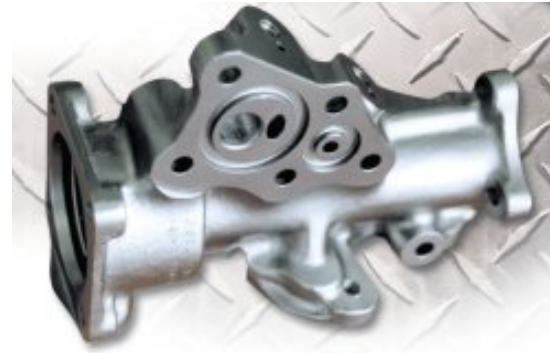


Electroless Nickel Features, Benefits, and Applications

Major Advantage of Electroless Deposition

- Electroless solutions produce coatings with a very high degree of uniformity
 - Ideal for complex shapes
 - Only if the plating solution can contact area being plated
- Electroless plating is ideal for the salvage of mis-machined parts & recycling worn components

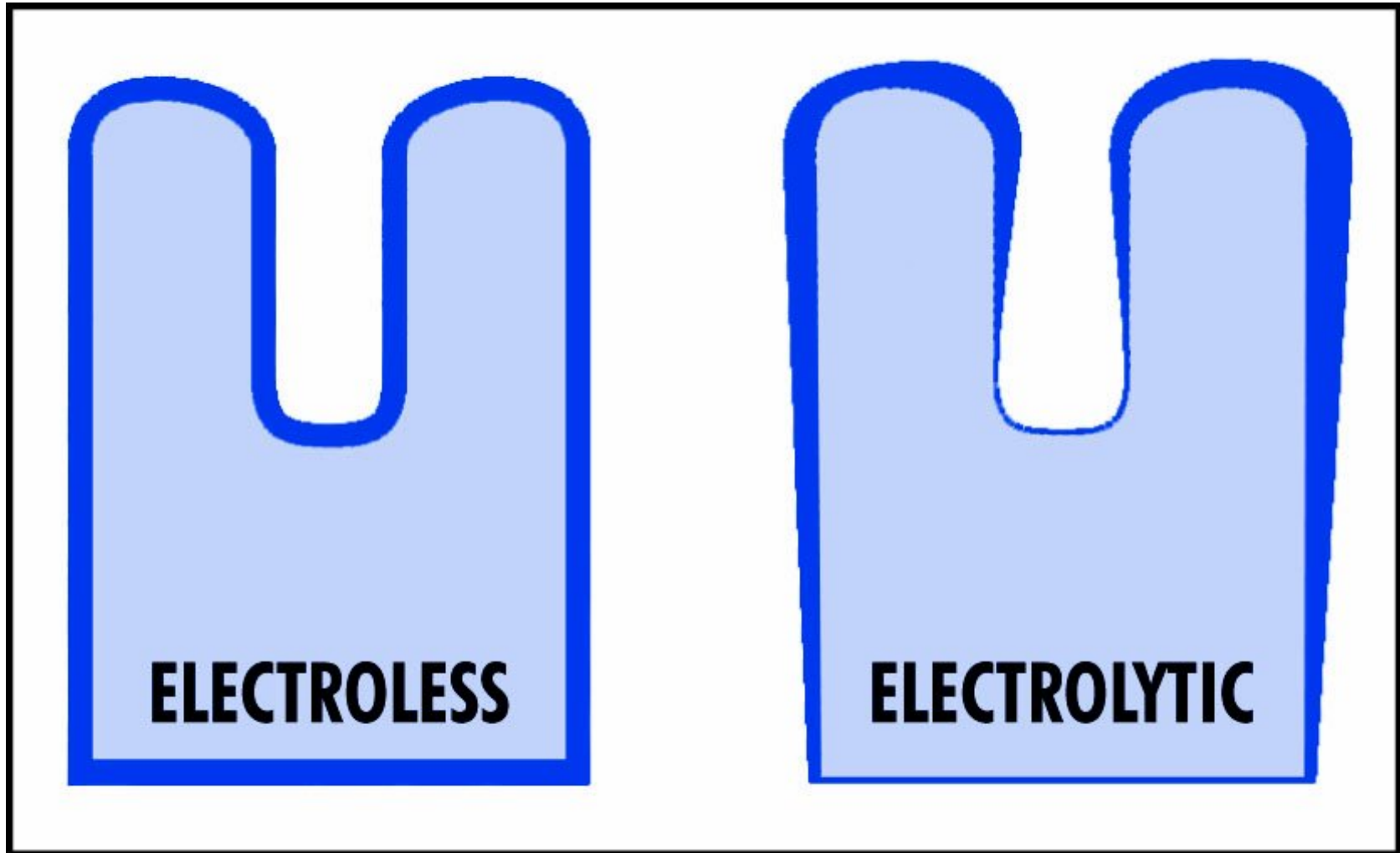


Electroless Nickel (EN) Plating

- ***Chemically applied*** nickel-alloy deposits using an autocatalytic immersion process without the use of electrical current.
- Electroless Nickel plating differs from Electroplating, which depends on an external source of direct (electrical) current to produce a deposit on the substrate material.
- Electroless Nickel is an entire “family” of coatings with very different properties for unique applications.

