

Electrocoating (*E-Coat*)

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Electrocoat (E-Coat)

Applicable Specifications: The military specifications for phosphate coatings is DOD-P-16232.

Description: Electrocoating is an *organic finishing method*, which uses electrical current to deposit a protective, corrosion resistant coating to a metallic substrate. The process works on the principal of "Opposites Attract". The primary difference between electroplating and electrocoating (also known as e-coating) is that electroplating applies an inorganic (metal) deposit whereas e-coating deposits an organic coating. Both use the fundamental physical principle of applying materials materials with opposite electrical charges attract each other. An electrocoat system applies a DC charge to a metal part immersed in a bath of oppositely charged paint particles. The paint particles are drawn to the metal part and paint is deposited on the part, forming an even, continuous film over every surface, in every crevice and corner, until the coating reaches the desired thickness. At that thickness, the film insulates the part, so attraction stops and electrocoating is complete. Depending on the polarity of the charge, electrocoating is classified as either anodic or cathodic.

Function & Physical Finish: There are numerous formulations available with various performance characteristics designed to meet a wide variety of applications.

Anodic Epoxy Electrocoat. The cure attributes of anodic epoxies offer the advantages of low-temperature cure (180°F), good weatherability, high gloss, and the ability to coat recessed areas.

Anodic Acrylic Electrocoat. Anodic acrylics offer economical, one coat, interior finishes. These products have an ultra smooth appearance with excellent color, gloss control, film hardness, chemical resistance, and corrosion protection.

Cathodic Epoxy Electrocoat. Cathodic epoxies define the global e-coat benchmark for corrosion resistance, throw power, and operational reliability. They also give the user the optimum selection of film builds with throw power that keeps film thickness uniform over every area of a part.

Cathodic Acrylic Electrocoat. These types of coatings combine strong corrosion and chemical resistance with the aesthetics and color control necessary in decorative applications. Cathodic acrylic coatings serve as primers for other topcoat finishes, i.e., liquid and powder.

Cathodic Acrylated Alkyd Electrocoat. This technology can be modified to cure at temperatures as low as 160° F. It has oxidative cure characteristics that allow it to complete the curing process after the part has exited the oven. Can be applied at a film thickness as high as 2 mils.

Examples of Use: Electrocoat is found in a variety of industrial market segments. Each of these markets has specific performance requirements.

SYSTEM	PROPERTIES	END USERS
Anodic Epoxy	Low Temp Cure	Agricultural Implements Automotive Parts Structural Steel
Anodic Acrylic	Color Control Gloss Control Interior Use Economical	Metal Office Furniture Air Diffusers Shelving Wire Screen & Hangers
Cathodic Epoxy	Corrosion Resistance Chemical Resistance	Automobiles & Parts Transformers Appliances
Cathodic Acrylic	UV Durability Corrosion Resistance Color Control	Lawn & Garden Agricultural Implements Trim Appliances
Cathodic Alkyd	Low Temperature Cure High Gloss Weatherability High Film Build	Agricultural Equipment Engines

ADVANTAGES OF ELECTROCOATING

REPORTED ENVIRONMENTAL ADVANTAGES

VOC

VOC's range from 0.1 pounds per gallon up to 3.0 pounds per gallon with most products below 1.0 pounds per gallon. Most electrocoat products are water based and very low in VOC. However, unlike UV coatings, they are not VOC free.

HAPS

HAPS (Hazardous Air Pollutants) levels are also low but not devoid with electrocoat technology. Most products are being formulated to be HAPS-free in response to the Clean Air Act of 1990; several HAPS-free epoxy and acrylic products are available.

BOD/COD

As solvent levels of electrocoat products have dropped over the years, so have BOD (Biochemical Oxygen Demand) levels. Cathodic technology has the capability to be run without any wastewater to drain via closed loop rinsing.

Solid Waste

There is a minimal amount of solid waste associated with a properly maintained electrocoat system. Most lines complete an annual clean out where the average system yields a half a drum or less of solid waste to dispose of.

Fire Hazard

Most electrocoat materials are not considered "Red Label" (flammable) because they are formulated as water-based materials. This simplifies shipping, storage and lowers insurance rates.

Clean Application

Electrocoat systems are clean systems and do not require disposable suits, respirators, and other paraphernalia to protect workers from airborne hazards that are a daily concern for spray painters.

REPORTED ECONOMIC ADVANTAGES

Transfer Efficiency

Transfer efficiency approaches 95 - 99% utilization of materials. This efficiency equates to extremely low operating costs for the manufacturer comparable to UV coatings.

Automation

One person can run the average electrocoat tank. Eliminating spray painters can reduce Labor costs.

High Productivity

Electrocoating allows the end user to densely rack parts while still achieving an even film build. Much like UV coatings, many electrocoat users have been able to eliminate multiple shifts because of the system's throughput capacity.

Film Uniformity & Control

Electrocoat paint films are controlled by voltage adjustments. Once the metal is insulated, deposition stops. There is no other paint method that can be controlled with the film uniformity of electrocoat. Typical systems are applied with variances of only 0.1-0.2 mil over the entire part. However, deposits of 2 mils are considered extremely thick. As coating deposit increased so does the insulating effects of the coating. Coating thickness over 2 mils is difficult or economically unfeasible with e-coat.

Rejects

Automated systems eliminate the human error factor and reduce rejection rates.

Pre-Assembly.

Pre-Assembly of products is possible since total coverage of the substrate is accomplished during application. This can lower reject rates by eliminating the need for handling after it leaves the paint shop

Maintenance

Daily spray booth maintenance is not necessary with electrocoat.

Insurance Rates

Like UV Coatings, when converting from high solvent products, electrocoat can lower insurance rates since most are non-flammable, water-based materials.

POTENTIAL LIMITATIONS OF ELECTROCOAT

While electrocoating offers many advantages, this process might not be for everyone. A listing of limiting factors is below.

