil - Common unit of measurement for film thickness. Equal to one thousandth of an inch (0.0254 mm).

Miscellaneous Metal Part or Product - Metal Parts and Products are usually defined as components or complete units fabricated from metal except those subject to the coating requirements of other specific district rules or any metal part not exempted from the rule. Some districts still contain the Suggested Control Measure definition for Manufactured Metal Parts. In these districts, the rule limits applicability to metal parts manufactured under Standard Industrial Classification Codes 25, 33, 34, 35, 36, 37, 38, and 39. Some rules still are titled Manufactured Metal Parts

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and Products. The manufactured designation has been changed to avoid enforcement questions at facilities which refurbish or rework metal parts and products.

Military Specification Coatings - Coatings which have a paint formulation approved by a United States Military Agency for use on military equipment.

Mixing Ratio - Ratio of coating to added thinner, catalyst, or other additives as mixed by the operator just prior to application (As applied).

Mold-Seal - Initial coatings applied to a new mold or a repaired mold to provide a smooth surface which when coated with a mold release coating, prevents products from sticking to the mold.

Motor Vehicle - A vehicle which is self-propelled and is a device by which any person or property may be propelled, moved or drawn upon a highway, excepting a device moved by human power or used exclusively upon stationary rails or tracks.

Nitrocellulose - Binder (Resin) based on polymer from cellulose in cotton. It was primarily used in laquers. It was widely used from the 1920's to the 50's on automobiles. (Thermoset)

Non-Flat - Coatings which register gloss of 15 or greater on an 85 degree meter or five or greater on a 60 degree meter, and which are identified on the label as a gloss, semigloss, or eggshell enamel coating. Definition is usually found in architectural coating rules.

Non-Photochemically Reactive - Solvents or blends of solvents which do not meet the definition of Photochemically Reactive in general organic solvent regulations. Do not confuse with exempt solvents, non-precursor, and non-reactive compounds.

Non-Precursor - See Exempt Compounds

Non-Skid Coatings - Non-skid coatings are coatings which have as their primary purpose the creation of traction to prevent slippage.

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Nylon Resins - Polyamide resins made from interaction of diamines and dicarboxylic acids. Used as thermoplastic powder coatings.

Oil Base - Coatings which form films through cross-linking of unsaturated plant oils (drying oils) in the presence of oxygen.

Orange Peel - An irregularity in the surface of a paint film resulting from the inability of the wet film to "level out" after being applied. Orange peel occurs as a characteristically uneven or grainy surface to the eye, but usually feels smooth to the touch (1).

Overbake - The result of curing the film at too high a combination of time and temperature.¹ This may result in a film that is brittle.

Overspray - Coating which does not land on the part and which is deposited on the surrounding surfaces.

Oxygenated Solvents - VOC which contains oxygen in addition to carbon and hydrogen. Includes alcohols, esters, ketones, and ether-alcohols.

Paints - Any pigmented liquid, liquefiable, or mastic composition designed for application to a substrate in a thin layer which is converted to an opaque solid film after application. Used for protection, decoration or identification, or to serve some functional purpose such as filling or concealing of surface irregularities, the modification of light and heat radiation characteristics.²

Pan-Backing Coating - Coating applied to the surface of pots, pans, or other cooking implements that are exposed directly to flame or other heating elements.

Peeling - Failure of a coating film to maintain adhesion with its substrate. Sheets or ribbons of the film can be removed. Can result from contaminated surfaces, or from excessive differences in polarity and thermal expansion characteristics between the surface and the film

Phenolic Resins - Resins made by condensation of phenols and aldehydes (Thermoset).

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Phosphating - Surface treatment/conversion process with chemicals containing metal phosphates or phosphoric acid used to form a thin phosphate layer prior to painting.

Photochemically Reactive Solvent (PCR) - Any solvents with an aggregate of more than 20 percent of its total volume composed of the chemicals classified below or which exceeds any of the following individual percentage composition limitations, referred to the total volume of solvent;

(a) A combination of hydrocarbons, alcohols, aldehydes, ethers, esters or ketones having an olefinic or cycloolefinic type of unsaturation except perchloroethylene; 5 percent;

(b) A combination of aromatic compounds with eight or more carbon atoms to the molecule except ethylbenzene, methyl benzoate and phenyl acetate; 8 percent;

(c) A combination of ethylbenzene, ketones having branched hydrocarbon structures, trichloroethylene, or toluene; 20 percent.

Whenever any organic solvent or any constituent of an organic solvent may be classified from its chemical structure into more than one of the above groups of organic compounds, it shall be considered as a member of the most reactive chemical group, that is, that group having the least allowable percent of the total volume of solvents.

This definition is used in the general organic solvent rules and should not be confused with volatile organic compounds. Most Metal Parts and Products rules do not use this definition, however operations which are exempted from Metal Parts and Products rules may be subject to the general organic solvent rule. Also some clean-up, storage, and thinning may be subject to the general organic solvent rule.

Pigment - Small particles added to the coating to influence properties such as color, corrosion resistance, mechanical strength, etc.¹

Pigment Volume Concentration (PVC) - The percent volume of a paint film occupied by the pigment. The critical PVC is reached when the particles pack together and contact each other.

Pinholes - Paint defect caused by rapid solvent loss which results in tiny

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holes in the film.

Polyester - A type of paint or plastic containing chemical group $-(RCOOCR)-x$.¹ Also has been used as thermoplastic powder coating; and as the following thermosetting powder coatings: epoxy polyester hybrid powder, urethane polyester powder, and polyester TGIC powder.

Polyethylene - Common thermoplastic polymer containing $-(CH_2CH_2)-x$. It is used in powder coating.

Polymers - Substances, the molecules of which consist of one or more structural units repeated any number of times (monomers).²

Polypropylene - Common thermoplastic polymer containing $-(CH_2CHCH_3)-x$. It is used in powder coating.

Polyurethane - See Urethane

Popping - Eruptions in a film of coating after it has become partially set so that craters remain in the film.²

Pot Life - The length of time a coating material is useful after its original package is opened, or after a catalyst or other ingredients are added.²

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

Precursor - See Volatile Organic Compounds

Pretreatment Wash Primers and Coatings - These coatings contain "a small amount" of acid to provide surface etching and are applied directly to bare metal surfaces to provide corrosion resistance and topcoat adhesion. The SCAQMD rule additionally requires that the coating must contain a minimum of 1/2% acid, by weight, and contain a maximum of 12% solids. These specifications can be verified through laboratory testing. The BAAQMD has specified a minimum of 1/2% acid, but has not specified a maximum solids content. BAAQMD has instead adopted a lower VOC content speciality limit to be effective in 1991.

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Primers - Coatings which are intended to be applied to a surface to provide a firm bond between the substrate and subsequent coats.

Reactive Diluent - Liquid which is a VOC during application, and one in which through chemical reaction, such as polymerization, 20 percent or more of the VOC becomes an integral part of the finished coating.

Reactive Organic Compound - See Volatile Organic Compound

Reducing - See Thinning

Repair - Repair coatings are used to re-coat portions of the surface of a product which has sustained mechanical damage to the coating surface following normal spray operations. Care should be used with this definition to ensure that re-coating operations are not considered repair.

