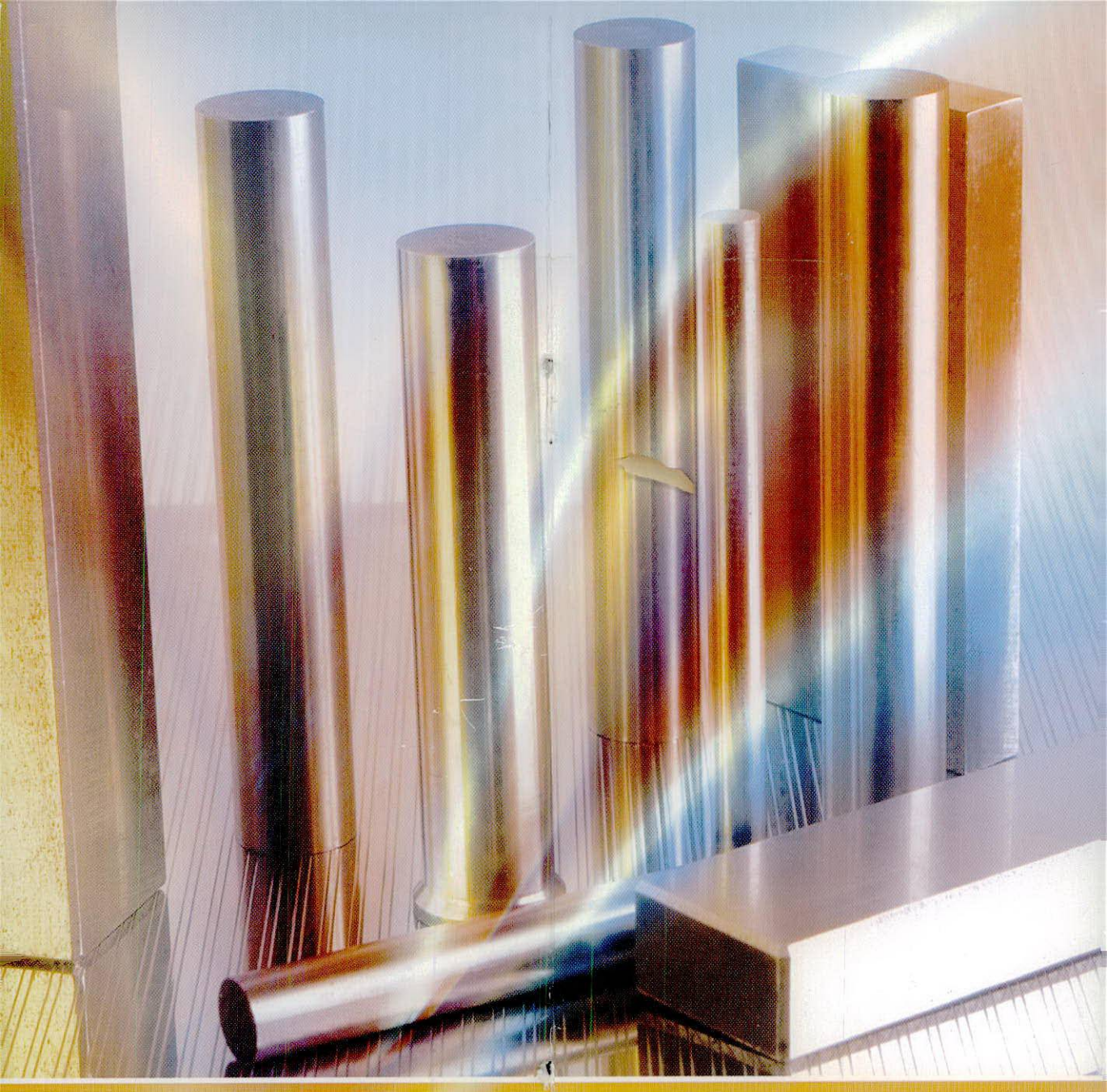

UNDERSTANDING SURFACE FINISHING

NATIONAL ASSOCIATION
FOR SURFACE FINISHING

www. nasf.org

NATIONAL ASSOCIATION FOR SURFACE FINISHING

The NASF is a trade association whose mission is to promote the advancement of the North American surface finishing industry globally. Membership is open to all surface finishing professionals, as well as those who provide services, supplies and support to the industry.

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WHAT IS SURFACE FINISHING?