Multiple Colors

If a prospective electrocoat user has multiple colors, it is often best to install a system to paint the 1-3 highest volume colors and continue to paint the remaining colors with another technology. It is often too expensive to install a system to paint small volume colors.

Capital Costs

When evaluating the installation of a new coating line, it is important to compare apples to apples. Most new lines will require a conveyor, pretreatment system and bake oven which usually account for two-thirds the cost of any coating line. An electrocoat system is often more expensive than a spray system, but very similar in cost to a powder system.

Total Coverage

Minor masking of parts is common with electrocoat, but if a major portion of the part is not to be coated, total coverage may be a disadvantage.

THE ELECTROCOAT PROCESS

The Electrocoat Process can be divided into four distinct sections:

- Pretreatment
- Electrocoat Bath and Ancillary Equipment
- Post Rinses
- Bake Oven

Parts are first cleaned and pretreated with a phosphate conversion coating to prep the part for electrocoating. Parts are dipped into a paint bath where direct current is applied between the parts and a "counter" electrode. Paint is attracted by the electric field to the part and is deposited on the part. Parts are removed from the bath, rinsed to reclaim undeposited paint solids, and then baked to cure the paint.

PRETREATMENT

The pretreatment section is where the metal surface is cleaned and phosphated to prep the part for electrocoating. Cleaning and phosphating are essential in achieving the performance requirements desired by the end user. Iron and zinc phosphate are common materials used in pretreatment systems. Both spray and immersion stages can both be utilized in this section.

ELECTROCOAT BATH

The electrocoat bath consists of 80-90% deionized water and 10-20% paint solids. The deionized water acts as the carrier for the paint solids that are under constant agitation. The paint solids consist of resin and pigment. Resin is the backbone of the final paint film and provides corrosion protection, durability, and toughness. Pigments are used to provide color and gloss.

ANCILLARY EQUIPMENT

The electrocoat system consists of a number of components that help maintain line parameters.

Rectifier-The rectifier supplies the DC electrical charge to the bath so coating takes place.

Circulation- Circulation pumps maintain proper paint mix uniformity throughout the electrocoat bath.

Heat Exchanger/Chiller- Temperature control of the paint bath is provided by a heat exchanger and chiller.

Filter- Tank filters remove dirt particles that are introduced into the paint system.

Ultrafilter- Ultrafilters control paint conductivity, produce permeate for rinsing, and allow for recovery of paint solids.

POST RINSES

During the electrocoat process, paint is applied to a part at a certain film thickness, regulated by the amount of voltage applied. Once the coating reaches the desired film thickness, the part insulates and the coating process slows down. As the part exits the bath, paint solids cling to the surface and have to be rinsed off to maintain efficiency and aesthetics. The excess paint solids are called "drag out" or "cream coat". These post rinses are returned to the tank to allow transfer efficiency greater than 95%.

BAKE OVEN

After exiting the post rinses the coated part enters the bake oven. The bake oven crosslinks and cures the paint film to assure maximum performance properties. Bake schedules range from 180°F to 375°F depending on the technology being utilized.

TYPICAL END USERS FOR ELECTROCOAT PRODUCTS

Electrocoat is found in a variety of industrial market segments. Each of these markets has specific performance requirements, leading to a number of electrocoat technologies formulated to meet their needs.

Applications of Electrocoat in the Industrial Marketplace

<u>End Use</u>	<u>Properties Added By Electrocoat</u>
Agricultural Equipment	High Gloss, Color Control, Weatherability, Corrosion Resistance
Appliance	Corrosion and Stain Resistance, Color Control in Recessed Areas
Automobiles	Corrosion and Chip Resistance, Weatherability
Automotive Parts	Corrosion, Chemical and Chip Resistance
Brass, Gold, Nickel, Aluminum	Aesthetic Quality and Corrosion Resistance
Can Coatings (Containers)	Barrier and Chemical Resistance, FDA-Approved, No Effect on Flavor
Electrical Switchgear	Corrosion Resistance and U.L. Approval
Fasteners	Corrosion and Edge Coverage
Heating, Ventilation, and Cooling	Corrosion Resistance, Color Control, and Weatherability
Laboratory Furniture	Chemical, Stain, and Corrosion Resistance, Color Control
Lawn and Garden	Corrosion Resistance and Weatherability
Printed Circuit Boards	Edge Coverage and Hardness
Shelving and Furniture	Color Control, Hardness, and Stain Resistance
Wheels	Corrosion and Chip Resistance, Weatherability

Electrocoat is also becoming an accepted finishing method in unusual areas such as specialty clear finishes over aluminum, brass and zinc plate; extremely low-gloss coatings for military and photographic applications; chemical-resistant coatings; and transparent, metallic-type finishes over nickel or zinc plating.

MATCHING ELECTROCOAT TECHNOLOGY TO YOUR PRODUCT

Electrocoat technology falls into two main categories: epoxies and acrylics. Both technologies are used extensively in anodic and cathodic systems, offering the following properties and end uses:

<u>SYSTEM</u>	<u>PROPERTIES</u>	<u>END USERS</u>
Anodic Epoxy	Low Cure	Agricultural Implements Automotive Parts Structural Steel
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Cathodic Epoxy	Corrosion Resistance Chemical Resistance	Automobiles & Parts Transformers Appliances
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NEW APPLICATIONS FOR ELECTROCOAT

Two Coat Electrocoat

An exciting recent development is the use of the Two-coat electrocoat process for extreme performance environments. The first coat is a conductive epoxy electrocoat, which when baked provides a surface that can receive a second coat of either epoxy or acrylic electrocoat. Two-coat electrocoat was developed to allow electrocoat users to have the best of both worlds: maximum corrosion resistance with no sacrifice in UV durability while also benefiting from the superior efficiencies of electrocoat. The two coat system is capable of providing long term exterior durability and corrosion resistance in excess of two thousand salt spray hours (salt spray test parameters – unknown). Typical examples of end uses for the two-coat process are transformers, marine engines, generators, and maintenance applications.