Resin - In the broad sense, the term is used to designate any polymer that is a basic material for coating and plastics.²

Retarders - Solvent added to a coating to slow down the rate of evaporation.¹

Ringing - The occurrence of circular spots in a sprayed repair area (Spotting).

Roll Coating - Application of coatings from a paint trough to a flat surface by a mechanical series of rollers.

Rusting (Face and/or Scratch) - Face rusting is appearance of rust (corrosion) on the surface of undamaged paint. Scratch rusting occurs where the film has been damaged.

Sagging - The downward flow of a coating film as a result of the film being applied too heavy or too fluid a wet coat.¹

Salt Spray Testing - Paint test which exposes the dry film to salt solution to accelerate the corrosion process.

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Sandscratch Swelling - Paint defect where repair coat solvent soaks into scratches from surface preparation and causes paint swelling.

Sealers - Coatings formulated for and applied to substrates to prevent subsequent coatings from being absorbed by the substrate or to prevent harm to subsequent coatings by materials in the substrate.

Shelf Life - Length of time coating can be stored under standard ambient temperatures without losing any properties. Each manufacturer will identify the shelf life of the coating.

Silicones - Resins consisting of silicon-oxygen linkages, unlike organic resins which contain carbon.

Silicone Release - A coating which contains silicone resins and intended to prevent food from sticking to metal surfaces such as baking pans. SCAPCD limits silicone release coatings to those used in the manufacturing processes for solid rocket motors.

Silking - Surface defect which results in parallel flow lines in the paint film.

Skinning - The formation of a surface skin on coating liquids usually due to the reaction with air or to rapid solvent loss.

Solar Absorbent Coatings - Coatings which have as their prime purpose the adsorption of solar radiation.

Solids - The non-volatile portion of the coating which after drying make up the dry film.

Solid Film Lubricant - Very thin coatings consisting of a binder system containing as its chief pigment material one or more of molybdenum disulfide, graphite, polytetrafluoroethylene (PTFE) or other solids that act as a dry lubricant between faying surfaces. This definition does not stipulate a minimum amount of specialized pigment which must be contained in the coating in order to qualify as a solid film lubricant.

Solvency - The degree to which a solvent holds a resin or other paint

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binder in solution.²

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 which can dissolve the coating. Solvent is often used to describe terpenes, hydrocarbons, oxygenated, furans, nitroparaffins, and chlorinated solvents.

Solvent Borne - For the purpose of this manual, solvent borne coatings are coatings in which VOC is the major solvent or dispersant.

Specific Gravity - Weight of given volume of any substance compared with the weight of an equal volume of water.² Relative density.

Stencil Coating - Ink or other coating which is rolled or brushed onto a template or stamp in order to add identifying letters and/or numbers to metal parts and products.

Strength - Ability of coating film to resist bending and stretching.

Surfacer - Easily sanded coating used to fill surface irregularities.

Tape Adhesion - Paint test which measures the adhesion of the film to the substrate by "jerking" paint away with a strip of tape.

Terpene Solvents - VOC that are obtained from pine tress and are the oldest solvents used in coatings. Includes turpentine, dipentene, and pine oil.

Texture - The structural quality of a surface.

Thermoplastic - Capable of being repeatedly softened by heat and hardened by cooling.³

Thermoset - A material which will undergo or has undergone a chemical reaction by the action of heat, catalysts, UV light, etc., leading to a relatively infusible state.³

Thinning - Adding volatile liquid to reduce the viscosity of the coating.

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This liquid may be solvents, diluents or mixtures of both. Also may be called reducing or "adding make-up solvent".

Thixotropy - The tendency for the viscosity of a liquid to be shear-rate dependent. When a liquid is rapidly shaken, brushed, or otherwise mechanically disturbed, the viscosity decreases rapidly.¹

Threshold Limit Value (TLV) - Maximum airborne concentration of a compound a person can be exposed to on a daily basis. TLVs are the concentrations that nearly all workers can breathe for an eight hour day without harm.

Throwing Power - The ability of electrodeposited coatings to cover interior surfaces.

Topcoat - Usually the final coating film or multiple layers of the same coating film applied to the surface.

Touch-up - Touch-up is that portion of the coating which is incidental to the main coating process but is necessary to cover minor imperfections. Some districts still include "...or achieve coverage as required" which may allow sources to "touch up" large surface areas.

Toxic Air Contaimants - Those air pollutants which may cause or contribute to an increase in deaths or serious illness or which may pose a present or future hazard to human health as listed by the Air Resources Board. Potentially toxic air contaimants are also listed as: substances currently under review, scheduled for review, or nominated for review; and those compounds for which health effects information is limited or not yet sufficient to support current review.

Transfer Efficiency - Transfer efficiency is the ratio of solids adhering to an object to the total amount of coating solids used in the application process expressed as a percentage. It is either defined in terms of a coating volume ratio or as a coating weight ratio.

Underbake or Undercure - The result of curing the film at too low a combination of time and temperature.¹ This may result in tackiness, softness, and inferior film durability.

GLOSSARY

Surface Coating
Operations
Metal Parts
and Products

Undercoaters - Coatings formulated and applied to substrates to provide a smooth surface for subsequent coats.

Urethane Polymers - Coating vehicles containing polyisocyanate monomer reacted in such a manner as to yield polymers containing any ratio, proportion, or combination of urethane linkages, active isocyanate groups, or polyisocyanate monomer. Categories of polyurethane coatings include: single component prereacted-urethane coatings; single component moisture-cured urethane coatings; single component heat-cured urethane coatings; two component catalyst-urethane coating; two component polyol-urethane coatings; and one component nonreactive lacquer-urethane solution coatings.² (Thermoset)

Vacuum-Metalizing Coating - Undercoat applied to the substrate on which the metal is deposited or the overcoat applied directly to the metal film.

Varnish - Clear or pigmented coatings formulated with various resins 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.

Vinyl Resins - Resins which involve the unsaturated vinyl group, (CH₂ = CH -). Resins include polyvinyl acetate, polyvinyl chloride, copolymers of these, the acrylic and methacrylic resins, the polystyrene resins, etc..² (Thermoset)

Vinyl Chloride Polymers - Polymers made up by the polymerization of vinyl chloride or copolymerization of vinyl chloride with other unsaturated compounds, the vinyl chloride being in greatest amount by weight. Can be used in thermoplastic powder coatings.

Viscosity - The property of a fluid whereby it tends to resist relative motion within itself.² A thick liquid such as syrup has a high viscosity. Viscosity is often measured using an efflux type cup which gives the time required for a given quantity of paint to flow through a hole in the bottom

GLOSSARY

of the metal cup at a given temperature (See Zahn Cup).