Electroless Nickel (EN) Plating

- Because electrical current cannot be distributed evenly throughout the component, uniform deposits are difficult to obtain with electrolytically-applied coatings.
- EN is the preferred choice among **functional** coatings for irregularly shaped, highly detailed part geometries because of its completely uniform deposit thickness and close dimensional tolerance capabilities.



The Electroless Nickel Family

Nickel - Phosphorus

- High-Phos 10-13 weight %
- Medium-Phos 6 - 9 weight %
- Medium-Low Phos 4 - 6 weight %
- Low Phos 1 - 3 weight

Composite Coatings

- Nickel - Phos - Teflon
- Nickel - Phos - Silicon Carbide
- Nickel - Phos - Others
- Nickel - Boron

Why use Electroless Nickel?

IT CAN...

- Reduce corrosion
- Reduce wear
- Be hardened
- Change magnetic tendency of a substrate
- Reduce galling and frictional resistance
- Be soldered

Electroless Nickel Deposits

- Are dense, nonporous, and crack free amorphous “metal-glass” alloys of nickel and phosphorus, which have the general appearance of stainless steel.
- Can be plated to most metals, including steel, stainless steel, iron, aluminum, titanium, magnesium, copper, brass, bronze, and nickel.
- Can also be plated to non-metals including plastics, ceramics, etc.
- Provide superior protection against corrosion, friction, wear, and contamination under severe conditions and in the most extreme environments.

- Complete uniform coverage to holes, deep recesses, inside diameters, and components with complex geometries
 - Many post-plate machining and finishing operations can be eliminated, resulting in significant cost savings and increased profitability.
- Critical tolerances can be maintained
 - Electroless Nickel can be controlled to $\pm .0001$ " per side on all surfaces regardless of the part geometry, provided fresh solution can reach the surface throughout the plating process. (Deep blind holes are an example of exceptions.)

Hardness and Wear Resistance

- As deposited, Nickel Phosphorous hardness measures 47-63 HRC, depending upon the phosphorus content of the deposit
- Medium Phos as plated is approx 52HRC,
- High Phosphorous is approx 47HRC
- Post-plating heat treatment can increase hardness to over 72 HRC
- Exceptional wear and abrasion resistance properties allows it to replace more expensive alloy materials and hard chromium

- Deposit adhesion ranges from 40 to 60 kpsi, which reduces chipping, flaking, and peeling under extreme conditions.
- Electroless Nickel deposits meet or exceed the stringent adhesion testing requirements outlined in ASTM B 571

Lubricity and Release Qualities

- Phosphorus in the Electroless Nickel alloy provides a natural lubricity which helps to minimize heat buildup and reduces scoring and galling.
- The coefficient of friction for EN vs. steel is about 0.13 under lubricated conditions and 0.4 under non-lubricated conditions, which is approximately 20% lower than chromium, one-half that of plain steel, and lower than aluminum or stainless steel.
- Electroless Nickel provides lubricity and functional release properties, making it an ideal plating for dies, gears, and molds. It can also be used as a cost-effective measure to repair and salvage molds.