Clear Coat Electrocoat

Gold, silver, brass, nickel, copper, zinc, aluminum, and steel are now being coated with both clear and opaque formulations. These products yield cured films with excellent mechanical properties and solvent/chemical resistance. Excellent clarity and non-yellowing properties are obtained as well.

GLOSSARY OF ELECTROCOATING TERMS

A

- Accelerator** - Oxidizer used to convert the ferrous ions to ferric ions and his oxidation rate increases the rate of coating deposition.
- Acetic Acid** - Typical cathodic paint solubizer.
- Acetate Ion** - Negative solubizer ion produced in E-Coat process which will pass through an anode cell membrane into the anolyte solution.
- Acidity** - See pH.
- Acrylic coatings** - Coatings composed of acrylic polymers characterized by excellent color stability and UV (sunlight) exposure resistance.
- Adhesion** - The force that makes two materials stick together. When paint bonds with paint it is called intercoat adhesion. Epoxies have great adhesion to most surfaces.
- Aeration** - Incorporation of bubbles of air in paint by stirring, shaking or pumping.
- Agglomeration** - Small particles of pigment gathering together forming a larger mass.
- Alkali Components** - Building blocks to alkaline cleaning removes the surface contaminates once the surface tension has been reduced.
- Alkyd Copolymer** - Biggest advantage is low temperature cure and moderate corrosion performance. Main disadvantage is the soft film initially which gets slightly harder on aging. Has poor exterior durability. Consideration by some implement companies for primer or casting sealer.
- Ambient air temperature** - Uncontrolled temperature of air surrounding a part or component..
- Amine** - Chemical used widely in anodic EDP paints to make the paint water dispersible. See also Neutralizer.
- Amine deficient feed** - A specific type of replenishment material which is deficient in amine.
- Amps** - Flow of electricity in coulombs/second
- Anionic (Anodic) Paint** - A paint that will form a film on the anode in an electrocoat system.
- Anions** - Negatively charged ions that will be attracted to the positively charged anode.
- Anode** - Positively charged electrode (it is the article being electrocoated in anodic electrocoating).
- Anolyte** - Solution surrounding the anode in the anolyte cell; sometimes referred to as solubilizer, it is essentially acetic acid and deionized water.
- Anolyte cell** - An anode enclosed in a plastic housing, and separated from the paint with a semi-permeable membrane; the membrane allows concentrated solubilizer to pass through, while excluding passage of paint molecules.
- ANSI** - American National Standards Institute.
- Aromatic solvents** - Hydrocarbon solvents with a benzene ring nucleus such as Xylol or toluol.
- Artificial weathering** - The testing of coatings in which aging is accelerated by exposure to UV light, moisture, etc.
- ASTM** - American Society for Testing and Materials.
- Auxiliary electrodes** - Portable electrodes inserted into recessed areas (or placed overhead) to increase paint film build in specific areas of the part..

B

- Bacteria** - Micro-organisms often composed of a single cell which may contaminate some paint baths, especially anodic epoxies.
- Base coat** - A highly pigmented color coat applied prior to a clear coating that gives the system the desired color.
- Bath** - A low solids dispersion of the paint in water, generally 5 to 21% solids. Also referred to as the "coating bath."
- Bath life** - Remaining useful life of a bath measured by total alkalinity and/or percent oil in a bath.
- Binder** - The non-volatile, film-forming liquid usually oils, alkyds, latex, varnishes or plasticizers which bind the pigment particles together in paint.
- Bleedout** - A condition where liquid is discharged from a seam or recessed area of a part while in the electrocoat curing oven. Possible causes are: improper part hanging (positioning), inadequate cleaning, inadequate rinsing and inadequate drain time. (Elimination sometimes requires a dry-off oven before painting or pre-cleaning of parts before assembly.)
- Blistering** - Pressure under the paint film from vapor or moisture will cause blistering. The vapor may come from trapping solvents or from chemical reaction.
- Bloom** - A bluish cast forming on the surface of some films. It may be caused by such foreign material as smoke, oil or dust, during the drying process.

Blushing - Usually caused by condensation during the drying period.

Body - A word used to indicate thickness or thinness of a liquid paint. A more acceptable term is viscosity or consistency.

Brittleness - Easily cracked or flaked when bent.

Brown elephant - (also thincoat) A part that received low film build. Possible causes: low bath temperature, low voltage, intermittent coating, and poor electrical grounding (contact).

C

Carnauba - A yellowish or greenish wax obtained from the young leaves of the Brazilian wax palm trees. It is sometimes used as an additive for paints and polishes..

Catalyst - An additive which increases the rate of chemical reaction, but is not itself consumed, or altered, by the reaction.

Cathode - Negatively charged electrode; it is the article being electrocoated in cathodic paints.

Cationic (Cathodic) Paint - A paint that will form a film on the cathode in an electrocoat process.

Cations - Positively charged ions that will be attracted to the negatively charged cathode.

Chalking - Powdering - consisting largely of pigments used in the formula and should be removed in order to avoid intercoat adhesion problems when repairing. Usually a white masking which causes colors to look faded.

Checking - Tiny breaks in the surface of the paint film. Usually "V" shaped and underlying surface is not visible.

Chelators - Added to cleaners and designed to tie up any hard water salts which may interfere with cleaner components.

Chipping - Separation of paint from previous coats in chips or flakes.

Chlorides - Any binary compounds of chlorine, i.e., 2 Cl⁻.

Chrome phosphate - Amorphous structure consisting of a mixture of chromic phosphate with aluminum oxides.

Circulation - The movement or flow of the paint liquid in the EDP bath. Maximum, constant circulation is necessary to prevent settling of pigments.

