Organic Finishing & Pretreatment*

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Applications

Organic finishing, in generic terms, is often defined as the application of an organic film or coating to a surface for the purpose of altering its inherent characteristics. The more widely accepted designation for such coatings is painting. As with electroplated finishes, the purpose of the painted surfaces are, in most cases, to provide improved corrosion resistance. In terms of square footage treated, painted surfaces far exceed those treated by plating. Many finishing shops will combine painting with plating in order to offer customers a full finishing capability.

Painted finishes are specified for a number of purposes. The decision to plate or paint for a specific application will depend on the following considerations:

- Cost—Generally, on a per-unit, surface-area basis, organic coatings will tend to cost less than plated deposits.
- Appearance—The broad range of colors and textures of painted surfaces often make it the finish of choice over plating.
- Corrosion resistance—In many cases, a properly selected paint coating applied over the pretreatment will perform better in outdoor exposures than a plated one.

From the standpoint of providing optimum corrosion protection with pleasing aesthetics, a designer may specify a combination of plating and painting; *e.g.*, an organic coating over electrogalvanized steel. By far, the largest and most familiar use of organic coatings is in the automotive industry. Home appliances are also a large user. In these applications, paints and painting processes are carefully selected to provide cost-effective coatings for corrosion resistance, abrasion resistance, good aging characteristics, and a pleasing appearance.

Other applications for paint finishes are altering the optical properties of surfaces (*e.g.*, reflectivity or absorbtivity), or making a surface fluorescent (*e.g.*, night-visible signs). Conducting surfaces may be made insulating, and nonconductive surfaces, such as plastics, may be coated with conductive paints for electromagnetic shielding. A major application of painted metals is in the use of precoated stock metals that are subsequently formed into finished products. Painted metals may be formed when the proper coatings and forming procedures are chosen. Such applications are common in the appliance and other consumer item industries.

Plating and painting complement each other in providing the best choices of finishes. Full-service plating shops are equipped to provide customers with both finishes, so that the advantages of both may be offered.

Processes

The painting process consists of three basic operations: (1) surface cleaning and pretreatment; (2) paint application; and (3) curing of the paint.

Surface Cleaning & Pretreatment

As with plating, quality paint finishes depend on proper pretreatment of the surface to be coated. Surface soils, scale, roughness, rust, etc., will affect the durability, adhesion and corrosion protection of the painted coatings. The degree of surface conditioning will depend on the end use and service requirements of the product. Typical cleaning processes include degreasing and aqueous cleaning. These processes are commonly available in most plating shops. For hot rolled steel, pickling is added to remove surface scale. For extremely rough and/or corroded surfaces, abrasive bead blasting, wire brushing, and/or grinding, in addition to pickling, may be necessary. In any cleaning process, it is important that foreign materials not be added to the metal surface. For example, buffing and polishing materials, inadequately removed from the surface, will adversely affect adhesion; dissimilar metals occluded in the surface may create galvanic differences that adversely affect corrosion resistance, even under the paint coating. Surface preparation may be summarized by the following important steps:

1. Removal of all dirt, oil, or other surface contaminants.
2. Smoothing of the surface to the degree required by the final finish requirements. A convenient way of accomplishing this may be plating or electropolishing using a paint undercoat, or by mechanical means. For smooth final finishes, it is preferable to use cold-rolled steel.
3. Filling of all joints, seams, and holes. As with plating, such areas are subject to entrapment of process solutions that can later leach out.
4. Conditioning of the surface with a chemical conversion coating to improve corrosion resistance and adhesion. Such chemical processes include etching, anodizing, phosphating and chromating.

Conversion coatings applied to the substrate are necessary for proper bonding of the paint film to the substrate. Phosphate conversion coatings are most common, either as an iron phosphate or a zinc phosphate. Iron phosphates are used for most applications where service conditions are not extremely severe. It is the least costly of the conversion coatings and is easiest to apply. In most cases, proprietary solutions are used that consist primarily of phosphoric acid. Coating weights between 25 and 100 mg/ft^2 are typical.

Zinc phosphate coatings are used where service conditions are more severe; for example, where improved corrosion resistance and outdoor endurance are required. Zinc phosphate solutions contain phosphoric acid plus zinc phosphate and activators. Zinc phosphate coatings are somewhat more costly than iron phosphate, and coating weights typically range from 150 to 500 mg/ft^2.

In larger, automated coating facilities, cleaning and phosphating are combined in continuous conveyorized systems. The coatings may be applied by air or steam-assisted spraying or by immersion. For smaller production shops, these pretreatments may be incorporated into the plating shop.

Iron phosphating can be done in a minimum of three stages—cleaning combined with the phosphate treatment; a water rinse; and an acidified rinse. A dilute chromic acid rinse is commonly used; however, non-chromic acid rinses are available. Zinc phosphating requires five to seven steps, since the zinc phosphate treatment is done separately from the cleaning. A typical sequence is: Alkaline clean; rinse; a second rinse containing an activator; zinc phosphate treatment; rinse; followed by an acidic rinse. It should be noted that after pretreatment, all parts must be completely dry prior to subsequent painting in order to avoid flash rusting and undesirable effects with the paint.

Although phosphating is the most common pretreatment for steel surfaces, there are additional coatings that may be used effectively for promoting adhesion and corrosion resistance. Chromates, or combined chromate-phosphate mixtures, are used to treat aluminum. Specialized processes are available for treating stainless steels and galvanized treatments. Information on such proprietary processes can best be obtained from process vendors.

Painting the Surface

Once the surface has been properly cleaned and pretreated, the paint can be applied. The durability and appearance of the paint film will depend on how well this preparation is done. With the phosphate coating, the surface is non-alkaline and promotes bonding of the paint. The significant increase in surface area of the phosphate provides sites for interlocking of the paint film.

