Corrosion Protection Benefits of Electroless Nickel Plating

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Raw metals other than precious metals can easily oxidize and corrode over time when exposed to various environmental conditions and corrosive applications. The proper design of any component must begin with a surface engineering evaluation to ensure that the product will function reliably over the intended service life. Even in relatively mild service applications, corrosion can result in functional issues and shortfalls. Electroless nickel plating can provide a robust solution to corrosive attack across a range of corrosive mechanisms including galvanic corrosion, chemical attack and erosion. Electroless nickel plating (EN) can be applied to a wide range of basis metals including steel, copper, brass and aluminum alloys. Electroless Nickel plating is currently utilized to promote corrosion performance across a diverse range of industries including heavy equipment, oil & gas, power transmission & distribution, automotive, marine and railway to name a few.

Electroless Nickel Plating Characteristics

EN is different from electrolytic nickel plating in that is does not require an external source of electrons for deposition. This auto-catalytic process does not need to pass electric current through parts to form the plated deposit which gives the EN deposit greatly improved uniformity over that of electrolytic deposits. The improved uniformity of electroless nickel plating is a principle deposit property that enhances corrosion resistance on all features of a part especially in features that are traditionally difficult to coat such as thru holes or counter bores. Another unique characteristic of electroless nickel plating is that the nickel co-deposits phosphorus of varying amounts from 4-13% based on the bath type. The level of phosphorus directly impacts key deposit properties such as hardness, corrosion resistance and ductility. In addition, post-plate heat treatment can be used to alter the structure of the electroless nickel plating thereby increasing hardness to as high as 70 Rc.

Advanced Electroless Nickel Plating Options

Advanced Plating Technologies has developed processes to further enhance the corrosion performance of electroless nickel plating by utilizing a multi-layer or duplex systems consisting of an underplate of copper and/or electrolytic nickel prior to the electroless nickel deposit. APT also offers

proprietary sealing technologies such as our H4 and H5 molecular sealers that can increase the salt spray performance of electroless nickel plating by as much as 2x.

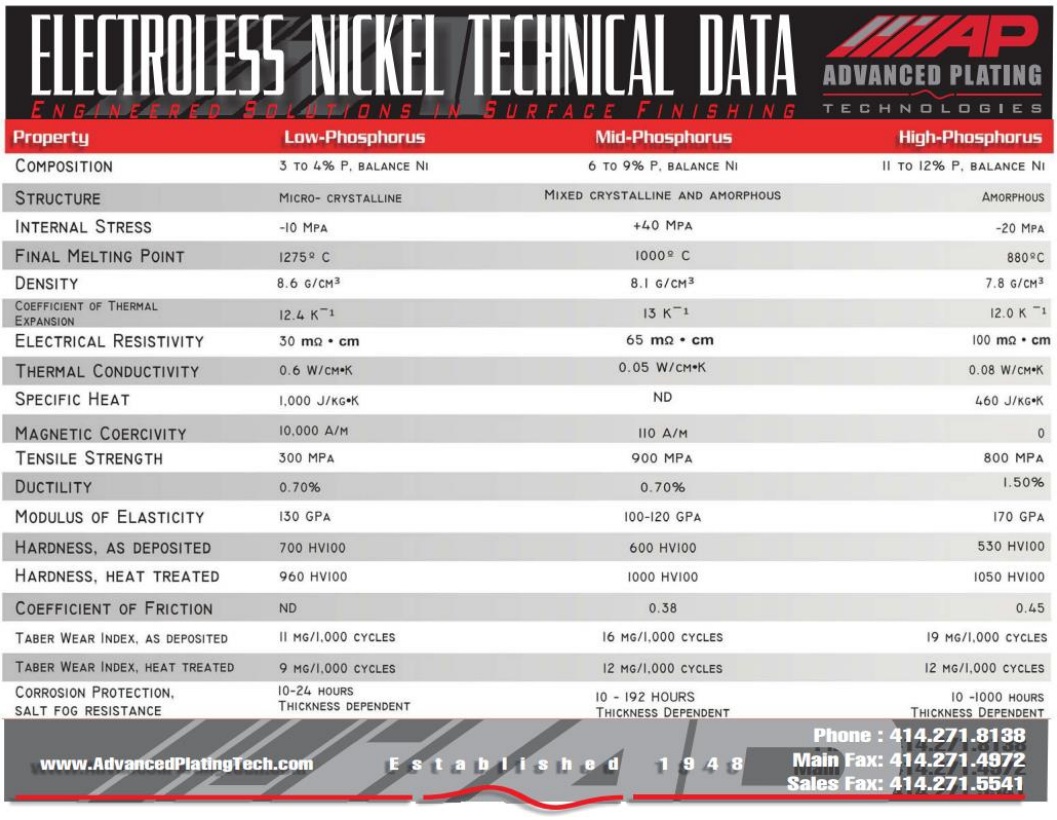
Types of Electroless Nickel Plating

Traditional electroless nickel phosphorus plating is broken down into three specific groups, 1) low phosphorus (<5% P), medium phosphorus (6-10% P) and high phosphorus (11-13% P). Depending upon design considerations and the corrosion performance required, the phosphorus level and deposit thickness can be adjusted accordingly. Advanced Plating Technologies offers both medium phosphorus electroless nickel plating and high phosphorus electroless nickel plating. A breakdown of each EN type is provided below:

- *High Phosphorus (11-13% P)*: High phosphorus electroless nickel plating (high-phos) provides the greatest corrosion resistance, is non-magnetic, has the lowest melting point (~ 880C) and is the most ductile of the EN deposits. As-plated the deposit has an amorphous structure with a hardness between 48-55 Rc that can be increased to 66-70 Rc with post-plate heat treatment. Due to the amorphous structure, high phosphorus electroless nickel has the lowest as-plated internal stress making it the best electroless nickel for heavy build deposits capable of being plated to thicknesses of up to 0.005 inches per side. The deposit tends to have a semi-bright appearance that will vary based upon the raw surface finish of the plated part. High phosphorus electroless nickel has a slower plating rate as compared to medium phosphorus electroless nickel which can increase cost.
- *Medium Phosphorus (6-10% P)*: Medium phosphorus electroless nickel (mid-phos) is often referred to as the "work horse" electroless nickel. It provides good corrosion resistance, solderability and a higher melting point (~1000 C). Mid-phos electroless nickel plates in a mixed amorphous/micro crystalline state and has a hardness of 58-62 Rc as plated and can be increased to 66-70 Rc with post-plate heat treatment options. Medium phosphorus electroless nickel plating has a semi-bright to bright appearance that will vary based on the raw surface finish of the part. A common advantage to using mid-phosphorus EN plating is the faster plating rate which can reduce cost over high-phos EN.

- *Low Phosphorus (5% or less P)*: A low-phosphorus electroless nickel plating (low-phos) provides the highest as-plated hardness (up to 60 Rc) and is the least ductile due to the micro-crystalline as-plated structure. Low-phos is also the least corrosion resistant of the three electroless nickel types but is the most conductive and solderable in the as-plated state. Fewer metal finishing job shops offer low phosphorus electroless nickel plating since there is typically a much higher commercial demand for medium or high phosphorus varieties.

APT has compiled a summary Technical Data Sheet to provide a simple one-sheet reference on the various properties of electroless nickel plating. Select on the image below to view, print or save this reference.



ELECTROLESS NICKEL TECHNICAL DATA

ENGINEERED SOLUTIONS IN SURFACE FINISHING

ADVANCED PLATING TECHNOLOGIES

Property	Low-Phosphorus	Mid-Phosphorus	High-Phosphorus
Composition	3 to 4% P, balance Ni	6 to 9% P, balance Ni	11 to 12% P, balance Ni
Structure	Micro- crystalline	Mixed crystalline and amorphous	Amorphous
Internal Stress	-10 MPa	+40 MPa	-20 MPa
Final Melting Point	1275° C	1000° C	880°C
Density	8.6 g/cm^3	8.1 g/cm^3	7.8 g/cm^3
Coefficient of Thermal Expansion	12.4 K^{-1}	13 K^{-1}	12.0 K^{-1}
Electrical Resistivity	30 mΩ • cm	65 mΩ • cm	100 mΩ • cm
Thermal Conductivity	0.6 W/cm•K	0.05 W/cm•K	0.08 W/cm•K
Specific Heat	1,000 J/kg•K	ND	460 J/kg•K
Magnetic Coercivity	10,000 A/m	110 A/m	0
Tensile Strength	300 MPa	900 MPa	800 MPa
Ductility	0.70%	0.70%	1.50%
Modulus of Elasticity	130 GPa	100-120 GPa	170 GPa
Hardness, as deposited	700 HV100	600 HV100	530 HV100
Hardness, heat treated	960 HV100	1000 HV100	1050 HV100
Coefficient of Friction	ND	0.38	0.45
Taber Wear Index, as deposited	11 mg/1,000 cycles	16 mg/1,000 cycles	19 mg/1,000 cycles
Taber Wear Index, heat treated	9 mg/1,000 cycles	12 mg/1,000 cycles	12 mg/1,000 cycles
Corrosion Protection, salt fog resistance	10-24 hours Thickness dependent	10 - 192 hours Thickness Dependent	10 -1000 hours Thickness Dependent

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Heat Treatment of Electroless Nickel Plating

A common question asked regarding electroless nickel plating is how heat treatment will affect the deposit properties. A brief summary of heat treatments are provided below:

Preplate Bakes: Some specifications recommend preplate bakes and/or shot peening of higher stress ferrous alloys to promote adhesion and reduce the risk of hydrogen embrittlement. Preplate bakes do not immediately affect the properties of subsequent electroless nickel plating.

Low Temperature Postplate Bakes (< 500F): These bakes are often used to promote adhesion especially on aluminum alloys and relieve hydrogen embrittlement in ferrous alloys. No appreciable change in deposit properties occur with these lower temperature bakes.

High Temperature Postplate Bakes (500F-750F): These bakes are often used to transition amorphous structure to crystalline structure in both medium and high phosphorus electroless nickel plating. Due to the structure change of the deposit both the hardness increases and corrosion resistance decreases

Advanced Plating Technologies offers controlled heat treatment of electroless nickel plating that reduces or can even fully eliminate cosmetic changes in the appearance of EN deposits (such as

darkening) during baking. In addition, APT offers a family of proprietary sealers that can enhance the corrosion performance of high-temperature baked electroless nickel deposits to offset and reductions in overall corrosion performance.

Summary of Electroless Nickel Plating

Electroless nickel plating is engineered finish that can be used to increase the corrosion resistance of various basis metals including cuprous, ferrous and aluminum alloys. The lack of applied current when plating auto-catalytic electroless nickel results in excellent deposit uniformity on even most complex shapes. In addition to enhancing corrosion performance, electroless nickel plating can be used to improve hardness, wear resistance, lubricity, solderability and appearance of components. The phosphorus content of the deposit affects the characteristics of the final finish. Post-plate heat treatments can be used to promote both the adhesion and hardness of electroless nickel plating.

You can find more information on our electroless nickel plating services page as well as contact a member of our technical sales staff to discuss your specific application further. Quote requests for electroless nickel plating of any other finish Advanced Plating Technologies offers can be submitted directly through our RFQ page.