Cleaner - Chemical which is designed to remove any and all surface contaminants which may interfere with the coating deposition.

Clearcoat - A transparent coating sprayed over a base or color coat to produce high DOI (distinctness of image) finishes.

Closed Loop - A phrase which means that little or no effluent is being added or removed from the EDP paint or rinse system. Is only possible where ultrafiltration is available.

Closed-Loop Rinse - An electrocoat paint subsystem using permeate extracted from the paint bath for process rinse. Normally, little paint or permeate goes to drain.

Coating - Any paints, varnish or lacquer. Chemical coatings denote industrial finishes. Also, the act of applying layer(s) of such materials onto a surface.

Cohesion - The state or process by which the particles of a body or substance are bound together.

Colloids - Finely divided particles which remain in suspension in a liquid media such as electrocoat paint.

Color Retention - This refers to the ability of a paint to retain its original color for a specific period of time.

Compatibility - The ability of the materials to mesh together without separation or reaction.

Conductive Primer - A primer when electrodeposited and cured will not act as an insulator of the coating metallic object, but will conduct current for the electrodeposition of a second coating or topcoat film.

Conductivity - The property of a substrate or mixture that describes its ability to transfer electricity; the current is carried by ions, as in solutions of acids, bases and salts.

Contamination - Any substance present in a solution or on a metal surface to be treated which is detrimental to the particular process being formed.

Contrast Ratio - The hiding power of paint is usually determined by coating both white and black areas of a draw-down sheet. The brightness of the film over the black area is divided by the brightness over the white area to determine the ratio. Normally expressed as percent. The higher the number the better the hiding.

Corrosion - To eat away by chemical action. An oxidation process such as rust on steel.

Coulombic Yield - The weight of the coating deposited per coulomb (amp-sec) of electricity passed through the bath during the coating process. This is usually expressed as coulomb/gram and is a measure of the electrical efficiency of the paint.

Covering Power - (Coverage) The ability of a coating to completely cover a surface. It is usually expressed in square feet per gallon.

Cracking - Larger than hairline breaks in the surface of the film. Usually curled edges and underlying surface is exposed.

Cratering - A bowl shaped depression (concave) in the paint film down to the substrate.

Crawling - The tendency of some liquids to draw themselves into beads or drops. Caused by high surface tension or applying paint on a high gloss surface.

Crazing - Minute cracks or lines in a paint film.

- Cream-coat** - Undeposited paint which adheres to the deposited film when a painted article is removed from the electrocoat tank. This is removed by the post-rinse system and returned to the paint bath; achieving extremely high transfer efficiency.
- Creepback** - Measurable amount of adhesion loss in the paint film due to undercutting by corrosion; applies to corrosion testing.
- Cross-Linking** - The curing processes whereby the separate molecules unite by chemical bonds into a single **macromolecule**.
- Cure** - To harden a coating film by applied heat or catalyst, or both.
- Curing Agent** - Catalyst to produce drying or hardening effect, or both.
- Current density** - Current flowing per unit area (amps/ft²).
- Current Draw** - The amount of electrical current (amps) flowing at a specific instant during the electrocoating process. Current draw increases as the amount of metal being coated increases.

D

- DC** - Direct electric current; Always used in the electrodeposition process.
- Degreaser** - Combination of solvents for the purpose of removing grease and oil from the surface in preparation for painting.
- Deionized (DI) water** - Water purified by the removal of virtually all ionic species.
- Deionizer** - Ancillary equipment, which converts tap water to de-ionized water. This can be accomplished by passing tap water through an ion exchange column or a reverse osmosis (R.O.) membrane.
- Demineralized Water** - A synonym for distilled water (sometimes used to identify D.I. water).
- Depletion** - Removal of only the solids of the electrocoating bath. The solids are continuously deposited out while other ingredients remain and build-up.
- Dialysis** - The separation of small molecules from macromolecules in a solution by means of a semipermeable membrane.
- Diode** - Any electronic device that restricts current flow chiefly to one direction.
- Dirt** - Particles in the paint film. Origins are: process, environmental and oven. Process dirt develops within the bath or rinses from pump shear, altered circulation that raises settled particles, coagulated paint from tank walls, etc. Environmental dirt is caused by airborne particles that settle on a part before entering the oven. Areas exposed to hi-lo vehicle traffic suffer most, especially with ventilation fans nearby. Oven dirt is caused by condensation of bake-off byproducts inside the oven that flake off as they dry. On a cured part, oven dirt is sharp and brittle while process and environmental dirt is somewhat smoother from being imbedded into the paint film.
- Dispersed** - Scattered or completely integrated as pigment disposed in a bath.
- Dispersion Agent** - A substance which aids holding pigments in a state of dispersion.
- Dissolution** - (or redissolution) A defect caused by excess solubilizer and/or high solvent levels where by the paint film is electrocoated then washed off or dissolved in the paint tank, post rinse, or oven.
- Drag out** - The small quantity of coating bath which is retained on the deposited film when the coated part is removed from the bath.
- Dry Film Thickness** - A measurement usually in mils of the paint film after drying and/or curing.
- Drying Time** - The expected time for a paint film to harden. Varying by product, temperature and atmospheric conditions, drying time is usually expressed as dust-free and completely dry or dry for recoat.
- Durability** - The lasting qualities of a paint film. The wearability of paint under conditions for which it was designed.
- Dwell Time** - The length of time that the part is immersed in E-coat bath.

E

- EDP** - Acronym for Electrodeposition of paint.
- Eductor** - Eductors (venturi nozzles) located laterally at intervals across the bottom of an immersion tank to help agitate the solution. (Eductors usually produce approximately four times as much agitation as a regular nozzle, so greatly reduces pump size and energy consumption.
- Effective titanium** - A measurement designed to determine the portion of the total titanium that deposits out at the nucleation site.
- Effluent** - Any liquid material; permeate, rinse water, D.I. water, or the paint itself which leaves the paint or rinse system.
- Elasticity-stretchability** - The ability to change size and return to normal without breaking. Most thermoplastic finishes are more elastic than cured coatings.
- Electrical Efficiency** - In E-coating, the number of coulombs of electricity required to deposit one gram of paint solids.

