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The Electrolizing Thin, Dense, Chromium Process

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28.1 General Definition

The Electrolizing process uniformly deposits a dense, high chromium, nonmagnetic alloy on the surface of the basic metal being treated. The alloy used in Electrolizing provides an unusual combination of bearing properties: remarkable wear resistance, an extremely low coefficient of friction, smooth sliding properties, excellent antiseizure characteristics, and beneficial corrosion resistance. Electrolized parts perform better and last up to 10 times longer than untreated ones.

The solution and application processes are carefully monitored at all Electrolizing facilities. The result is a fine-grained chromium coating that is very hard, thin, and dense and has absolute adhesive qualities. The Electrolizing process deposits a 99% chromium coating on the basis metallic surfaces, whereas normal conventional chromium plating processes tend to deposit 82 to 88% chromium in most applications.

Electrolizing calls for the cleaning and removal of the matrix on the basis metal's surface by multi-cleaning process, using a modified electrocoating process that causes the chromium metallic elements of the solution to bond to the surface porosity of the basis metal. It is during this process that the absolute adhesive characteristics and qualities of Electrolizing are generated. The Electrolizing coating will not flake, chip, or peel off the basis metal substrate when conventional ASTM bend tests and impact tests are performed. Three basic factors are always present after applying Electrolizing to metal surfaces:

- Increased wear (Rockwell surface hardness of 70 to 72 R_c)
- Added lubricity characteristics
- Excellent corrosion resistance

TABLE 28.1 Uses for Electrolizing

Basis Metal Hardness Range (R_c)	Application	Thickness of Electrolizing Recommended (in.)
18–30	Electrolizing will handle low-loaded or stress conditions and provide basic corrosion resistance.	0.0001
30–40	Electrolizing increases wear resistance where the metal will basically support the wear factor. Corrosion resistance is good in this range.	0.0007–0.0009
40–50	Corrosion resistance increases as basis metal gets harder. Wear resistance properties begin to improve greatly.	0.0003–0.0005
≥50	This is the most common and recommended range for an Electrolizing application. Corrosion resistance is superior, and the maximum wear resistance benefits are exhibited.	0.00005–0.0003

28.2 Applications

28.2.1 General

Electrolizing can meet a variety of engineering needs: chrome plating according to specifications, flash chrome plating, repair or salvage work, and heavy chrome application before grind. Electrolizing increases wear resistance, reduces friction, prevents galling and seizing, minimizes fretting corrosion, offers resistance to erosion, and provides corrosion resistance. It can be applied to all commonly machined ferrous and nonferrous metals, including aluminum, titanium, stainless steels, coppers, brass, and bronze. The coating is not recommended for magnesium, beryllium, columbium, lead, and their respective alloys.

On aluminum, Electrolizing increases wear life and surface strength, reduces oxidation and corrosion, enhances appearance, and prevents galling, seizing, and erosion. Electrolizing is also conductive, whereas other treatments to aluminum are nonconductive. The result with Electrolizing is no static buildup.

Because it is a thin, dense coating, Electrolizing exhibits its best wear and lubricity properties on hardened surfaces. It is most effective when the basis metal is 40 R_c or harder. In severe wear applications, a basis metal should be hardened to the 50 to 62 R_c range before Electrolizing is performed. Electrolizing will improve performance on any basis metal, but it is not a substitute for heat treating.

Table 28.1 lists appropriate uses for Electrolizing at various basis metal Rockwell hardness ranges.

28.2.2 Specific

Electrolizing is used across a variety of industries for a multitude of purposes. With Electrolizing, dies and molds for both rubber and plastics have better release characteristics and reduced wear (especially when abrasive materials are involved); cutting tolls experience longer wear life; nuclear components exhibit better antigalling and corrosion resistance properties; dies used in stamping, drawing, forming, and blanking have sharper cuts and increases in work life; engine and transmission parts (such as valves, valve guides, pistons, gears, and splines) are protected without detrimental tolerance changes or variations; standard pumps and meters handle corrosive liquids and materials much better; and bearing and bearing surfaces can run longer and cooler and are superior to a 400 series stainless steel for corrosion protection. In fact, Electrolizing makes it possible to use standard ferrous steels in place of stainless steel in many applications, including food processing, medical environments, and ball or roller bearing applications.

