



Standard Specification for Electrolytic Plasma Treatment Processing of Conductive Materials¹

This standard is issued under the fixed designation A1093/A1093M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the requirements for cleaning, coating, or surface modification, or combinations thereof, of conductive materials, primarily metals.

1.2 This specification covers any conductive material treated or processed by the electrolytic plasma process (EPP) including: products designated as long products, including wire and fine wire; flat-rolled materials; fasteners; connectors; bolts; assemblies; structural materials; hardware items; and medical items.

1.3 Products created under this process shall specifically specify requirements for the specific product being processed using the EPP process.

1.4 This specification is applicable for orders in either inch-pound or SI units.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

¹ This test method is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.12 on Wire Specifications.

Current edition approved Oct. 1, 2015. Published November 2015. DOI: 10.1520/A1093A1093M-15.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

A924/A924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

D2200 Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces

F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.2 SSPC Standard:³

SSPC-VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *anode, n*—positively charged device within the plasma reactor.

3.1.2 *applied potential, n*—direct current (dc) voltage applied between two electrodes, anode and cathode.

3.1.3 *aqueous plasma, n*—use of water as the source of the $H_2 - H^+ + H^+ + 2e^-$.

3.1.4 *cathode, n*—negatively charged work piece within the plasma reactor.

3.1.5 *electrolyte, n*—aqueous solution containing ions capable of conducting electric current.

3.1.6 *micro-roughness, n*—features formed as a result of the kinetic energy produced from the implosion and rapid quenching phenomenon that occur during electro-plasma technology (EPT) processing.

3.1.7 *plasma, n*—collection of free moving electrons and ions capable of conducting electric current.

3.1.7.1 *Discussion*—In this case, the gas is hydrogen and the ion is H^+ . Energy is required to make plasma. Without sustaining energy, plasma recombines into molecular hydrogen, H_2 .

³ Available from the Society for Protective Coatings, 40 24th St., 6th Floor, Pittsburgh, PA 15222.

3.1.8 *plasma reactor, n*—device housing that confines the plasma within the work zone containing the electrolyte, which allows the formation of plasma.

3.1.9 *salts, n*—refers to the soluble metal salts used within the aqueous plasma process.

3.1.10 *surface morphology, n*—unique surface characterized by the presence of micro-craters and spheroids created by the electro-plasma process.

3.2 Acronyms:

3.2.1 *EPP*—Electro-plasma processing

3.2.2 *EPT*—Electro-plasma technology

4. Electro-Plasma Process (EPP)⁴

4.1 Electro-plasma processes (EPP) are a hybrid of conventional electrolysis and atmospheric plasma processes. All the independent studies lead to a common observation that, at a certain value of voltage between two electrodes in an aqueous electrolyte, will lead to deviation from Faraday's normal electrolytic regime. Applied voltage is significantly greater when compared to the conventional electrolysis leading to the analogous phenomenon that is accompanied by the formation of a continuous plasma envelope around either the cathode or the anode with the presence of luminous discharge or glow plasma. The critical factors that influence the formation of the continuous plasma envelope include applied potential, electrolyte temperature, geometry of the electrodes, nature and properties of the electrolyte, and flow dynamics of the electrolyte and work piece. Most of the studies are concentrated on the anodic regime.

NOTE 1—In the EPT process described here, the work piece is the cathode and it is negatively charged. Plasma forms on the cathode. The anode is the positively charged electrode.

Electro-plasma technology (EPT) is used to engineer metal surfaces in the cathodic regime, but it can be used in the anodic regime depending on desired results. EPT processing is a dynamic process that involves delivery of aqueous electrolyte into a confined chamber (EPT reactors) on the surface of the work piece. Balance between electrolyte flow and plasma generations ensures a uniform treatment of the metal surfaces.

4.2 EPP is an environmentally friendly technology applied in a closed-loop system.

NOTE 2—There are no solid wastes generated from EPT. Vapor generated during the process can be captured and returned.

5.1 In a cathodic regime with an electrolyte of near neutral salts, cleaning of a metal surface can be achieved. EPT can effectively remove lubricants, dirt, metal oxide scale, and so forth from metal surfaces. Organic materials are disassociated

into their gaseous components, thick oxides are broken and blasted off the surface, and thin residual oxide layers are reduced back to their pure metallic element.

5.2 EPT cleaning uses thermal shock, electrical current, chemical reaction, and kinetic energy in the form of cavitation.

5.3 Plasma formed on the surface of the work piece in a liquid electrolyte results in unique surface characteristics and a unique morphology (micro-roughness).

6. Electro-Plasma Cleaning Process

6.1 Electro-plasma cleaning of a continuous length of a conductive metal is accomplished by passing the item through an appropriately designed reaction chamber. The number of reactors required is speed-dependent and they are run in tandem.

6.2 The reactor chamber is supplied with electrolyte in a controlled method.

6.3 A large potential is set between the anode and cathode (work piece), normally in the range of 25 to 250 V.

6.4 Luminous plasma is generated at the work piece surface and the work piece is cleaned of contaminants and oxides.

6.5 The work piece then passes through a hot (70 ~ 80°C [160 ~180°F]) water spray rinse and is dried.

6.6 The product can now be collected on a typical package or it can go directly into EPT deposit reactors for coating with a variety of metals and alloys.

7. Testing Requirements: Cleaning

7.1 The degree of cleaning is typical for a specific industry but is typically done by comparing the appearance of the dirty component to the cleaned component and, therefore, is an attribute rating. In this case, it is recommended that the surface be examined under a magnification of 20× for signs of residual lubricant, soils, and oxides. A minimum of at least three areas should be observed and the estimate of cleanliness recorded. A rating is developed by estimating the percent of the field that contains no signs of residual lubricant, soils, or oxides. The average of these estimate observations are recorded and used to rate the level of cleanliness. The actual cleanliness level of a specimen may vary widely and still be acceptable for the intended end use. The user will be responsible for determining the minimum level of their particular application. It has been the experience when using EPT that the surface is 99 to 100 % free of any visual contamination.

8. Electro-Plasma Deposition

8.1 EPT has the ability to deposit metal and alloy coatings such as zinc, nickel, zinc-nickel, nickel-copper, molybdenum, tin, and so forth. EPT coatings exhibit excellent adhesion with the substrate and are deposited at significantly high deposition rates as compared to conventional electrolytic processes. EPT has also been used to alloy metals such as

⁴ The electrolytic plasma process, Patent number US 6585875 is covered by a patent. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

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