Electro-chemical equivalent - The weight in grams of paint solids deposited when on coulomb of electricity is passed through the EDP bath.

Electrocoating - An electrochemical process where a voltage difference is applied across two electrodes immersed in an aqueous solution of organic material. The organic material migrates to one of the electrodes and forms a film on the electrode.

Electrocoating anodic - Specific type of electrocoating system wherein the paint film will form on the anode. (See Anionic Paint).

Electrocoating cathodic - Specific type of electrocoating system wherein the paint film will form on the cathode. (See Cationic Paint).

Electrodeposition - Synonym for Electrocoating.

Electrodip coating - Synonym for Electrocoating, Electrodeposition.

Electroendomosis - The movement of water/solvent away from the depositing electrode by diffusion through film formed during electrodeposition.

Electrolysis - The passage of current via charged particle (ions) which are discharged on the relevant electrodes.

Electrons - All matter contains vast numbers of sub-atomic particles of negative charges called electrons. Current flow in electric circuits can be thought of as a stream of electrons traveling through conducting wires.

Electrophoresis - The movement of charged particles suspended in a polar liquid under the influence of an applied electric field.

Epoxy-acrylics - Replaced epoxy esters as the best anodic detergent resistance primer. Has slightly better exterior durability than epoxy esters. (Usually being replaced by cathodic epoxy.)

Epoxy coatings - Condensation of epichlorohydrin and bisphenol. A film made from epoxy resins is extremely durable and solvent resistant.

Epoxy esters - Higher performance, first detergent resistance primers for appliance industry. Main automotive body primer prior to cathodic epoxy being developed. Poor exterior durability.

Evaporation - To convert into a gaseous state or vapor. (Most non-electrocoat finishes, i.e., lacquers, vinyl and most latex finishes dry by the evaporation of solvents.)

Exposure tests - By exposing applied film to the conditions the film will have to withstand, its wearability can be determined. These conditions are simulated in the laboratory and the action accelerated in a weatherometer.

F

Fastness - The ability of a coating to withstand exposure to heat, light and weather. (See gloss.)

Flexibility - Ability of a film to be easily bent without cracking or losing adhesion. (See elasticity.)

Floating - The tendency of some pigments to separate and float to the surface. Also called flooding and results in streaked or spotted application.

Flocculation - The agglomeration of particles either by settling out or forming a gel.

Flushable Electrode - The anode in cathodic E-coating is often placed inside a semi-permeable membrane enclosure so that the excess solubilizer generated at the anode can be continuously removed by water (anolyte) insulated through the electrode. Flushable electrodes in anodic e-coating can also be used for the cathode.

Flux - The rate at which permeate is produced by an ultrafilter, usually expressed as GFD (gallons per square foot of membrane surface per day) (See Ultrafilter)..

Forced drying - Drying by introducing heat to the coated part(s).

Free acid - Amount of acid in the bath which is allowed to initiate the attack on the metal substrate.

Free alkalinity - Measure of a cleaner's concentration; indication of a bath's ability to remove soil from the surface.

Freeboard - Distance between tank lip and paint surface in tank.

G

Gassing - The generation of gasses at the electrode.

Gloss - A degree of lustre. Range 0 to 100, indicating flat to highest gloss..

Gloss meter - An instrument that measures the degree of gloss of a film by its reflectance. Also called a glossimeter. Most commonly used is a 60° meter which measures gloss at an angle of 60 degrees.

Gloss retention - The length of time a finish retains its gloss without flattening or dulling.

Graininess - A gritty appearance of a film due to the lumping of pigment.

Ground (Electrical Ground) - An electrical term for an object so massive that it can lose or gain overwhelmingly large numbers of electrons without becoming perceptibly charged is "grounded". The earth on which we stand is the best electrical ground

possible. (In both anodic and cathodic electrocoating systems, the part being painted is usually grounded for safety purposes.)

Grounded electrode - The electrode with a conducting connection between the electric circuit or equipment and the earth or some other conducting body. (See Ground).

H

Hardness - The capability of a surface or film to resist scratching. (Usually measured by pencil hardness).

Hash marking - A film defect which sometimes occurs on vertical surfaces when the part is entering the tank with power-on (live) entry. This is generally associated with "jerky" conveyor movement.

Hexavalent chrome - Cr+6, usually used in conjunction with trivalent chrome (Cr+3) as the basis for the sealing of the phosphate coating during the pre-treatment process. (Requires a reduction type waste treatment system).

Hiding power - The ability of a paint product to hide previous coats or surface beneath. (See Contrast Ratio).

Hold out - Primers have "hold out." The ability to seal surfaces so that the finish coat will be of even gloss and color.

Hopite - The zinc containing portion, $Zn_3(PO_4)_2$, of the phosphate coating.

Horizontal settling - "Dirt" settling which is evident on the top of surfaces electrocoated in a horizontal position.

Hue - The name of a color. The property of a color by which it can be distinguished. Red, blue, yellow, etc.

Hydroxides - Contain the OH- radical; also known as caustics and alkalis.

I

In-line blending - Adding feed material along with bath material at a given ratio through a blending unit prior to entry into the bath. (Usually with a static-mixer).

Incompatible - Paints that should not be mixed together or should not be applied over another are said to be incompatible. For instance, water paints and oil paints should not be mixed. Epoxies might "lift" certain finishes.

Induction time - The time interval from onset of current until paint deposition occurs.

Initial fill composition - The paint composition used to fill a new tank.

Insulated Electrode - An electrode surface which is separated from the tank by an electrical insulating material.

Intercoat adhesion - Refers to adhesion between two coats of paint.