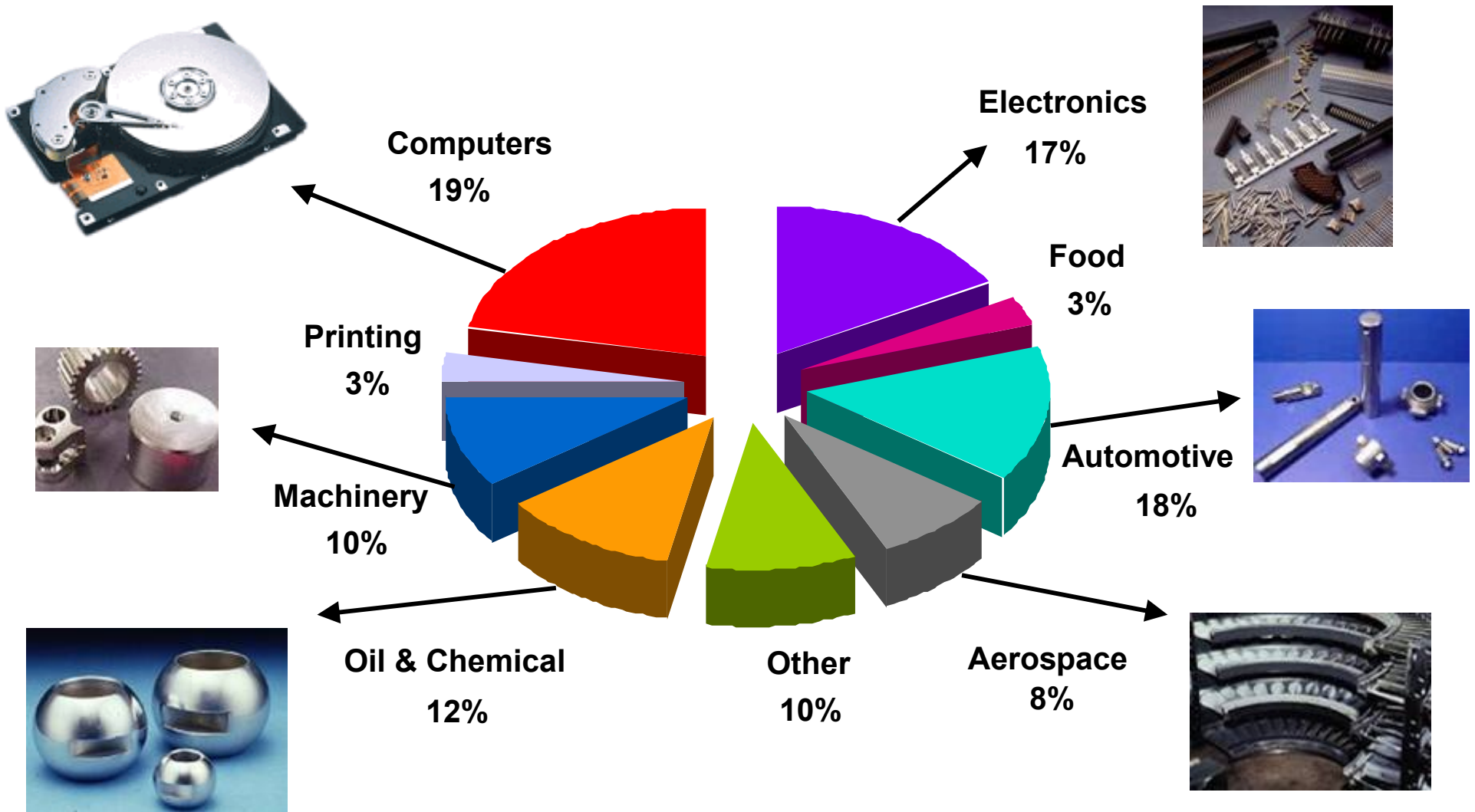
Composite Coatings

- Electroless Nickel/Teflon Co-deposition deposits a durable, dry lubricating coating that combines the low coefficient of friction of PTFE (Teflon[®]) in a strong, hard matrix of EN.
- Cost-effective alternative to expensive specialty alloys in applications that involve high speed/low load or slow speed/moderate load under dry lubrication.
- Unlike “topically-applied” PTFE coatings, distribution of PTFE particles is uniform throughout the entire thickness of the Electroless Nickel deposit. The surface is continually renewed throughout it’s service life to provide continued lubricity.



Electroless Nickel Applications

Primary Electroless Nickel Industry Applications

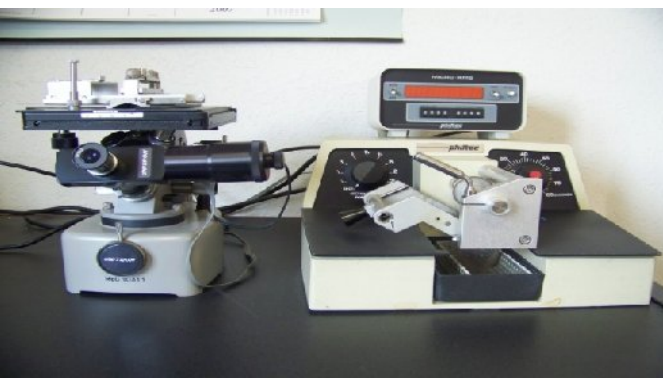




Electroless Nickel in Electronics

Application	Base Metal	Coating um	Thickness mils	Reason for use
Heat Sinks	Aluminum	10	0.4	Corrosion Resistance and solderability
Computer drive mechanisms	Aluminum	18	0.7	Corrosion and Wear Resistance
Memory Disks and Drums	Aluminum	25	1.0	Corrosion and Wear resistance and uniformity
Terminals and lead wires	Alloy Steel	2	0.1	Solderability
Chassis	Aluminum / Steel	12	0.5	Corrosion Resistance and solderability