Volatile Organic Compound (VOC) - Any compound of carbon which may be emitted to the atmosphere during the application of and or subsequent drying or curing of coatings, excluding exempt compounds which are defined as 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) (Also See Exempt Compounds). The exact listing of compounds may vary. Some districts use the terms precursor or reactive organic compounds to denote VOC. During the calculation of the VOC content of the coating, these exempt compounds and water are excluded and are not considered to be part of the coating. As a note, many of these compounds which are listed as exempt compounds may contribute to upper atmosphere ozone destruction. Other exempt compounds are being investigated as possible toxic air contaminants. Finally, carbon dioxide is considered to be a "Greenhouse gas" which may contribute to global warming, and carbon monoxide is a primary pollutant.

Volatility - The tendency of a liquid to evaporate. Liquids with high boiling points have low volatility and vice versa.¹

Water Borne Coatings - Coatings in which water is the major solvent or dispersant. These include water soluble polymers (water reducible), water soluble colloidal dispersions, and emulsions (including latex).

Water Reducible Coatings - See Water Borne Coatings

Wet-on-Wet Finishing - Applying a new coat over an earlier applied coat which has been allowed to flash-off but not to cure.

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

Wrinkling - Wrinkled texture formed by the swelling of the film surface skin due to absorbing of liquid within the film.

GLOSSARY

Surface Coating
Operations
Metal Parts
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Zahn Cup - Commonly used efflux cup used for measuring the viscosity of coatings. Two other widely used viscosity cups are the Fischer cup and the Ford cup. These measure the time required for a given quantity of paint to flow through a hole in the bottom of the metal cup at a given temperature. Different drain hole diameters and cup sizes are available for use depending on the viscosity of the coating.

GLOSSARY

REFERENCES

- 1 Schneberger, Gerald L., Understanding Paint and Painting Processes, Third Edition, Wheaton, Ill., Hitchcock Publishing Company, 1985.
- 2 LeSota, Stanley, and others, Paints/Coatings Dictionary, Philadelphia, PA, Federation of Societies for Coatings Technology, 1978.
- 3 American Society for Testing and Materials (ASTM)
- 4 Joseph, Ron., Getting Into Compliance With California's Air Pollution Laws For Industrial Coatings, Ron Joseph & Associates, Inc.

SECTION III MORE EFFICIENT APPLICATION

Improved transfer efficiency reduces waste and solvent releases.

Improvements in the efficiency of transfer of coatings to the workpiece lead to less paint waste and lower emissions from the carrier solvent. The reason for this is that smaller quantities of paint need to be applied to get the required coverage, and overspray is reduced. The use of more efficient application methods saves on paint costs, VOC control costs, and hazardous paint waste disposal costs. The use of the air spray method is fast becoming obsolete because newer more efficient spraying methods are available. These include:

- Airless and airless, air-assisted spray
- Electrostatic spray and air-assisted, electrostatic spray
- Electrostatic bells and high-speed disk spray
- High-volume, low-pressure (HVLP) spray.

Before examining these methods, you should be aware of the more important factors in evaluating coating techniques and results.

Transfer Efficiency. Transfer efficiency is the term used to describe the relative volume of paint reaching the workpiece. It is the net amount of paint solids deposited on a part, divided by the total paint solids sprayed, expressed as a percentage. It is calculated using the formula:

$$TE = W_p / \%S \times Q \times T$$

where

- TE = Transfer efficiency
- W_p = Weight of paint solids on the workpiece after baking
- $\%S$ = Percent of paint sprayed that is solid
- Q = Paint flow rate through the gun
- T = Time the paint is flowing (spraying time).

Typical paint spray efficiencies have been reported in the New York State Waste Reduction Guidance Manual (ICF 1989) and by A. C. Walberg at Paint Con '87 (1987). These are tabulated below as "NY Manual" and "Conference," respectively.

Spray Method	Transfer Efficiency	
	NY Manual	Conference
Conventional, air atomized	30 to 60%	25%
Airless spray	65 to 70%	40%
Air-assisted airless		40%
High-volume, low-pressure (HVLV)		65%
Electrostatic, air atomized	60 to 70%	
Electrostatic, airless	70 to 95%	70%
Electrostatic, rotating discs and bells	80 to 90%	85%

The wide range in quoted transfer efficiency is due to variations in the methods of measuring.

Some nonspray methods of applying coatings should be mentioned here for comparison sake. Electrocoating, described in the previous section, is 90 to 99 percent efficient in paint usage. This high efficiency is achieved because loose paint particles in the rinse water are recycled to the coating tank. Roll coating, which is usually used in continuous coating of coils of aluminum or steel, is reported to be 90 to 98 percent efficient in paint usage. Dip coating and flow coating are reported to have transfer efficiencies of roughly 90 percent.

Unfortunately transfer efficiency is not a definitive term in the real world of spray painting. Minimizing paint waste is not necessarily achieved by using the technique that has the highest rated transfer efficiency. Other factors that must be considered include:

- Quality of finish
- Production rate
- Uniformity of applied film thickness
- Desired film thickness
- Edge buildup
- Need for manual touchup
- Faraday cage effects (in electrostatic spraying).

When comparing application techniques for possible use in your plant, you should consider spray efficiency and the above factors as part of the testing.

Other factors, however, must be considered when attempting to improve transfer efficiencies.



Transfer efficiency decreases as particle size decreases.

Finish Quality. The quality of the finish is generally improved as spray particle size is reduced. Unfortunately, as spray particle size is decreased, transfer efficiency decreases. Some of the finest particle sizes are achieved with conventional air atomized spraying; however this is the least efficient means of applying paint. Customer finish requirements must be met; therefore, a compromise between transfer efficiency (paint savings) and quality must be achieved.

Transfer efficiency varies with production rate.

Production Rate. It is necessary to establish a desired production rate before determining a "transfer efficiency" for your application. The efficiency of spray devices will vary with the rate of application. This is especially true if coating is being done on a conveyerized system that includes other operations.

Desired versus applied thickness is a factor in transfer efficiency.

Film Thickness and Uniformity. The thickness of the applied film versus the thickness desired is important to establish when determining real transfer efficiency. If a 1-mil-thick film is specified, but the spray device can only deliver a quality film of 2 mils or greater, then at least 50 percent of the paint is wasted. Thus, even if all of the paint used is applied to the workpiece, the real transfer efficiency is only 50 percent.