Intermittent coating - (also brown elephant, thincoat) This occurs when parts lose electrical contact during the coating process. Contact may be regained, only to be lost again. In any event, the electrocoating process has been interrupted prematurely and very low film build is obtained. Possible causes are inadequately cleaned hooks or racks, too aggressive bath circulation, or a faulty power supply (rectifier).

Iron phosphate - Amorphous structure consisting of a mixture of iron phosphate and iron oxides, used to improve adhesion and corrosion resistance.

J

Jellied - Products which are allowed to thicken by adding certain products. Or a formula failure.

K

Ketone - As used in paint, these are colorless volatile thinners or solvents.

L

Laddering - See "Hash marking."

Laminar flow - A description of fluid flow in which all molecules travel parallel to the main direction of flow. This is in contrast to irregular or turbulent flow, in which the molecules move in constantly changing directions while also moving in the main direction of flow.

Leveling - The quality of a spreading out into a smooth, level film. A paint with good leveling properties will dry without brush marks or the appearance of orange peel.

Lifting - When the solvents of the topcoat penetrate the coat underneath then cause wrinkling. Usually penetrates the undercoat and breaks the adhesion.

Limiting film - The film thickness at a given voltage which will insulate the surface and cause deposition to stop.

Low-gloss - A surface with a specular gloss reading above 5 gloss units but not exceeding 40 gloss units at a specular angle of 60 degrees. (See Flat).

M

Masking - To protect areas by masking tape, etc., from paint application where it is not wanted.

Membrane - A porous synthetic which acts as a highly efficient filter in the range of molecular dimensions, allowing passage of ions, water, and other solvents and very small molecules, but almost impermeable to macromolecules.

Membrane Separation Process - An operation using a semipermeable membrane to separate molecules of different sizes.

MEQ (Milliequivalents) - The concentration of E-coat solubilizer in the bath is expressed in MEQ per liter.

Metameric (metamer) - A close color match under a particular light illumination which changes to an appreciable color difference under other light sources.

Micrometer - (Micron) Unit of measuring film thickness, 1 micrometer equals one millionth of a meter.

Micro-ohm - One-millionth of an ohm, a unit for measuring electrical conductivity.

Micron - Unit of measuring film thickness, 1 micron equals one thousandth of a millimeter. (25.4 microns equals 1 mil).

Mil - Unit of measuring film thickness, 1 mil equals one thousandth of an inch (0.001 inch).

Mileage - A general term which indicates the coverage obtained from a quantity of paint. (See covering power.)

Mills - Machines for grinding pigment and vehicles, such as Kady, Ball Mills, Cowles Hi-Speed, Dispersion Mills, etc.

Mist coat - A semi-transparent spray coat of paint.

Morphology - The size and shape of the crystals formed during the phosphating process.

N

Neutralizer - The ingredient in the EDP paint which makes the paint water dispersible. In anodic systems this is an amine while in cathodic systems it is an acid.

Nitrates - Salts of esters from nitric acid.

No-coat - (also white elephant) This is a part that receives no electrocoat film. Usually the cause is a lack of electrical contact but could also be no applied power (voltage) or a rectifier malfunction. (also bare metal).

Non-chrome - A post phosphate treatment which reacts with the phosphate coating to improve corrosion resistance similar to chrome bearing sealers only without the environmental impact.

Non-volatile (solids) - Does not evaporate.

O

OEM - Original Equipment Manufacturer.

Ohm - A standard unit of resistance to electrical flow.

Ohm's law - the relationship between voltage, current and resistance in a DC circuit.

Ohmmeter - Electrical resistance in a circuit is measured in units of ohms with this device.

Oleoresinous - Earliest developed electrocoat materials. Spin-off of water reducible technology. Low performance and poor exterior durability.

Opacity - The ability of a paint to hide the substrate.

Orange Peel - A film that has the physical appearance of an orange peel caused by improper spray application or the application of some finishes by roller or spray.

Overcure - This defect is evident when the cured film has shrunk to the point of conforming very closely with the substrate. The film does not appear smooth. Severe cases degrade the film to the point where some of it rubs off or it appears to fail a solvent rub test for undercure. The cause is too high an oven setting or a line stoppage where the oven does not drop to a pre-determined set-back temperature.

Oxides - Minerals in which metallic atoms are bonded to oxygen atoms.

Oxygen rupture - In the anodic EDP process oxygen gas bubbles are formed on the substrate surface. These normally diffuse through the wet film, however if they form too rapidly they burst through the film, resulting in rough films. See also "Plugging" and "Gassing."

P

P-ratio - Ratio used to describe the amount of iron in the zinc phosphate coating.

P/B - The ratio of pigment to binder in the paint or paste.

Passivation - Refers to the conversion of a normally irregular, electrically conductive surface which is susceptible to electrochemical corrosion to a relatively uniform, non-conductive one.

Passivity - A property shown by iron, chromium, and related metals, involving loss of their normal chemical activity in an electrochemical system or in a corrosive environment after treatment with strong oxidizing agents like nitric acid, and when oxygen is evolved upon them during electrolysis, forming an oxide coating.

Peak Amperage - The maximum amperage due to the initial surge of voltage and the conductive metallic object being coated. Amperage peaks within 5 to 15 seconds and falls off very rapidly as the film builds up and the object becomes insulated.

Peeling - Loss of adhesion. Stripping paint film from the surface.

Percent Solids - The non-volatile content of the paint bath.

Permeable - Porous to passage or penetration by fluids.

Permeate - The fluid substance (water, solubilizers, and dissolved material) separated from the paint bath by ultrafiltration. That fluid which passes through the ultrafilter membrane, usually 0.25 to 0.35 percent solids.

Permselectivity - Function of ion exchange membrane which can selectively exclude electrolytes based on charge.

pH - The relative acidity or basicity of aqueous liquids is indicated by the pH scale. Numbers below the neutral pH of 7 are increasingly acidic; and above pH7, are increasingly basic (alkaline).