Electroless Nickel in Electronics



Application	Base Metal	Coating um	Thickness mils	Reason for use
Connectors	Steel / Aluminum	25	1.0	Corrosion and Wear Resistance and solderability
Diode and transistor cans	Steel	5	0.2	Corrosion Resistance and Solderability
Interlocks	Steel / Brass	12	0.5	Corrosion and Wear Resistance
Junction Fittings	Aluminum / Plastic	10	0.4	Corrosion and Wear Resistance, Solderability, and Conductivity
Printed Circuit Boards	Plastic / Resin	5	0.2	Solderability and weldability



Electroless Nickel on a Car

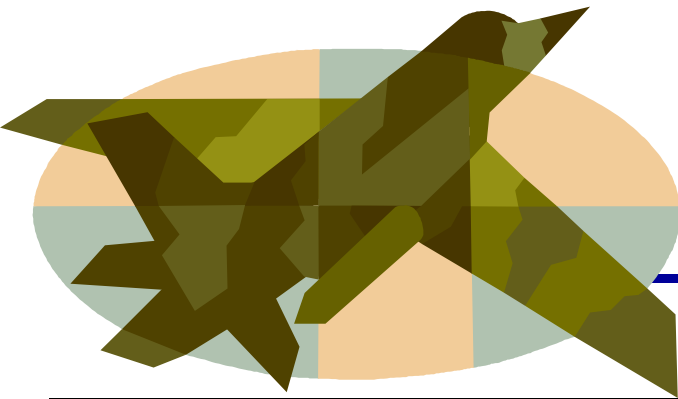
Application	Base Metal	Coating um	Thickness mils	Reason for use
Heat Sinks	Aluminum	10	0.4	Corrosion Resistance, solderability, uniformity
Carburetor Components	Steel	15	0.6	Corrosion Resistance
Fuel Injectors	Steel	25	1.0	Corrosion and Wear Resistance
Ball Studs	Steel	25	1.0	Wear Resistance
Differential pinion shafts	Steel	10	0.4	Wear Resistance
Disc Brake Pistons and Pad Holders	Steel	25	1.0	Wear Resistance



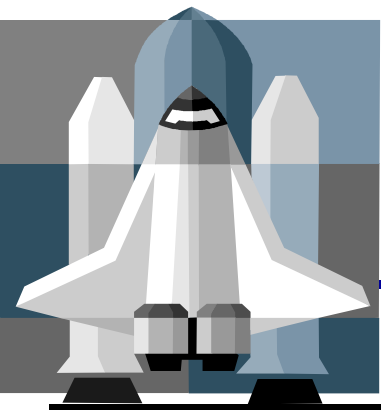
Electroless Nickel on a Car

Application	Base Metal	Coating um	Thickness mils	Reason for use
Transmission thrust washers	Steel	25	1.0	Wear Resistance
Synchromesh Gears	Brass	30	1.2	Wear Resistance
Knuckle Pins	Steel	38	1.5	Wear Resistance
Slip Yokes	Steel	15	0.6	Wear and Corrosion Resistance
Gears and assemblies	Carburized Steel	25	1.0	Wear Resistance and surface build-up
Hose Couplings	Steel	5	0.2	Corrosion and Wear Resistance

Electroless Nickel in Aerospace



Application	Base Metal	Coating um	Thickness mils	Reason for use
Bearing Journals	Aluminum	38	1.5	Wear Resistance and uniformity
Servo Valves	Steel	18	0.7	Corrosion resistance, uniformity and lubricity
Compressor blades	Alloy Steel	25	1.0	Wear Resistance and uniformity
Hot Zone Hardware	Alloy Steel	25	1.0	Wear and Corrosion Resistance
Piston Heads	Aluminum	25	1.0	Wear Resistance
Engine Shafts and propellers	Steel	>38	>1.5	Wear Resistance and Build-up