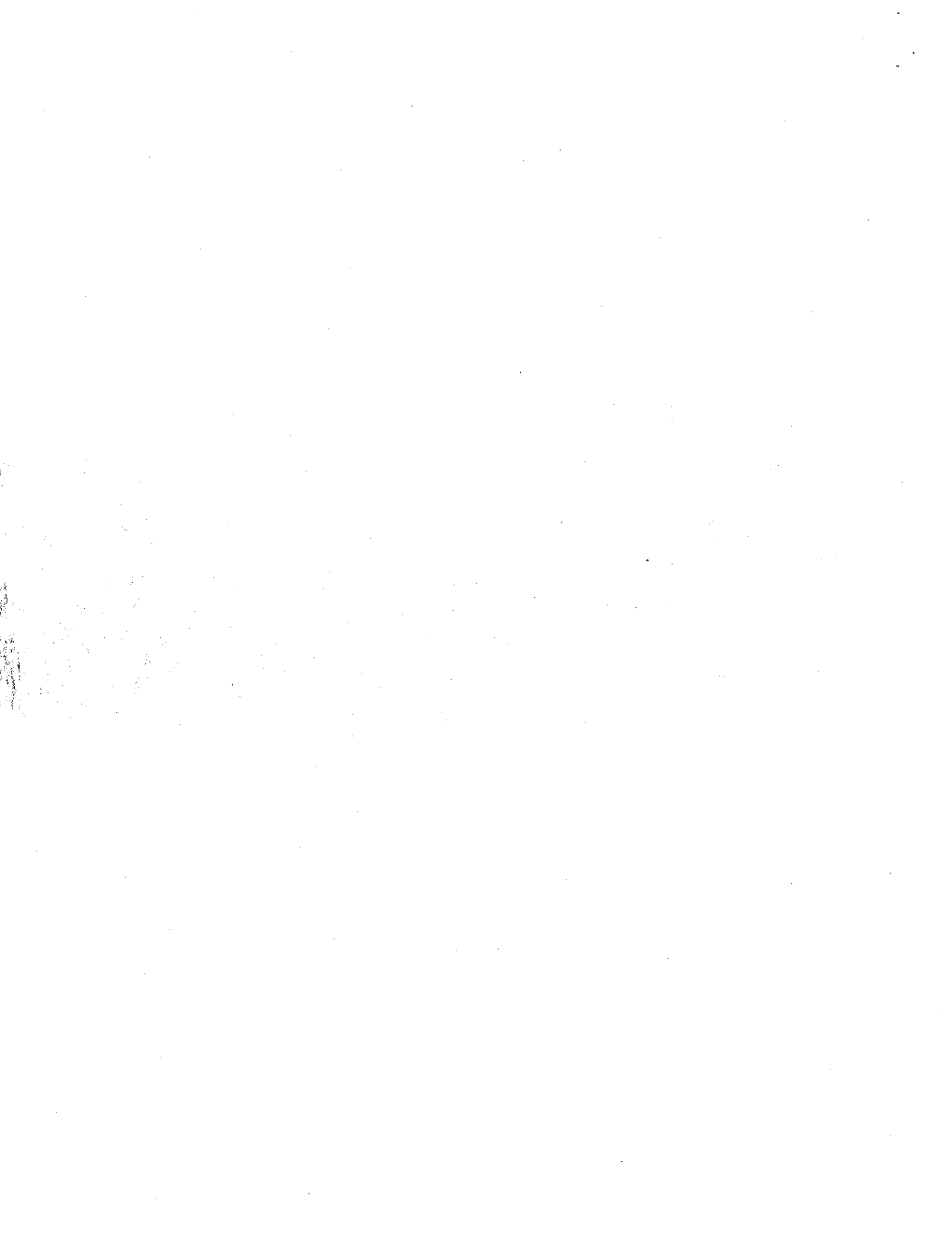
Uniformity of coating varies with spray pattern.

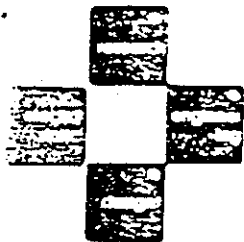
Film uniformity also should be considered. A flat, fan-shaped spray pattern can hold film thickness variations to 10 percent in a well engineered painting system. However, a round doughnut-shaped pattern is obtained in some systems. This type of spray pattern delivers a film thickness variation of about 1 mil. That is, if the desired film thickness is 1 mil, the coating can have areas that are 2 mils thick. The doughnut-shaped spray pattern can waste about 25 percent of the paint even when all the paint is applied. Thus, at best the real transfer efficiency is 75 percent.

Excess buildup and manual touchup affect real transfer efficiency.

Other Issues. In electrostatic painting, edges normally attract paint spray that would normally pass by the workpiece. Paint builds up on the edges (edge buildup). This represents wasted paint even though it is transferred to the workpiece.

The Faraday cage effect is encountered in electrostatic painting. In recessed areas, the electrostatic field force limits the entry of paint particles. To achieve coating in the recessed area, overpainting of the nonrecessed area or manual touchup often is required. In this situation, real transfer efficiency is less than the quoted transfer efficiency.





ELECTROSTATIC CONSULTANTS CO.

P.O. BOX 9055 DOWNERS GROVE, ILLINOIS 60515

PHONE 708-628-8027

TRANSFER EFFICIENCY

BY

ARVID C. WALBERG

PRESIDENT

ELECTROSTATIC CONSULTANTS CO.

PRESENTED AT

PAINT CON '87

MARCH 31 - APRIL 2, 1987

O'HARE EXPO CENTER

CHICAGO, ILLINOIS

"TRANSFER EFFICIENCY"

ARVID C. WALBERG
PRESIDENT
ELECTROSTATIC CONSULTANTS CO., WHEATON IL

The basic definition of "transfer efficiency" brings to mind the story of Diogenes, the Greek Philosopher in the years around 320 B.C.. Diogenes traveled the streets of Athens with a lantern searching for an honest man - but never finding one. Many methods for measuring and computing transfer efficiency skirt the truth in one manner or another and cannot be taken at face value. This brings up the customary commercial warning, "caveat emptor", let the buyer beware.

The basic definition of "transfer efficiency" is the percentage of the total paint sprayed that ends up on the work being coated. This is only a partial definition however since it fails to take into account many items such as quality of finish, production rate, film thickness, uniformity of applied film, edge build-up, Faraday Cage Effect, manual touch-up requirements, reject rate and other important factors.

QUALITY OF FINISH

The quality of finish must be established first prior to any attempt to measure "transfer efficiency". If the product being painted is coated at 100% transfer efficiency but the quality is not acceptable, the item becomes a reject and

all of the paint has been wasted. The painting efficiency is actually zero even though all of the paint ended up on the product. It therefore becomes necessary to set up a standard of quality and work to this same standard at all times when comparing different spray devices.

In general, quality of finish is improved as spray particle size is reduced. Unfortunately, as spray particle size is reduced, the transfer efficiency goes down. It is necessary to establish a happy median between quality and efficiency. There is no end of spray equipment on the market that can improve transfer efficiency by lowering the quality of finish. Since paint is frequently a decorative coating designed to enhance the appearance to improve the sales potential of a product, a lowering of quality may be entirely unacceptable. The decision must be made if Class A, Class B or lower quality of finish is acceptable for a given product. There is no point in lowering manufacturing costs if the end product becomes unsaleable because of poor quality.

Another word of caution must be applied to "eyeballing" the test results and making a judgment call. Major differences in painting efficiency cannot be detected by the human eye.

year of added waste in some production shops.

UNIFORMITY OF PAINT FILM

The spray pattern produced by a spray device can affect film thickness and transfer efficiency of a painting operation. Figure No. 3 shows a flat fan-shaped spray pattern and a cross section of the applied film. This is a common form of spray pattern used and it can hold film thickness variation within the desired 10% in a well engineered painting system.

