





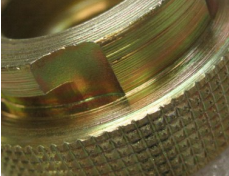






Coatings and platings applied to fasteners can (a) protect against corrosion, (b) improve appearance / aesthetics (c) reduce friction (d) reduce scatter in achieved clamp load for a given installation torque. The appropriate finish is contingent upon factors such as the base material, application, cost and environmental factors.

## ELECTROPLATE / ELECTRODEPOSIT COATING Zinc (Sacrificial)

Zinc due to its galvanic potential will sacrificially corrode to protect base steel. Electroplating is the most common method of applying a zinc coating to a steel fastener. Electroplating is relatively low cost of offers a good corrosion resistance to environments with excessive moisture. The service life of zinc coating is a function of its thickness, environmental exposure, conversion treatments and post-plate sealers.

Finish	Description	(Preferred) Standard	Code	Thk	Coating	Conversion	White Rust / Red Rust (hr)	HE Risk?	RoHS?	Approx Cost*	Notes
 <p><b>Zinc and Clear</b></p> <p>A clear or blueish chromate finish is applied on top of the zinc to protect the zinc from premature white rust (oxidization).</p> <p>Typical call out : <i>Electrodeposited Zinc alloy Coating, Yellow Fe/Zn 5A per ASTM F1941M-2016</i></p>	<p><a href="#">ASTM F1941</a></p>	Fe/Zn 3A	3µm	Zinc	Clear Hexavalent (Cr6)	6 / 12	Yes	No	\$\$	TCP (Trivalent commercial plating (72 / 96)	
		Fe/Zn 5A	5µm			8 / 24					
		Fe/Zn 8A	8µm			8 / 48					
		Fe/Zn 3AN	3µm			6 / 12					
		Fe/Zn 5AN	5µm			8 / 24					
		Fe/Zn 8AN	8µm			8 / 48					
		Fe/Zn 5ANS	5µm			96 / 120					
		Fe/Zn 8ANS	8µm			96 / 192					
 <p><b>Zinc and Yellow</b></p> <p>Yellow hexavalent chromate finish offers a higher corrosion resistance than clear. With a Trivalent conversion coating the color is simply a dye and offers no additional corrosion protection.</p> <p>Typical call out : <i>Electrodeposited Zinc alloy Coating, Yellow Fe/Zn 5C per ASTM F1941M-2016</i></p>	<p><a href="#">ASTM F1941</a></p>	Fe/Zn 3C	3µm	Zinc	Yellow Hexavalent (Cr6)	24 / 24	Yes	No	\$\$	YIC, Yellow Irridiscant Chromate, Z&Y, Zinc and Yellow	
		Fe/Zn 5C	5µm			72 / 96					
		Fe/Zn 8C	8µm			72 / 120					
		Fe/Zn 3CN	3µm			6 / 12					
		Fe/Zn 5CN	5µm			8 / 24					
		Fe/Zn 8CN	8µm			8 / 48					
		Fe/Zn 5CNS	5µm			96 / 120					
		Fe/Zn 8CNS	8µm			96 / 192					
 <p><b>Black Zinc</b></p> <p>Black zinc has a slight irridescence with a relatively low corrosion resistance.</p> <p>Typical call out : <i>Electrodeposited Zinc alloy Coating, Yellow Fe/Zn 5E per ASTM F1941M-2016</i></p>	<p><a href="#">ASTM F1941</a></p>	Fe/Zn 3E	3µm	Zinc	Black Hexavalent (Cr6)	-	Yes	No	\$\$		
		Fe/Zn 5E	5µm			12 / -					
		Fe/Zn 8E	8µm			24 / 72					
		Fe/Zn 3EN	3µm			6 / 12					
		Fe/Zn 5EN	5µm			8 / 24					
		Fe/Zn 8EN	8µm			8 / 48					
		Fe/Zn 5ENS	5µm			96 / 120					
		Fe/Zn 8ENS	8µm			96 / 192					
 <p><b>Olive Green</b></p> <p>Olive green with a shading of brown or bronze (referred to as Opaque in ASTM F1941). Not preferred due to quality issues.</p>	<p><a href="#">ASTM F1941</a></p>	Fe/Zn 3D	3µm	Zinc	Opaque (Olive Green) Hexavalent (Cr6)	24 / 24	Yes	No	\$\$	Not recommended because of quality control limitations (See Black Zinc or Black Zinc Nickel instead)	
		Fe/Zn 5D	5µm			72 / 96					
		Fe/Zn 8D	8µm			96 / 144					
		Fe/Zn 3DN	3µm			6 / 12					
		Fe/Zn 5DN	5µm			8 / 24					
		Fe/Zn 8DN	8µm			8 / 48					
		Fe/Zn 5DNS	5µm			96 / 120					
		Fe/Zn 8DNS	8µm			96 / 192					