Phosphating - Treatment of metal surfaces by chemical solutions containing metal phosphates and phosphoric acid as the main ingredients to form a corrosion inhibiting layer which also improves paint adhesion.

Phosphate streaking - This appears as streaks underneath the paint film. The streaks alternate from smooth to rough. The cause is inadequate phosphating with the root cause being inadequate cleaning, low-free acid levels or low accelerator levels.

Phosphophyllite - The iron containing portion, $Zn_2Fe(PO_4)_2$, of the phosphate coating.

Pigment - Organic and inorganic colorants used to make specific colors and control gloss and hiding power. Certain pigments also contribute to substrate protection.

Pigment/Binder ratio - Proper ratio of pigment to resin for optimum performance.

Pigment volume - The amount of pigment, by volume, in the non-volatile portion of the paint.

Pigskinning - A film defect characterized by a regular pattern of small pockmarks in the deposited film after baking.

Pinholing - Tiny round breaks in a paint film giving the appearance of a pinhole.

Plaguing - Rough film due to excess current. Also referred to as "Oxygen rupture" or "Gassing."

Plague voltage - The applied voltage at and above which plaguing occurs.

Polycrystalline phosphate - A defined crystalline structure containing three or more metal ions.

Polyesters - Able to give pastel colors and has reasonable exterior durability and corrosion protection similar to acrylics. Somewhat better flexibility and impact than acrylics.

Poor rinsing - This appears as unusually rough paint film. The cause is undeposited paint that has been allowed to dry on the part or poor rinse maintenance or prolonged line stoppages.

Post treatment - Acidic processing solution used to treat the surface after the phosphate coating deposition which maybe comprised of trivalent, hexavalent or non-chrome components.

Power Conveyor (Monorail) - An electrically driven cable or chain power conveyor is mechanically attached to hooks, onto which parts to be painted are hung. The conveyor is used to carry parts through the painting process operations. When the line is operating, all individual hooks on the line will continue to move and maintain their spacing.

Pre-bake drying - This appears as unusually rough paint film. The cause is a line stoppage between rinses or before the oven.

Pre-cleaner - Cleaning solution which is typically used outside the spray or immersion washer.

Premix - High solids paint concentrate blended with deionized water. See also "Replenishment."

Primers - Undercoats which bind topcoat to substrate.

Purge - Permeate diverted to drain for removal of water or water-soluble bath contaminants.

Q

R

Reagent - Substance used to measure the amount of specific chemicals present in a liquid.

Rectifier - An apparatus which converts Alternating Current (AC) to Direct Current (DC).

Red label goods - Products requiring a red label for shipment according to ICC regulations. The requirement is for products having a flash point below 80°F.

Reduce - To thin in viscosity by adding thinner or solvent.

Relative humidity - A scientific way of measuring moisture in the air. The percentage ratio of water vapor in the air to

the amount required to saturate it at the same temperature and pressure.

Replenishment - High solids paint concentrate added to an operating EDP bath to maintain a proper balance of solids, MEQ, solvent, color, etc.

Resin - Non-volatile solids or semi-solids exudation from the pine trees and plants. Also synthetically made by polymerizing molecules. Examples of natural resins are rosins and damar. Types of synthetics are alkyds, phenolics, etc.

Resistance - Opposition to flow of current, expressed in ohms.

Resistivity - The electrical resistance of a paint bath or permeate solution. See also "Conductivity."

Reverse osmosis (RO) - A membrane system used to separate brines by raising differential pressure higher than the normal osmotic pressure, i.e. desalination of sea-water, and de-ionization of water.

Ripple - The superimposition of alternating voltage on a D.C. output of a rectifier. (Usually reduced by a filter/choke).

Ru O2 - Ruthenium Oxide Coated Titanium - Ruthenium dioxide coated titanium. Used to extend life of electrodes and reduce ferric ion contamination of bath..

Run-out - (See Bleed-out).

Runs - Usually caused by improper consistency or paint or applying too heavily.

Rupture - The bursting of the electrodeposited film caused by an excessive generation of gas at the depositing electrode, due to excessively high voltage.

S

Sags - The sagging of paint. A curtain effect. Usually caused by applying too heavy a coat of paint or thinning too much.

Scab - Description of a type of corrosion that produces a rust-colored blister on steel surfaces; also, the name of a test procedure designed to measure this condition on painted panels.

Sealer - A primer which does not allow succeeding coats to permeate. Also seals in material that might otherwise bleed through the surface.

Seeding - A lumping of pigment or the vehicle becomes gelatinous, forming relatively large particles in the coating.

Semipermeable - Describes a membrane which separates components of a fluid by differences in one or more properties of the components such as size and shape, electrical charge, solubility, and diffusion rate.

Settling - (See Agglomeration).

Sheen - Lustre, gloss, semi-gloss, eggshell, etc.

Shelf life - The length of time a paint product may remain on the shelf or stored and still be usable. Affected by storage condition.

Shelf roughness - See horizontal settling.

Shutdown - (Shut-off) Ability of a wet deposited film to restrict additional current flow as the film increases. This produces the extreme evenness of film thickness on all surfaces and edges with the electrocoating process.

Skin - A tough, skin-like covering that forms on paints, varnishes, etc. when left exposed to air for long periods. Formed by oxidation or polymerization.

Solids - The pigment and non-volatile vehicle components of paint. Material which remains on surface. Can be measured by weight and volume.

Solubilizer - Paint stabilizer that aids in maintaining paint solids in solution.

Soluble - The ability of one product to dissolve into another.

Solution Paint - If resin molecules are fully dissolved by solvents the paint is a solution paint.

Solvent - That component of a solution which dissolves other components. In paint, the liquid is usually volatile.

Sparger - Synonym for eductor or venturi.