Surface finishing is the process of altering the surface on an object (e.g., plating, polishing, anodizing, coating) for the purpose of enhancing its appearance or functional properties.

Apart from its decorative uses on a wide range of consumer and industrial products, surface finishing provides essential functional properties, such as:

- CORROSION RESISTANCE
- ABRASION RESISTANCE
- WEAR RESISTANCE
- IMPROVED LUBRICITY
- NON-TOXICITY AND BIOCOMPATABILITY
- DIMENSIONAL ALTERATION
- LIGHT REFLECTIVITY / ABSORPTION
- ELECTRICAL INSULATION / CONDUCTIVITY
- SOLDERABILITY
- THERMAL MANAGEMENT
- MAGNETISM
- CATALYTIC ELECTRODES AND DEVICES
- ENHANCEMENT OF PAINT ADHESION
- WIRE BONDING
- RUBBER BONDING

These surface properties can be delivered singly or in combination, bringing economic benefit and conserving materials.

Natural resources are conserved both because surface coatings preserve products, as an irreplaceable weapon in the war against corrosion and because rare and costly materials can be used only on surfaces to impart desired physical properties while a more abundant and less costly material can be used as the base.

Without surface finishing, many of your metal conveniences would no longer exist. Virtually every metal object has been finished to improve its appearance or shelf life. Imagine a world with no metal objects! How would your life change if there were no cars, airplanes, silverware, TVs, cell phones or music players?

THE SURFACE FINISHING INDUSTRY

In addition to many in-house surface finishing installations in manufacturing plants, the industry involves more than 4,000 job-shop finishing firms across the United States, with total annual sales exceeding $4 billion. Their work is an essential part of the production of virtually all manufactured durable goods, ranging from nuts and bolts and surgical instruments to computer circuits and aerospace components.

There is not a piece of metal in our homes, businesses, automobiles or in our pockets that has not passed through a surface finishing plant somewhere. Without this industry the entire economy would grind to a halt.

Examples of major industries serviced by surface finishers include:

- AUTOMOBILES
- AIRLINES
- COMMUNICATIONS
- COMPUTER EQUIPMENT
- CONSTRUCTION HARDWARE
- DEFENSE
- ELECTRICAL HARDWARE
- FURNITURE
- JEWELRY
- MOTORCYCLES AND BICYCLES
- HOUSEHOLD APPLIANCES AND ACCESSORIES
- TOOLS AND DIES
- OIL DRILLING EQUIPMENT
- STEEL MILL PRODUCTS
- FOOD
- MEDICAL
- PHARMACEUTICALS
- TOYS
- SPORTING EQUIPMENT

The independent job shops comprise an industry of small businesses performing a wide range of finishing services and employing some 100,000 people. A typical surface finishing firm employs 15 to 20 people, is capitalized at about $400,000 and generates approximately 1,400,000 per year in gross revenues.

NASF membership is worldwide and open to industry suppliers, companies engaged in various surface finishing activities, and individuals.

The association is headquartered in Washington, D.C. Each year NASF sponsors an annual convention, various management seminars, surveys, an industry-wide tradeshow and conference, a government relations effort and regularly scheduled training sessions. In addition, NASF offers comprehensive group insurance programs to members, and regularly publishes periodicals and manuals to help members increase their management skills and knowledge of the industry.

THE FINISHING TOUCHES

Now that you have learned how the surface finishing industry touches the lives of so many people, it is important to remember some key points emphasized in this brochure.

- The metal finishers arm of NASF is an industry of small businesses, and the services we provide are an essential part of the production of virtually all manufactured durable goods.
- Natural resources are conserved by the use of coating for preserving products, or by applying a surface coating of an exotic material that will provide its desired physical properties onto a substrate of an abundant and less costly base material.
- We serve every industry, large and small, none of which would survive without surface finishing.
- Our commitment to a clean environment and a safer work place is as strong as our commitment to the overall success of our industry. We know we cannot have one without the other.
- We believe our industry is an important part of the business backbone of this continent. We are small, independent organizations that make large contributions to the economy.