Other applications include drive transmissions, power transmissions, gears, molds, screws, sleeves, threaded parts, and valves. In the automotive industry, applications include not only engine parts, but also large metal form dies for auto body parts. Electrolizing has been utilized on applications in these and other industries:

- Aerospace
- Aircraft and missiles
- Armament

- Automotive
- Business machines
- Cameras and projectors
- Computers
- Cryogenics
- Data processing
- Electronics
- Food processing
- Gauges and measuring equipment
- Medical instruments
- Metalworking
- Molds (plastic and rubber)
- Motor industry
- Nuclear energy
- Pharmaceutical
- Photography (motion and still)
- Refrigeration
- Textile industry
- Transportation

Specifically, Electrolizing is approved and meets the following aerospace, nuclear, and commercial specifications:

- Air Research Company, Garrett, CO
- American Can Company
- AMS 2406
- AMS 2438
- AVCO Lycoming — AMS 2406
- Bell Helicopter
- Bendix Company
  Utica, NY, division
  Teterboro, NJ, division
  Kansas City, MO, division
  South Bend, IN, division
- Boeing
  BAC 5709 Class II, Class IV
  QQC 320
- Cleveland Pneumatic Tool-CPC Specs (Chromium), QQC320
- Colt Industries
  Menasco, TX, division
- DuPont
- Fairchild Camera
- Fairchild Republic
- General Dynamics
- General Electric
  Lynn, MA
  Cincinnati, OH (aircraft)
  Wilmington, MA
  Wilmington, NC (nuclear)
  Fitchburg, MA
- Gillette Company, Boston
- Grumman Aircraft

- IBM, 40 to 45
- Johnson & Johnson, New Jersey
- Kaman Aircraft
  QQ–C–320
  AMS 2438
- McDonnell/Douglas
  PS 13102
  QQC320
- MIL–C–23422
- Nabisco Company
- Ozone Industries
- Perkin Elmer Company, most divisions
- Pratt & Whitney
  QQC320
  PWA 48
  AMS 2406
- Procter & Gamble, Cincinnati, OH
- QQ–C–320 B Class II
- Raytheon
- U.S. Navy
  Newport News, Electric Boat, Portsmouth Naval Shipyard
  Hamilton Standard
  HS 332, HS246
  QQ–C–320B
- Western Gear Company
- Western Electric Company
- Westinghouse

28.3 Surface Preparation

Substrate surfaces must be free of oil, grease, oxides, and sulfides. Parts should be surface finished before shipment to an Electrolizing facility, where they will undergo further cleaning and surface preparation through a multicleaning process. Surfaces will not be changed significantly in configuration by the Electrolizing process.

A clean surface is very important. When conventional chrome is utilized, component failure is often erroneously attributed to "spalling." The effect is actually due to a residual contaminant, which was covered or surrounded by electrodeposited chrome and subsequently dislodged as a result of sliding or other mechanical action. This leaves a void in the chrome plating which, in turn, causes further deterioration of the surface.

The surface must be free from scale and soils to secure the best corrosion resistance. Any scale left on the surface will gradually acquire a rusty appearance and act as a nucleus for additional rust to form. On articles that are to have a "stainless" appearance, every trace of scale must be removed by grinding, pickling, or polishing.

The solution of Electrolizing, Inc., is to use a multicleaning procedure. Multicleaning is not a trade name, nor is it a novel, or supercleaning, technique. It is merely a designation for a carefully planned cleaning program prescribed for each individual part, utilizing every possible cleaning method available — such as vapor degreasing; solvent, detergent, diphase, and alkaline cleaning; dry vapor honing; electrolytic and ultrasonic cleaning; vibratory cleaning; and hydroblasting. Maintained throughout are high level quality control standards, consisting of microscopic before-and-after inspection of each part, intermittent inspection between processing phases, and disciplined handling procedures.

The significant surfaces to be coated should be completely finished prior to processing. For best results, the surface finish should be 32 RMS or better. The finer the surface, the better it is to Electrolize. This is true to a finish of 2 to 4 RMS or better. Surface finishes that are received by Electrolizing with 4 RMS or less may show some slight roughing of the surface after application. In most cases, these finishes can be tapped or polished back to their original condition. All surfaces should be free from plated coatings. Parts that have been nitrided should be machined or vapor-blasted before processing. The Electrolizing coating will not adhere to brazed or welded areas unless these are machined or vapor-blasted to remove all impurities before processing. Unless otherwise specified, the coating should be applied after all basis metal processing has been completed. This includes heat treatment, stress relieving (when required), machining, brazing, welding, and forming. The coating should be applied directly to the basis metal without any intermediate coating.