A round doughnut shaped spray pattern generated by spinning bells and some spray guns is also commonly used. Figure No. 4

shows this type of pattern and a cross section of the applied film. This type of spray pattern allows as much as 2:1 variation in film thickness. If we specify a minimum of 1 mil in film thickness, once more the high spots reach two (2) mils of film thickness. While most painting systems are normally given full credit for the extra film applied, the extra film-build in spots should actually be charged off as wasted paint. The extra film thickness is no longer available to coat additional pieces per gallon. A doughnut shaped spray pattern will waste 25% of the paint even when all of the paint is applied to the product. It should be rated at 75% painting efficiency at best. A spray

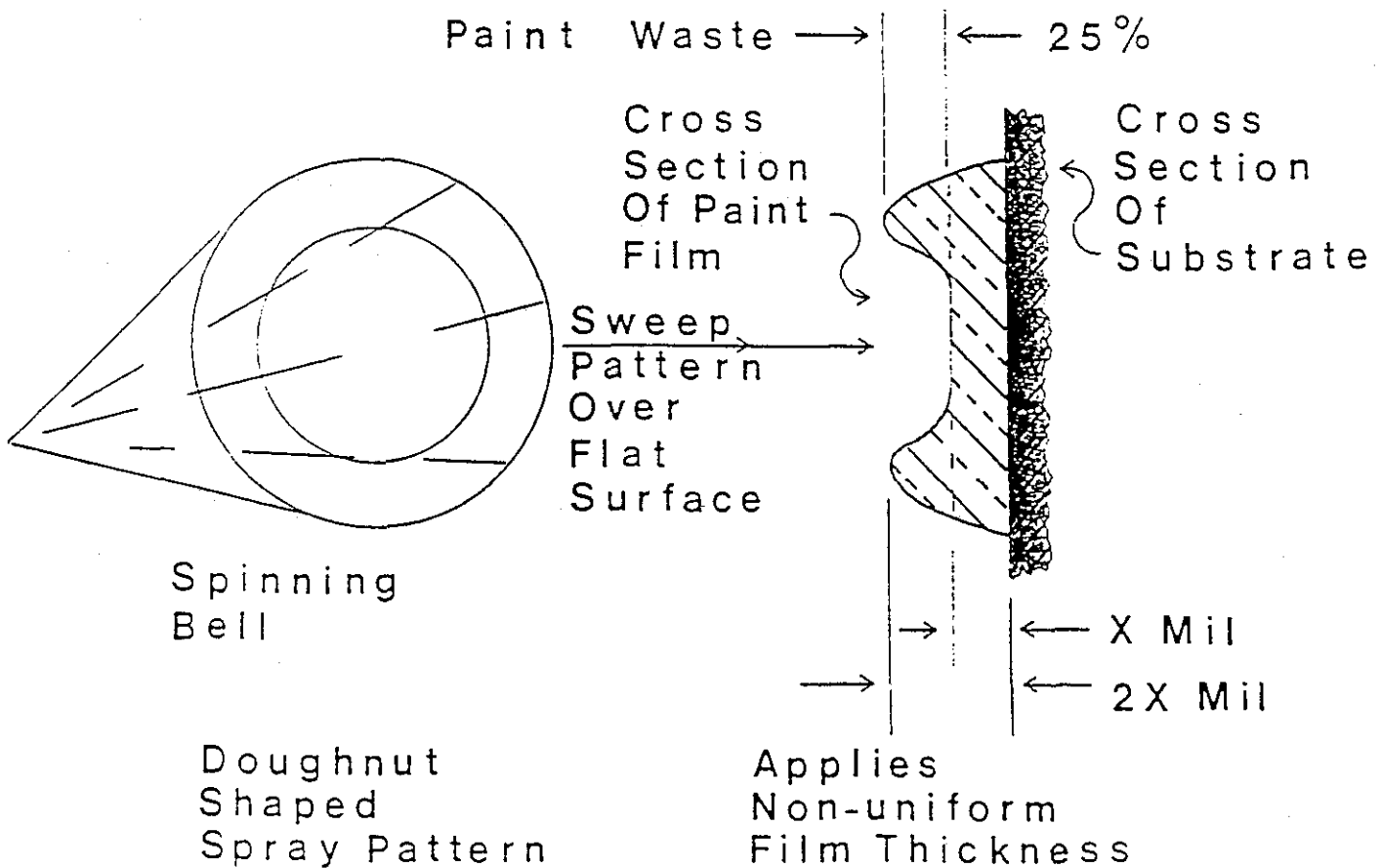


FIGURE NO.4

more can be eliminated by controlling the applied film thickness more precisely. This is not always as easy as it sounds. Not all spray equipment is capable of applying the desired film thickness. You cannot assume that a device that applies a satisfactory 2 mil film can also be adjusted to apply a satisfactory 1 mil film. If the spray particles are large, a thicker film will be applied. The spray particles must be very small to permit the applying of thinner films. The most economical paint film is one that is applied exactly to the specified thickness over a entire surface and holds this thickness with a high degree of precision. While Figure No. 2 shows the specified 1.0 mil film

thickness, it is very difficult to hold this requirement. The 1 mil film thickness represents 50% paint waste yet the error is only 0.001 (one thousandth) of an inch. It is desirable to hold the film thickness variation within 10% or 0.0001 (one ten thousandths) of an inch. This tolerance is much closer than that encountered in most machine shops. The importance of holding within 0.0001 of an inch is more readily understood if we realize that one ten thousandth of an inch thickness could easily represent \$50,000 worth of paint per year in a fairly low production operation. It obviously cannot be disregarded. The 1 mil error in film thickness in Figure No. 2 might easily represent \$500,000 per