SELECTION OF COATINGS

Important considerations in the selection of coatings include:

- Purpose
- Use
- Cost
- Expected useful life
- Environmental exposure

NASF . . . PLAYING A VITAL ROLE

The surface finishing industry is served by National Association for Surface Finishing (NASF), dedicated to the advancement of North American surface finishing. The association is a partnership of three sister organizations:

- The American Electroplaters and Surface Finishers Society, Inc. which is committed to education and training
- The Metal Finishing Suppliers' Association (MFSA) which develops and markets the equipment and processes necessary for today's surface finishing
- The National Association of Metal Finishers (NAMF) which is comprised of the job-shop surface finishing businesses.

Originally developed by the NAMF and updated in 2007 by NASF, this brochure is one of many NASF projects designed to represent our membership in the most skillful and professional manner possible. NASF is the only official representative of suppliers, custom and job shop surface finishers and individual members, and plays a vital role in the industrial world.

Although many manufacturers have their own surface finishing facilities in-house, there has been a long-range trend toward subcontracting such work to independent firms as a result of the increasingly high technology required, the high cost of starting and operating surface finishing processes at less than full capacity, expensive government-mandated pollution abatement programs and environmental and worker safety regulations which virtually demand staff specializing in surface finishing environmental management.

The surface finishing industry continues to make positive contributions to many other industries and to the general economy with continuous research, constantly updated equipment and the new processes necessary to keep pace with the development of space-age and wireless-age products and ever more demanding coating requirements. Look around and you will discover the endless number of traditional items that have been served by this vital industry, as well as the new needs of medicine, transportation, information technology and personal electronics.

. . . AND THE ENVIRONMENT

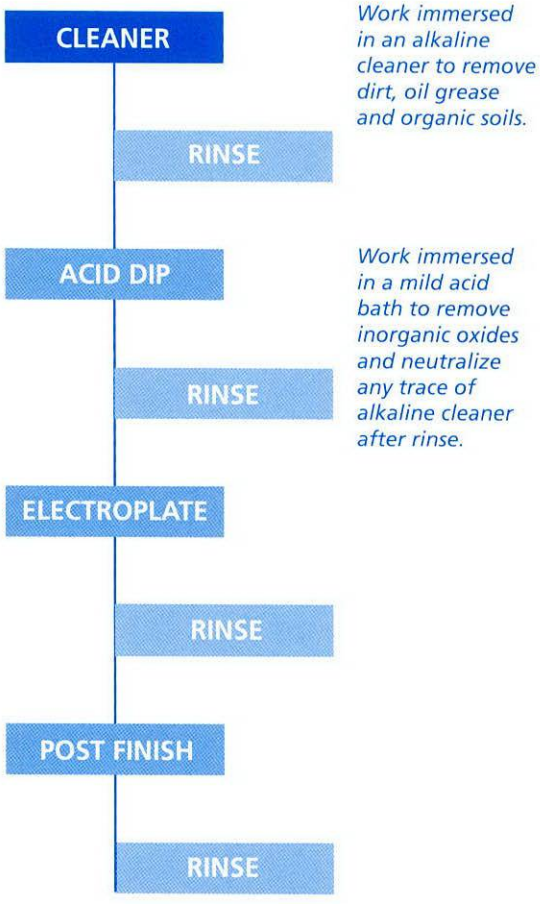
The continued demand for finishing services dictates that the surface finishing industry embraces the responsibility to conduct its operations with a serious concern for the environment. The industry works side-by-side with the U.S. Environmental Protection Agency (EPA) as well as other federal, state and local regulatory agencies to achieve superior environmental performance. In striving to attain this goal, the surface finishing industry, through a voluntary partnership with EPA known as the National Metal Finishing Strategic Goals Program, continues to implement waste minimization and pollution prevention techniques, to use tools such as Environmental Management Systems (EMS) to enhance environmental compliance and to work cooperatively with federal, state and local regulators.

As a result of these efforts the surface finishing industry has demonstrated significant success in environmental protection and has established itself as one of the nation's industrial leaders in environmental protection.

METAL FINISHING
COATING AND SURFACE TREATMENTS

Electroplating is an electrochemical process which deposits a metallic coating on the base material of an object by immersing it in a properly designed solution and applying a suitable low voltage electric current flow which causes the metal ions to be attracted to and deposited upon the object being plated.

A typical basic electroplating sequence looks something like this:



Work immersed in an alkaline cleaner to remove dirt, oil grease and organic soils.

Work immersed in a mild acid bath to remove inorganic oxides and neutralize any trace of alkaline cleaner after rinse.