Electrolizing is a low temperature process. The temperature of parts during the cleaning and coating process does not exceed 180°F. There is no distortion or annealing of the basis metal.

Generally, parts should be less than 20 ft long, 30 in. in diameter, and 4000 lb in weight. Parts exceeding these limits should be discussed with Electrolizing, Inc.

28.4 Solution

Electrolizing is a blend of some of the best chrome salts and selected proprietary catalysts and additives that create its unique proprietary features. The solution is carefully monitored and its quality maintained through the use of exacting, sophisticated equipment and laboratory controls. The materials are distributed only of accredited licenses within the Electrolizing licensee program.

28.5 Properties

28.5.1 Thickness

Electrolizing is applied in a very thin, dense layer on the basis metal. The Electrolizing process does not create a buildup on corners or sharp edges; it conforms exactly to the surface. There is no change in either the conductivity or magnetic properties of the basis metal.

Electrolizing deposits range from 0.000010 to 0.003 in. per side. The practical coating range is from 0.000025 to 0.01 in. The average deposit is 0.0004 to 0.0008 in. per surface. Thickness tolerances of ±0.000010 to ±0.000050 in. can be maintained, depending on thickness specified and the quality level of the part. Coating thickness that may exceed 0.001 in. can be applied, and tolerances can be maintained to eliminate post-Electrolize grinding operations. Table 28.2 and Table 28.3 list thickness ranges and tolerances for most metals. It is recommended that the coating thickness and tolerance be established by consulting with Electrolizing, Inc.

TABLE 28.2 Thickness Ranges for Most Metals

Coating/Side (in.)	Tolerance (in.)
0.000050	±0.000010
0.0001	±0.000020
0.0002	±0.000050
0.0003	±0.000050
0.0004	±0.000050
0.0005	±0.000050
0.0006	±0.000075
0.0007	±0.0001
0.0008	±0.0001
0.0009	±0.0001
0.001	±0.0002

TABLE 28.3 Thickness Ranges for Aluminum

Coating/Side (in.)	Tolerance (in.)
0.0001	±0.000020
0.0002	±0.000050
0.0003	±0.0001
0.0004	±0.0001
0.0005	±0.0002
0.0006	±0.0002
0.0007	±0.0002
0.0008	±0.0003
0.0009	±0.0003
0.001	±0.0003

Electrolizing thickness is always in direct relation to the basis metal and will vary from one basis metal to another. However, the thickness established for each will remain constant and predictable. In all applications calling for a close inspection to monitor deposit thickness, Electrolizing, Inc., recommends the use of an exacting reverse etchant method of ascertaining deposit thickness. This method is nondestructive to the basis metal. If necessary, destructive microphotos will verify deposit thickness and consistency.

28.5.2 Adhesion

Electrolizing has outstanding adhesive characteristics. The adhesion of the coating is such that when examined at four diameters, it will not show separation from the basis metal on test specimens bent repeatedly through an angle of 180°, on a diameter equal to the thickness of the specimen, until fractured.

The Electrolizing coating forms a lasting bond with the surface by permeating the surface porosity of the basis metal, but it can be removed by licensed Electrolizing plants without detrimental effects to the basis metals.

28.5.3 Corrosion

Electrolizing resists attack by most organic and inorganic compounds (except sulfuric and hydrochloric acids). The Electrolizing coating is typically more noble than the substrate; therefore, it protects against corrosion by being free of pores, cracks, and discontinuities, and by providing a uniform structure and chemical composition. Porosity, hardness, and imperfect surface finishes of basis metals will affect the corrosion-resistant properties of Electrolizing; however, all basis metals that are Electrolize coated will have enhanced corrosion-resistant characteristics.

Samples can be subjected to standard ASTM B–117 and B–287 salt spray tests. The Electrolizing process also meets the following specifications: QQ–C–320, AMS–2406, Mil–C–23422, Mil–P–6871, ANP–39, and NASA ND–1002176.

28.5.4 Wear Resistance (Surface Hardness)

Electrolizing is one of the hardest chromium surfaces available, measuring 70 to 72 R_c, as applied. “As applied” refers to the measurable hardness of the Electrolizing coating when measured on the basis metal to which it is applied. The basis metal plays an important role in determining how wear resistant the Electrolizing surface will be. Generally speaking, Electrolizing increases measurable hardness 10 to 15 points, as shown in Table 28.4.