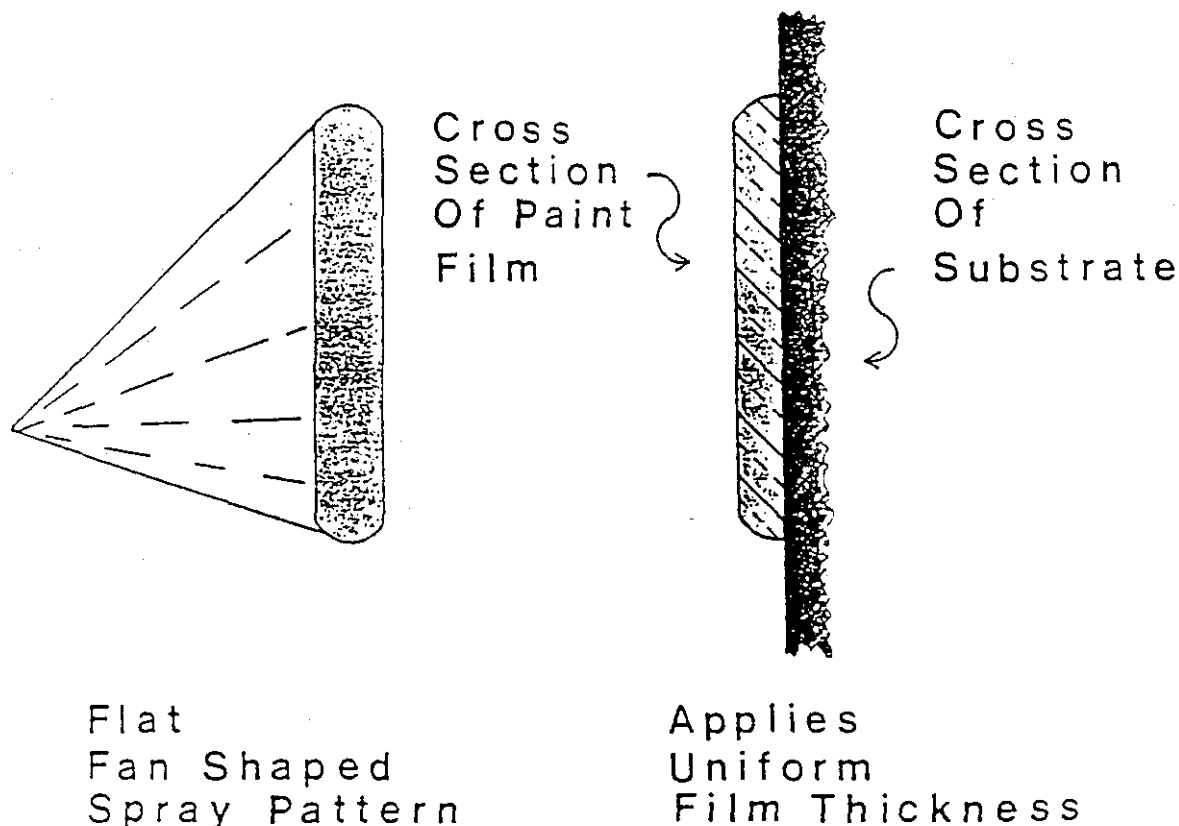


FIGURE NO. 3

PRODUCTION RATE

It is also necessary to establish the desired production rate before measuring "transfer efficiency". A spray gun is similar to an automobile. It produces more miles per gallon at 30 MPH than it will at 80 MPH. There is no point in measuring "transfer efficiency" when coating 10 pieces per hour when you are planning a production rate of 100 pieces per hour. You will end up with unreliable information. Quality of atomization also varies with production speed with some spray devices. Comparing different pieces of equipment at different production speeds is the equivalent of comparing apples with oranges.

FILM THICKNESS

The next variable that must be pinned down is the film thickness since the cost of a paint film is directly proportional to applied film thickness. If a film thickness of 1 mil is specified, everything applied in excess of one mil film thickness is wasted even though it happens to collect on the product. The extra film thickness applied is no longer available to coat additional pieces per gallon. Figure No. 2 shows how the actual paint waste can be 50% or more even though a "transfer efficiency" of 100% is claimed.

The paint waste of 50% or

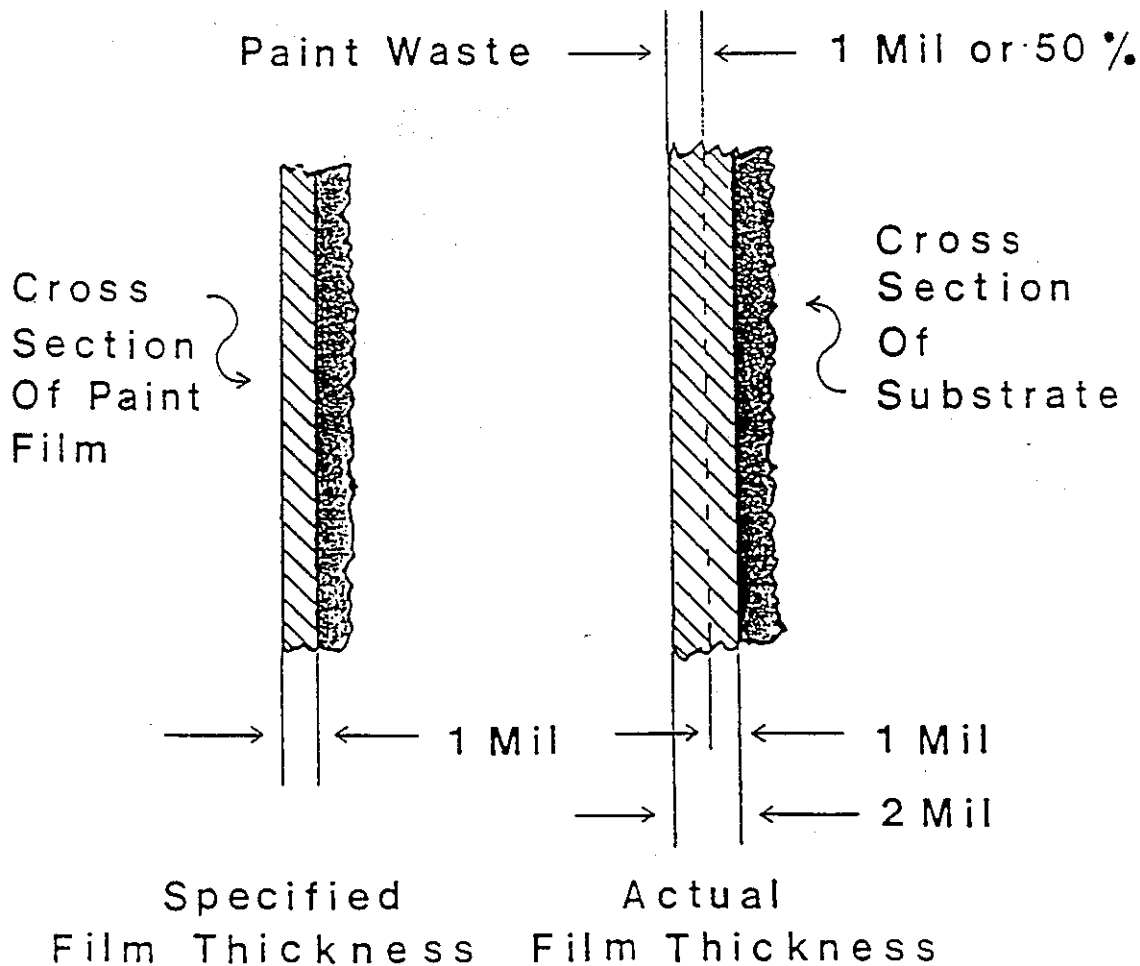


FIGURE NO. 2

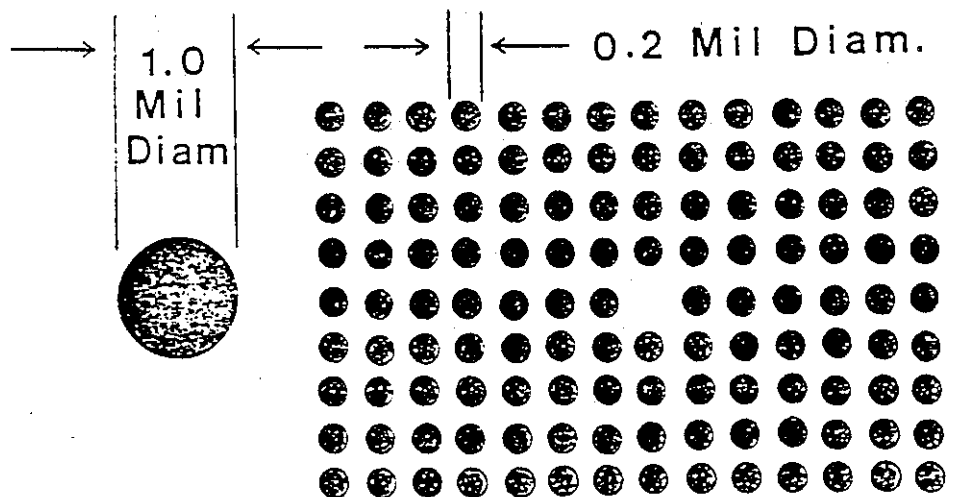
When looking for overspray, it is easier to detect when quality of atomization is the best.