PHOSPHATE COATINGS: These are porous crystalline coatings of zinc, iron or manganese phosphate produced on ferrous metal surfaces by the reaction of the surface metal to the phosphate solution. The coatings are widely used for a number of reasons:

- Prolonging the life of organic coatings
- Providing good paint bonding
- Improving corrosion resistance by providing a good base for absorbing and retaining rust preventive materials
- Providing an excellent base for holding lubricants and drawing compounds

PASSIVATION: This is the use of an acid solution to render the surface of stainless steel in a "passive" state that enhances its corrosion resistance.

CHEM-FILM: Aluminum may be anodized as was previously described, but an alternative and popular process is chem-film, sometimes called chromate conversion coating. While anodizing puts an electrically-insulating aluminum oxide coating on the parts, chem-filming builds an electrically-conductive coating that can serve as a corrosion resistant final finish or as an excellent base for paint.

In addition to offering electroplating, its sister electrolytic processes and electroless plating, specialty surface finishing job shops may offer additional processes to deliver the required surface engineering:

MECHANICAL PLATING AND DIP-SPIN PROCESSES: Zinc and some other sacrificial metals can be deposited on surfaces "mechanically" by burnishing the parts in a mix of fine metal flakes and tiny glass beads. The glass beads concentrate the force of parts impacting each other onto a very tiny surface area, pounding the zinc flake onto the surface. Dip-spin processes involve zinc-rich paint-like coatings that can deliver sacrificial protection to steel parts.

PVD PROCESSES: Physical vapor deposition processes employ some variety of electrical or plasma discharge in a vacuum chamber to transport very thin highly conformal layers of hard and colorful metallic or semi-metallic coatings to the substrate. For example, the familiar gold-toned coating on high-speed drills and jewelry is titanium nitride. The "lifetime" finishes on door hardware and plumbing fixtures is comprised of nickel electroplating for brightness and corrosion resistance followed by a PVD coating for hardness and coloration.

ORGANIC COATINGS: This refers to processes that deposit paint or an organic material similar to paint, as opposed to a metallic coating. In addition to the previously mentioned e-coating, autophoretic coating and dip-spin coating, paint can be applied by dipping or spraying with solvent-based or water-based paint, or by applying the organic coating as a dry powder which is subsequently baked.

> ***Powder coating*** is one of the newest and most environmentally sound innovations in the surface finishing industry. Powder, applied electrostatically or by fluidized bed processing, adheres to the parts, which are subsequently baked. These plastic powders may be either thermoplastic or thermoset, but in either case the powder melts and fuses in the oven into a continuous pinhole-free coating, which then hardens. Powder coating allows an unlimited range of colors and special "looks" like metallic or iridescent. As no solvents or thinners are used, there are no (or almost no) volatiles to contend with from an environmental standpoint, and over-sprayed materials can be recovered and reused.

Some of the more common electroplated coatings and their functions include:

BRASS: Plated for decorative purposes on such items as household lamps, furniture, accessories and builders' hardware, either as a bright or satin finish or oxidized to offer various antique effects. As a functional coating, specialty brass metallurgies can be produced via electroplating that cannot be cast or otherwise obtained.

CADMIUM: A silver-white deposit used to minimize galvanic corrosion on assemblies of dissimilar metals and for sacrificial corrosion protection properties combined with lubricity and malleability.

CHROMIUM: The bright, shiny, mirror-like finish so common on everything from trucks and motorcycles to bicycles and toys, furniture, appliances large and small, and plumbing fixtures. This timeless and versatile finish provides outstanding corrosion protection and good wear life, as well as beauty.

HARD CHROMIUM: A heavy, dense deposit of chromium used to provide wear resistance and lubricant retention on such parts as pistons, cylinders, aircraft engine parts, cutting tools, dies, oil tool parts and valves. Also used on press plates for printing everything from money to catalogs, and producing high pressure laminate flooring and countertops. Variations on the hard chromium theme include flash and thin dense chromium.

COPPER: A reddish deposit used for plating through-holes on circuit boards in the electronics industry, the circuitry paths of the fastest microprocessors, steel wire used in making high-strength electric cable, and as a stop-off to prevent case hardening on selected areas of machine parts. All pennies made since mid-1982 are zinc cores with copper electroplating. Copper is the first layer in the highest quality "Show Chromium" plating.

GOLD: A yellow deposit heavily relied upon in the electrical and electronics industry to provide long-term, dependable electrical contact, solderability, temperature resistance and corrosion protection in all kinds of devices including telephones, cell phones, printed circuit boards, televisions, satellites, rockets and so on. Gold is also commonly deposited as a decorative finish on jewelry, pens and optical products.