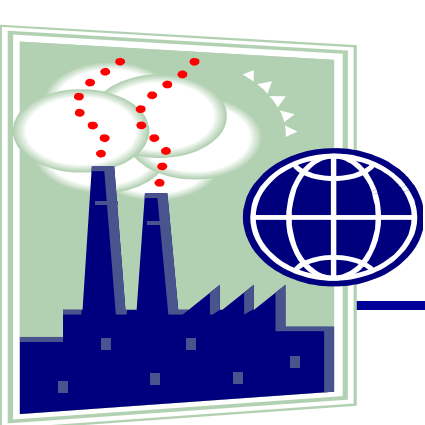
Electroless Nickel in Aerospace

Application	Base Metal	Coating um	Thickness mils	Reason for use
Seals and Snaps	Steel	20	0.8	Corrosion and Wear Resistance
Landing Gears	Aluminum	>125	>5.0	Build-up of mis-machined surfaces
Connectors	Aluminum	20	0.8	Corrosion and Wear Resistance
Pilot Tubes	Brass/ Stainless Steel	12	0.5	Corrosion and Wear Resistance
Engine Mounts	4140 Steel	25	1.0	Corrosion and Wear Resistance
Gyro Parts	Steel	12	0.5	Wear Resistance and Lubricity



Electroless Nickel in the Chemical/ Petroleum Industries

Application	Base Metal	Coating um	Thickness mils	Reason for use
Pressure Valves	Steel	50	2.0	Corrosion Resistance
Reactors	Steel	100	4.0	Corrosion Resistance and product purity
Mixer Shafts	Steel	38	1.5	Corrosion Resistance
Pumps and Impellers	Cast Iron / Steel	75	3.0	Corrosion and erosion Resistance
Compressor Blades	Steel / Aluminum	125	5.0	Corrosion and erosion Resistance
Spray Nozzles	Brass / Steel	12	0.5	Corrosion and Wear Resistance



Electroless Nickel in the Chemical/ Petroleum Industry

Application	Base Metal	Coating um	Thickness mils	Reason for use
Ball, gate and plug valves	Steel	75	3.0	Corrosion Resistance and lubricity
Chokes and control valves	Steel / Stainless	75	3.0	Resists wear, corrosion and stress corrosion cracking
Oil Field Tools	Steel	75	3.0	Corrosion and Wear Resistance
Oil Well Tubing and Pumps	Steel	50	2.0	Corrosion and Wear Resistance
Drilling Mud Pumps	Alloy Steel	75	3.0	Corrosion Resistance, prevents stress corrosion cracking
Blowout Preventors	Alloy Steel	75	3.0	Corrosion and Wear Resistance

Electroless Nickel in the Medical / Pharmaceutical Fields



Application	Base Metal	Coating um	Thickness mils	Reason for use
Disposable surgical Equipment	Steel / Aluminum	12	0.5	Corrosion Resistance and ease of operation
Sizing Screens	Steel	20	0.8	Corrosion Resistance and cleanliness
Pill Sorters	Steel	20	0.8	Corrosion Resistance and cleanliness
Feed Screws and extruders	Steel	25	1.0	Corrosion and Wear Resistance and cleanliness



Electroless Nickel for Molds and Dies

Application	Base Metal	Coating um	Thickness mils	Reason for use
Zinc Die Cast Dies	Alloy Steel	25	1.0	Wear Resistance and Part Release
Glass Molds	Steel	50	2.0	Wear Resistance and Part Release
Plastic Injection Molds	Alloy Steel	15	0.6	Corrosion and Wear Resistance and Part Release
Plastic Extrusion Dies	Alloy Steel	25	1.0	Corrosion and Wear Resistance and Part Release



Electroless Nickel in the Military

Application	Base Metal	Coating um	Thickness mils	Reason for use
Fuse Assemblies	Steel	12	0.5	Corrosion Resistance
Mortar Detonators	Steel	10	0.4	Corrosion Resistance
Tank turret bearings	Alloy Steel	30	1.2	Corrosion and Wear Resistance
Radar Wave Guides	Aluminum	25	1.0	Corrosion Resistance and uniformity
Mirrors	Aluminum / Beryllium	>75	>3.0	Uniformity and reflectivity
Commercial and Military Firearms	Steel	8	0.3	Corrosion and Wear Resistance and Lubricity

General Salvage and Repair

- **Repair mis-machined parts**
 - Cost effective compared to hard chrome
 - Often eliminates subsequent machining or grinding operations
- **Rework worn parts**
 - Molds, shafts, landing gear, gears

To Recap, Electroless Nickel is used for:

- Uniform Coverage
 - Hardness / Wear resistance
 - Corrosion Resistance
 - Excellent Adhesion
 - Lubricity / Release characteristics
 - Brazing / Solderability
 - RF Shielding
 - Electrical Conductivity
 - Co-deposition Technology
 - Salvage worn or mis-machined parts
-

Questions?



Thank You!