The well atomized spray particles that produce the highest quality of finish are much easier to see. They reflect light much better since far more spray particles are generated for a given volume of paint. By cutting back the quality of atomization, fewer particles are generated. While the particles are much larger in size, they reflect less light and are harder to see. A single 1.0 mil diameter spherical particle is equivalent to 125 0.2 mil diameter particles since the volume of a sphere varies by the diameter cubed. This comparison is shown in Figure No. 1.

The above analysis can be compared with a heavy rain and a dense fog. There is a lot more water in the heavy rain but the dense fog is far more reflective and is much easier to see.

The large particles control the quality of finish so the largest particle must be reduced in size until they produce the required quality of finish. "Orange peel" finishes are caused by large particles. It is necessary to greatly reduce particle size to provide a smoother finish. This, of course, also reduces "transfer efficiency" so it becomes impossible to make comparisons between different pieces of equipment unless the quality standard is pinned down first.

ATOMIZED SPRAY PARTICLES



Ratios:	Diameter	5:1
	Volume	1:1
	No. of Particles	1:125
	Reflectivity	1:5

FIGURE NO. 1

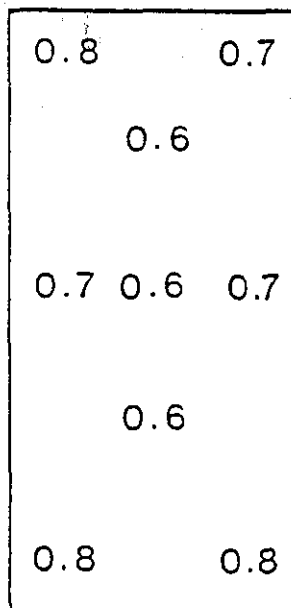
shows this phenomenon.

Obviously, there are some serious flaws in averaging the film thickness for various types of painting systems. This gives the advantage to those systems that provide poor tolerances on film thickness and penalize those systems that hold much closer tolerances. Figure No. 6 shows two panels painted to the same minimum film thickness to provide equivalent corrosion resistance. The uniformly coated panel "A" on the left will use 30% less paint even when both panels are coated at the same "transfer efficiency". Panel "A" could be painted at 70% transfer efficiency and use exactly the same amount of paint as panel "B" on the right if it was coated at 100% transfer efficiency.

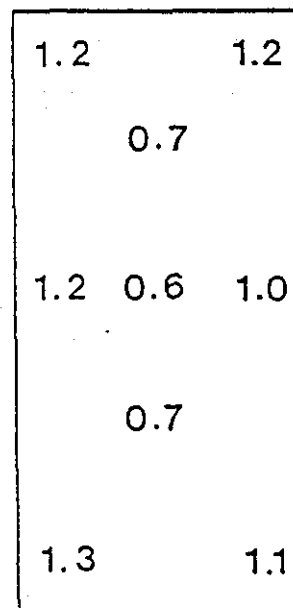
Let's consider the possibility that 0.6 mil of film thickness is not adequate for corrosion resistance or pitting but 0.9 mils would be adequate. By going back to Figure No. 5, we see that Panel "A" meets the specifications and Panel "B" falls short. Panel "B" is a reject and requires manual touch-up down the center of the panel to reach the specification of 0.9 mils minimum film thickness. The alternative is to apply more paint film with the automatic equipment to reach 0.9 mils minimum. This will produce 1.5 mils average and 1.8 to 1.9 mils maximum around the edges for Panel "B". The system will require 50% more paint but would still carry the same rating of 100% "transfer efficiency".

EQUAL CORROSION RESISTANCE

Panel A



Panel B



30%
Less
Paint

Average 0.7 Mil
Film Thickness

Average 1.0 Mil
Film Thickness

FIGURE NO. 6

device should not be given credit for paint applied in the wrong place or to excessive film thickness.

EDGE BUILD-UP

When an electrostatic painting system operates with very low spray velocity to reduce overspray, the paint sprayed at open spaces tends to collect on neighboring surfaces in an uncontrolled manner and produces what is defined as "edge build-up". This may or may not be beneficial depending on the type of product being painted. Figure No. 5 shows two panels sprayed to the same average film thickness of 1.0 mils. Even when both panels are coated at 100% transfer

efficiency, there is an extremely obvious difference in end results. If we computed transfer efficiency to the minimum film thickness instead of average film thickness, the panel on the left would produce 90% transfer efficiency. This is assuming everything over 0.9 mils is wasted even though it ended up on the product. The panel on the right would produce only 60% transfer efficiency. The panel has the corrosion resistance of a 0.6 mil paint film and everything over 0.6 mils on the panel is wasted. If both panels were painted to exactly the same minimum film thickness, the panel on the left would use 30% less paint at a so-called 100% "transfer efficiency" for both panels. Figure No. 6

FILM THICKNESS DISTRIBUTION

Panel A

Panel B

Superior
Corrosion
Resistance
For
Panel A



1.1	1.0	
	0.9	
1.0	0.9	1.0
	0.9	
1.1	1.0	

1.2	1.2	
	0.7	
1.2	0.6	1.0
	0.7	
1.3	1.1	

Average 1.0 Mil
Film Thickness

Average 1.0 Mil
Film Thickness

FIGURE NO.5

achieve this type of coverage with an electrostatic gun. The "Faraday Cage Effect" tends to apply primarily to spinning disc and ball systems and to a far lesser degree with most mechanical atomizing electrostatic guns. The mechanical limitation should not be confused with the "Faraday Cage Effect".

Part "A" of Figure No. 7 may be acceptable as shown but if paint is needed in the recessed area, it must be added with a mechanical atomizing spray gun, preferably an electrostatic gun. This is equivalent of adding Part "B" coverage to Part "A" coverage to produce results as shown on Part "C" of Figure No. 8. The film thickness is doubled but provides the equivalent corrosion resistance of

Part "B" alone. This problem is caused by the "Faraday Cage Effect" and substantially increases paint consumption. The normal definition of "transfer efficiency" gives credit for paint applied in the wrong places due to the "Faraday Cage Effect" when actually the "overall transfer efficiency" may be quite low because of the need for increased manual touch-up.