NICKEL: A silver-white deposit used generally on industrial products for corrosion protection, and in the chemical and food processing industries to prevent iron contamination. As a decorative finish, brushed nickel and satin nickel are consumer favorites.

SILVER: Used on tableware and hollowware because of its resistance to foods, as well as in jewelry. Functional uses include preventing galling or seizing of metal surfaces under high loads, such as on bearings, threads on stainless steel bolts and on titanium compressor blades. It is also used in the electrical and electronics industries because of its outstanding conductivity. Reconstructive surgery requires silver-plated electrosurgical tools.

TIN: A white, non-toxic, solderable, soft deposit useful for its resistance to corrosion and tarnish. Since tin is non-toxic, it is used as a coating on sheet steel for making "tin cans" as well as on food handling equipment. Tin, either alone or as an alloy, is very widely used in the electronics industry for good surface conductivity and solderability.

ZINC: A bluish-white deposit which serves as an inexpensive decorative and sacrificial protective coating against atmospheric corrosion of iron and steel parts. Countless millions of nuts, bolts and washers are zinc-plated, as well as wire goods, fasteners, stampings and sheet metal parts. The trend today is towards higher technology zinc alloy plating such as zinc-cobalt, zinc-iron, zinc-nickel and tin-zinc, which can offer highly, engineered electrochemical potentials to minimize corrosion.

WHITE BRONZE: The rising incidence of nickel allergy in some countries has prompted the search for a replacement for nickel for jewelry and skin-contact applications. This alloy plating of tin, copper and zinc enjoys growing popularity.

Processes akin to electroplating, which employ solutions charged with low voltage electricity to alter surface properties, include:

ANODIZING: An electrochemical process which converts an aluminum surface to a coating of aluminum oxide. This coating can be applied thick (hardcoat anodizing) to produce exceptionally hard and wear resistant machine components, or thinner and nearly transparent, making it suitable for streetlight reflectors or for dyeing in a wide variety of colors.

> ***Coloring anodized aluminum*** is accomplished by anodizing the item, dipping it in the desired color dye bath, then immersing it in hot deionized water or an alternative sealing process, which closes the microscopic pores in the coating, locking in the color. A wide variety of colors give this finish broad appeal as a decorative finish for giftware, novelties, automotive and appliance trim, nameplates and exterior architecture.

ELECTROPOLISHING: This electrochemical process is the reverse of plating. Instead of adding a coating or plating, electropolishing dissolves metal from the surface, leaving a very smooth, clean, bright finish not achievable by mechanical polishing. It provides a surface that is less porous, allowing for reliable sterilization in the medical and food industries. Electropolishing is most often done to stainless steel, but can also be performed on aluminum, copper alloys and titanium.

E-COATING / ELECTROPHORETIC LACQUERING: A method of "painting" by immersing the article in a charged tank which electrochemically deposits the insulating coating to allow the thinnest most even deposits.

ELECTROFORMING: Similar to electroplating except that the substrate is removed and the plated layer itself becomes the object of question. Stampers for vinyl records, compact discs and Fresnel lenses are made this way, as are waveguides, hollow gold and silver jewelry and ultrathin precision screening.

ELECTROLESS PLATING: This is the chemical deposition of a metal coating on a substrate by immersion in the appropriate plating solution. Electricity is not involved in this process; instead, a reducing agent causes the deposition. Therefore, uniform deposits can be obtained which possess unique mechanical, chemical or magnetic properties. The process can be applied to properly treated non-metallic objects such as plastic and glass. In fact, most exterior automotive brightwork (grills, headlamp surrounds, taillight bezels, insignia) consists of copper-nickel-chromium electroplating on top of electroless-plated plastic.

> ***Electroless nickel*** provides better corrosion resistance, and greater hardness, wear resistance and lubricity than electroplated nickel.
>
> ***Electroless copper*** is applied on non-conductors to provide a conductive layer, and also in the printed circuit industry for crossover connections.
>
> ***Electroless gold*** is commonly used in integrated circuit applications.

AUTOPHORETIC COATING: This process is to e-coating and electrophoretic lacquering as electroless plating is to electroplating. That is, the deposition process proceeds directly from the chemistry of the bath rather than requiring an external electrical source.