In all cases, Electrolizing is 70 to 72 R_c. However, the basis metal directly affects the measurable hardness that can be achieved. The harder the basis metal, the higher the Electrolizing measurable hardness will be. Test measurements of the surface hardness should be made using the Knoop or Vickers method with a 5 to 10 g load on a diamond point.

TABLE 28.4 Measurable Hardness (R_c)

Basis Metal	Electrolizing Coating
≤18	18–25
18–35	30–50
35–50	50–70
50+	70+

High hardness values indicate good wear resistance, but there are other factors to consider, such as coating surface texture, coating density, substrate cleanliness before coating application, interfacial energy of adhesion between the coating and the substrate, energy of adhesion between coating surface and the opposing sliding material, type of lubricant used, and the combination of opposing materials.

Increased density improves wear resistance, because it results in fewer cracks, inclusions, and voids, which in turn, reduces the rate of corrosive attack and provides more resistance to fragmentation, spalling, and wear.

Surface fatigue wear — the category to which true spalling belongs — also affects wear resistance in conventional QQ–C–320 chrome plating. The stress concentrations here are generated during the electrodeposition, an integral phenomenon when chromium crystals are formed. The Electrolizing coating — essentially a chromium alloy — is virtually devoid of these internal stress concentrations, and therefore has minimal tendency to spall. This is one of the reasons for the substantial superiority in wear resistance under mechanical impact conditions of Electrolizing to most conventional chrome platings.

The Electrolizing coating also has a lower kinetic friction coefficient, and in wear resistance, it is superior to all other chrome platings (including electroless nickel and a tungsten-carbide coating), as measured on three different test machines: the Taber, the Falex, and the LFW–1.

Finally, the Electrolizing coating exhibits extremely low adhesive wear coefficients: 1.72×101^{-7} on steel against a copper alloy, and 1.19×10^{-7} on steel against steel with a petroleum oil (10^{-8} representing the ultimate or best wear coefficient ever measured).

28.5.5 Lubricity

An Electrolized coating has a coefficient of friction of 0.11. Electrolizing also produces kinetic friction coefficients as low as 0.045 under unidirectional sliding test conditions with fluorosilicone oil on the LFW–1 test machine, and a 0.069 with an addictive-free white mineral oil on the Falex lubricant tester. Electrolizing's low friction factor is invaluable when extreme temperatures are involved.

28.5.6 Conformity

Electrolizing works best when applied to a relatively smooth surface (12 to 32 RMS or finer). Below 4 RMS, the process may deter slightly from the fine finish of the part, requiring post-Electrolize operations.

Internal and external surfaces of nearly all shapes and configurations can be uniformly processed. Slots or grooves less than 0.187 in. wide, having a depth greater than width, and bores less than 0.187 in. diameter will require special engineering to assure a uniform coating. Electrolizing, Inc., recommends test runs for such parts and special discussions with Electrolizing engineers on dimensions less than 0.187 in.

28.5.7 Heat Resistance

The maximum operating temperature recommended for the Electrolize coating is approximately 1600°F (710°C). Time at temperature should be reviewed with Electrolizing, Inc., before testing or specifying Electrolizing. In general, oxidation occurs around 1100°F (430°C), progressing to 1650°F (740°C), and then to diffusion.

28.5.8 Brightness

The Electrolizing coating is smooth, continuous, fine-grained, adherent, uniform in thickness and appearance, and free from blisters, pits, nodules, porosity, and edge buildup. Electrolizing is used as the final coating on parts and equipment. The Electrolizing coating is shiny by application. However, satin (matte) finishes can be attained, if specified.

28.5.9 Hydrogen Embrittlement

During conventional chrome plating processes, a detrimental side effect occurs: hydrogen occlusion. Hydrogen penetrates into the substrate and causes embrittlement of the metal part with subsequent reduction of mechanical properties, particularly fatigue strength. Most conventional chrome plating control documents, therefore, specify a final 375°F bake to remove hydrogen gas.

The longer the plating cycle, the more likely it is that hydrogen embrittlement will occur. Embrittlement is also more likely to occur after an acid clean. Shot peening and/or liquid honing can be used to relieve embrittlement stress.

Hydrogen embrittlement is extremely unlikely with Electrolizing because the Electrolizing processing avoids most of the causes of a true hydrogen embrittlement. Electrolizing, Inc., does not include postprocess baking in its process technique. However, if postprocess baking is required by a customer, Electrolizing, Inc., is able to include it as a standard procedure.