To the average observer, appearance is the most significant factor in the choice of a paint. The choice is broad and selection must be made according to intended functional requirements. In most cases, the designation of a paint comes from the designer or from a customer.

Paints are formulated primarily as solvent-based, waterborne, or powder coatings. Space does not permit detailing the specifics of the many paints available; however, this information is readily available from the paint formulators. Paints are often categorized in the following manner:

1. By their formulation or composition—*e.g.,* by their *solvent*, binder, and pigment types.
2. By how they are cured—*e.g*, air dried, baked, vapor cured, etc.
3. By their intended function—*e.g.,* undercoat, primer, top coat, etc.

The following list describes several of a broader list of paint types:

- Enamels—Paints that cure into a solid film through a chemical reaction between components; usually high gloss; also modified to semi-gloss or flat.

- Lacquers—Paints that cure through the evaporation of the solvent.
- Latex—A water-based paint that cures through the evaporation of water and a coalescing of the paint particles.
- Powder paints—Paint of a finely ground powder that is cured above its melting point. The film is formed as the melted material coalesces and solidifies.
- Air drying paints—Paints that cure without the addition of heat.
- Oven curing paints—Paints that require heating or baking to cure.
- Primers or undercoats—First coat applied to a surface to promote adhesion of the topcoat and to provide corrosion protection to the surface.
- Surfacer—A pigmented paint used to fill in surface irregularities of a rough substrate. Usually sanded after curing to improve smoothness.
- Sealer—used to promote adhesion between two coats of dissimilar paints. Also serves as a barrier to prevent migration of the inner film constituents into the top coat.

Paints are applied in a variety of ways. The most familiar method utilizes spraying. Air spraying utilizes compressed air that is applied to the paint and the spray gun. In the gun, this air is combined with the paint to disperse it into small droplets. As the mixture exits from the gun nozzle, it is delivered as a cloud of fine mist to the part surface. Airless spray systems differ in that the atomization and delivery of the paint are accomplished by using very high pressures (typically 1000 to 4000 psi). As the highly pressured paint exits the gun to the relatively low pressure region immediately external to the gun, the drop in pressure causes atomization. Air/airless combinations may be used where the highly pressurized paint is atomized and directed to the part with the assistance of compressed air. In some cases, air and airless spray systems are fed with heated paint, usually to reduce the paint viscosity. Higher solids paints may be sprayed in this manner, thus requiring less solvent in the paint mixture. Spray painting can be convenient for use in small shops involving low cost. The process can be automated through the use of automatic spraying equipment or robotics for larger operations where increased productivity is required.

Other methods for applying paints include:

- Electrostatic spraying—The atomized paint is electrically charged and attracted to the part, which is grounded.
- Dip coating—A simple process where the part is immersed in a paint and the excess is allowed to run off.
- Flow coating—A variation of dip coating where the part is not immersed, but coated under a stream of paint.
- Electrophoretic coating—Analogous to electroplating. Electrically charged paint particles are deposited out of a liquid suspension onto a conductive part.
- Powder coatings—Fine, dry-paint particles are fluidized and adhere to a part. The powdered coating is then thermally cured to produce a solid film. The powder can be applied to a preheated part in a fluidized bed or applied as an electrically charged powder in a fluidized bed or with a spraying system. Powder coating systems are extremely versatile and have found increasing use in electroplating shops where full-service coatings are provided.

Paint Curing

Once the paint is applied to the product, some form of curing is required to cure the paint into a durable film. Air drying paints will cure in ambient environments through the evaporation of the solvent. In most cases, heat is applied to accelerate the curing reaction.

For smaller operations, bench-top or floor-mounted convection-type ovens may be used. For larger volumes of production, ovens are conveyorized with zoned heating. In all cases, hot air ovens should be equipped with exhaust systems to dispose of the volatilized by-products. Provisions must also be made for a supply of clean, dust-free make-up air.

Other methods for paint curing include infrared radiation, electron beam radiation, ultraviolet radiation, catalysts and vapor curing.

Curing is a critical operation in obtaining optimum quality in a paint finish and should not be regarded lightly. Over- or under-baking will adversely affect film properties. Various methods for testing the quality of the paint films are available.

Health Impact

Heavy emphasis must be placed on controlling the exposure of employees to materials contained in paints, particularly volatile organic compounds (VOC). Proper ventilation must be provided for exhausting solvent fumes. Sprayers should be required to wear safety equipment including protective clothing, gloves, respirators and eye protection. With the handling of such materials, it is also important to maintain an awareness of fire hazards. Insurance underwriters are a good source of information regarding this item.

Environmental Status

Wastes from organic finishing operations can include materials that are considered toxic materials and must be disposed of using approved methods. Surplus solvents, paints, and sludges from water wash spray booths can be conveniently incinerated. Some materials, particularly solvents, are recoverable. Paints have been developed to meet VOC restrictions that offer alternatives for meeting compliance—these include compliance solvents, waterborne paints and powder coatings.

Trends

Environmental controls will continue to drive the painting technologies in the direction of developing compliance solvent systems. Powder coatings, because of their advantages in providing a wide range of available materials and because they reduce environmental concerns, are finding increased uses. Painted coatings are replacing electroplated finishes in many applications because, when properly engineered, they can provide improved corrosion resistance while offering a broader range of aesthetically pleasing appearances.

***Author's note:** Due to the wide scope and diversity of the pretreatment and finishing technologies associated with organic finishing, it is not possible to address in detail this subject in the space allotted. This section is intended as an overview and aims to provide a summary and definitions on the subject. For more specific information, the reader may contact through AESF, members of the Organic Finishing and Chemical Pretreatment Committee.*