Specific Conductivity - Conductivity in micro-ohms/cm.

Specific Resistivity - Resistivity expressed in ohm-cm.

Specifications - Written instructions on details of paint applications, types of products to be used, areas to be painted and painting procedures. Quantitative to performance of formula.

Static stability - The ability of an EDP paint to remain stable over long periods of time (up to 3 months) with relatively no coating of old paint or addition of new paint.

Substrate - A material on the surface of which a coating is applied.

Sulfamic Acid - H_3NO_3S -- cathodic paint solubilizer.

Surface conductivity - The electrical resistance of a particular surface.

Surface preparation - The conditioning of a surface to receive a coating.

Surface tension - A property of liquid or solids matter due to unbalanced molecular forces near the surface. A measurement of this property.

Surface preparation - The conditioning of a surface to receive a coating. For instance, surface must be free from dirt,

grease, dust, and properly sanded, etc.

Surfactants - Surface active agents designed to reduce surface tension of the soils and once removed they hold the soil in solution.

T

Tacky - That sticky condition that exists in the drying process. Between wet and dry stages.

Telegraphing - A hand print, rag mark, or hose mark, etc. on one-coat or substrate that reads through on a subsequent coat.

Temperature - Controls viscosity of the wet deposited film which relates to the ability of the film to stop amperage flow by resistance. This controls film deposition to the desired film thickness.

Tensile strength - The load necessary to break a film when pulled in the direction of length. The stress necessary to break.

Thermoplastic - Soft and pliable when heated returning to solid when cooled.

Thermosetting - Type of plastic that becomes hard and unmoldable when heated and thereafter is heat resistant.

Thincoat - (See Elephant).

Thinner - A volatile liquid with which the viscosity of a paint product can be modified. The thinner evaporates when the coating is drying.

Thixotropy - The property exhibited by certain paints that gel in the container. A return to the liquid state occurs when shaken or stirred.

Throwing power - The ability of an electrodeposit to penetrate into "hard to reach" areas, such as a hollow metal object.

Tint - To add color. A letdown with white.

Tinting strength - The coloring power of a paint or pigment.

Titanium salt - Major component of a conditioning bath prior to the zinc phosphate stage which acts as sites for the zinc phosphate crystal growth in an immersion phosphate bath.

Titration - Process of determining the required amount of a substance's concentration in a solution.

Toluol - A relatively inexpensive solvent used in industrial finishes.

Tooth - Roughening a surface with sandpaper or cleaning with a liquid degreaser in preparing a surface for painting. A condition of a surface which helps adhesion of succeeding coats of paint.

Toughness - The quality of a hard film to resist scratches, abrasion and breaking.

Total acid - Amount of acid which exists in the bath as either free or metal acid phosphate.

Total alkalinity - A measurement of the cleaner bath's total concentration of active materials as well as contaminates.

Total titanium - A measurement designed to determine the overall concentration of titanium in the paint bath.

Transfer Efficiency - Term used to measure the overall efficiency of a paint system (computed as the weight ratio of dry film deposited on parts and the total solids used as replenishment - usually above 95%).

Trivalent chrome - Cr+3, which is used as a basis for the final pre-treatment and usually does not require waste treatment.

Turnover - When the paint solids in the bath or dip tank are completely "replaced" (moved) or replenished by an equivalent amount of solids materials, the bath has "turned over" one time.

U

Ultrafilter - A mechanical unit used in the membrane separation process.

Ultrafiltrate - Synonym for PERMEATE.

Ultrafiltration - A process for separating high-molecular-weight, colloidal, or very fine solid materials by filtration through microporous or semipermeable membranes. (See Ultrafilter and Permeate).

Ultraviolet light - The invisible rays of the spectrum lying outside the violet end of the visible spectrum. Responsible for much film failure in exterior exposure. (Also used to control bacteria in recirculated D.I. water systems).

Undercoat - A primer over which a topcoat will be applied.

Undercure - The part will appear excessively glossy. The part is not fully cured and will fail a solvent rub test. The cause is too low an oven setting or inadequate time in the oven.

V

Vehicle - A liquid, as oil, which is mixed with pigment to make paint.

Viscosity - The thickness or thinness of a liquid. A measure of resistance to flow.

Volatile - Any material that passes off in the form of vapor.

Volatile thinner - Liquid which evaporates during the drying of the film.

Voltage - A measure only of the potential difference (force or pressure) in electrical systems; it does not indicate amount of current.

Volts - The potential difference between two points.

VOC - Volatile organic compound.

W

Ware - The parts to be coated in the EDP process. See also "Substrate."

Water spots - A film deformity or defect caused by rinse water remaining in a bead formation on the electrodeposited film before it is cured.

Weathering - The exposure of paint films to the weather to determine their behavior to natural elements and pollution.

Weatherometer - An electrical testing instrument that accelerates various weather conditions on panels exposed to ultraviolet light and water spray.

Weir - The (often adjustable) barrier that controls the paint depth in an E-coat tank and over which the paint flows to the circulation pump and removes foam from tank surface.

Wet film thickness - The measurement of the coating when applied, but before the evaporation of the solvent.

Wetting agent - An aid to dispersion by addition of substances to lower the surface tension of water.

White elephant - This is a part that receives no electrocoat film. The cause is usually lack of electrical contact but could also be a lack of applied power (voltage) surface contamination or a rectifier malfunction.

X

Xylol-xylene - A solvent used in industrial finishes which has a higher boiling point than toluol. Similar to that liquid, otherwise.

Y

Z

Zinc dust - A medium gray pigment with extreme hiding power. Zinc-rich paints adhere unusually well to galvanized metal. Other desirable qualities are on-coat hiding, weather and heat resistance and it inhibits rust.

Zinc phosphate coating - Non-metallic, crystalline foundation applied to clean metallic surfaces by spraying or by immersion to improve paint adhesion and prevent under-film corrosion.