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COATING RECESSED AREAS

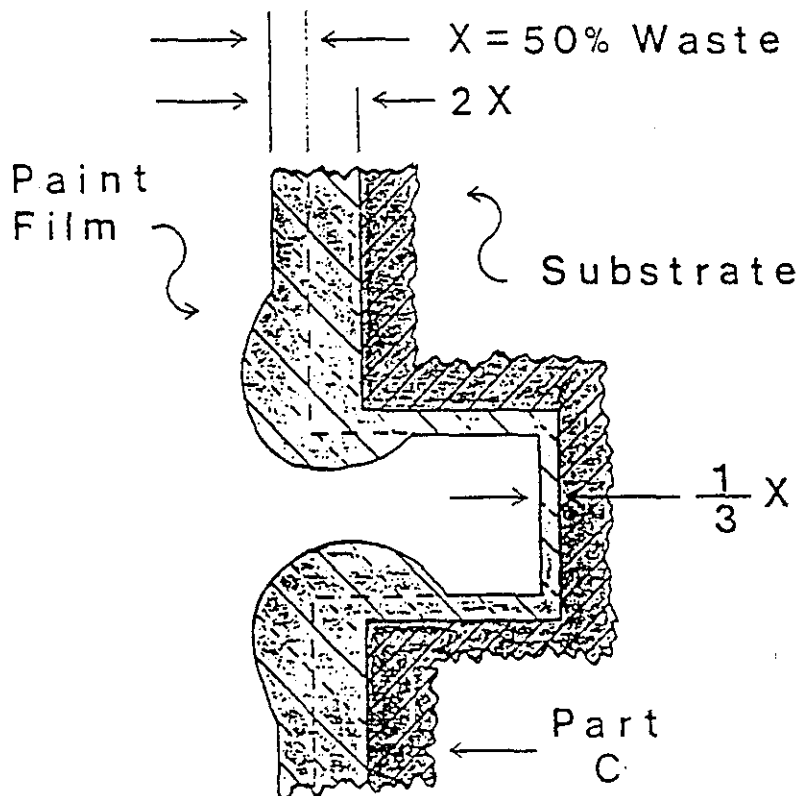


FIGURE NO. 8

In this latter case, the 1.6 to 1.9 mils of film thickness is perhaps getting much closer to a "run" and "sag" condition. To avoid this problem, the paint formulation becomes more critical. It is certain that paint formulators would prefer a 0.9 - 1.1 mils film thickness range as compared to a 0.9 - 1.9 range.

FARADAY CAGE EFFECT

The "Faraday Cage Effect" also interferes with applying a uniform film thickness. This is defined as the electrostatic field force that prevents charged paint particles from penetrating into recessed areas with an electrostatic painting system. It is very similar to the previously

discussed "edge build-up" except the paint collects on surfaces surrounding the recessed areas instead of on surfaces surrounding an open space. The recessed surface collects very little, if any, paint as shown on Part A of Figure No. 7.

All recessed areas also have a mechanical limitation as shown on Part B. Since the recessed area to be painted is three times as great as the area of the opening, the paint will cover to only one third of the film thickness. This is approximately the type of coverage that will be achieved with a non-electrostatic spray gun and with some mechanical atomizing electrostatic guns. It is necessary to control particle size, spray direction and spray velocity to

COATING RECESSED AREAS

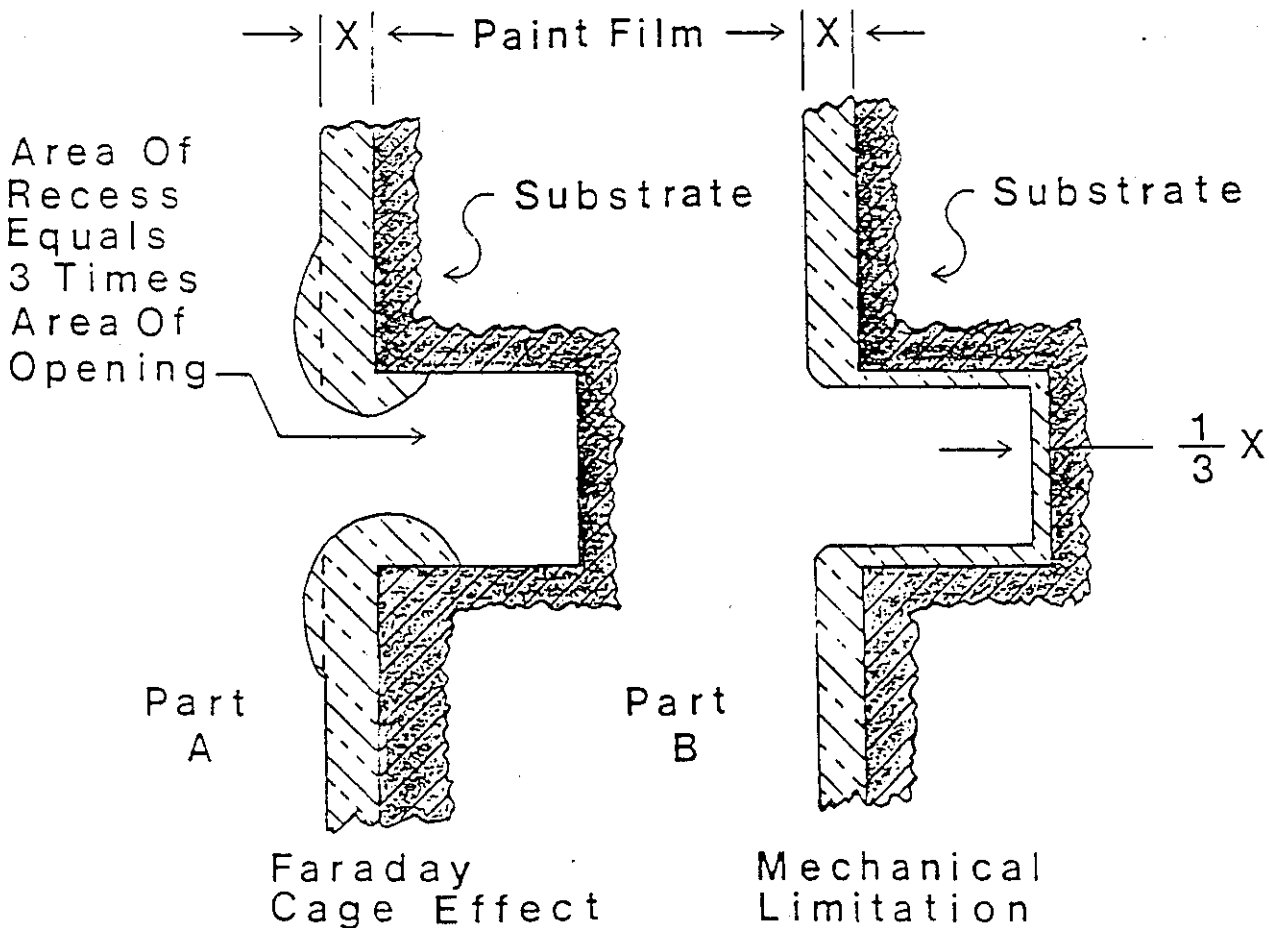


FIGURE NO.7