 <p><b>Zinc Nickel</b></p>	<p>The zinc Nickel alloy provides excellent corrosion resistance due to the Nickel content. The black passivation layer makes the finish looks aesthetic. The BZN is suitable for applications where the performance and appearance are required.</p> <p>Typical call out : <i>Electrodeposited Zinc-Nickel alloy Coating, Fe/Zn-Ni 8B per ASTM F1941M-2016</i></p>	<p><a href="#">ASTM F1941</a></p>	<table border="1"> <tr><td>Fe/Zn-Ni 5B</td><td>5µm</td></tr> <tr><td>Fe/Zn-Ni 8B</td><td>8µm</td></tr> <tr><td>Fe/Zn-Ni 12B</td><td>12µm</td></tr> <tr><td>Fe/Zn-Ni 5B5</td><td>5µm</td></tr> <tr><td>Fe/Zn-Ni 8B5</td><td>8µm</td></tr> <tr><td>Fe/Zn 12B5</td><td>12µm</td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </table>	Fe/Zn-Ni 5B	5µm	Fe/Zn-Ni 8B	8µm	Fe/Zn-Ni 12B	12µm	Fe/Zn-Ni 5B5	5µm	Fe/Zn-Ni 8B5	8µm	Fe/Zn 12B5	12µm					<p>Zinc-Nickel</p>	<table border="1"> <tr><td>Trivalent Clear Zinc Nickel</td><td>20 / 150</td></tr> <tr><td> </td><td>20 / 240</td></tr> <tr><td> </td><td>20 / 500</td></tr> <tr><td>+ w/ Sealant Top Coat</td><td>150 / 300</td></tr> <tr><td> </td><td>150 / 400</td></tr> <tr><td> </td><td>150 / 620</td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </table>	Trivalent Clear Zinc Nickel	20 / 150		20 / 240		20 / 500	+ w/ Sealant Top Coat	150 / 300		150 / 400		150 / 620					<p>Yes, (but less than zinc due to permeability of plating)</p>	<p>No</p>	<p>\$\$\$</p>	
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 <p><b>Zinc-Iron</b></p>	<p>Not common (refer to standard : Fe Zn-Fe)</p>	<p><a href="#">ASTM F1941</a></p>	<table border="1"> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </table>																	<p>Zinc-Iron</p>	<table border="1"> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </table>																			<p>\$\$\$\$</p>	

<p><b>Cadmium</b></p> 	<p>Not common (refer to standard : Fe/Cd).</p> <p>Cadmium plating has the same chromate conversion as zinc plating and offers high corrosion resistance especially in Marine and salt environments.</p> <p>Formerly very popular due to high corrosion resistance but is toxic and banned in all but military applications. Avoid if possible.</p>	<p><a href="#">ASTM F1941</a></p>		<p>No</p>	<p>\$\$\$\$</p>	
<p><b>Zinc and Green</b></p> 	<p>Common on ground / earth electrical screws</p>					
<p><b>Zinc-Tin</b></p> 	<p>Zinc-Tin with a 70% tin / 30% zinc mix offers a good protect compared to zinc plating and can be considered a good alternative to cadmium without toxic issues. RoHS complaint when used without hexavalent-chromate coating. Often used to facilitate soldering.</p>			<p>No</p>	<p>\$\$\$\$</p>	

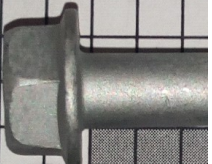
## HOT DIP GALVANIZED (or HDG)

<b>Hot Dip Galvanized</b>			
	Coating is achieved by immersion of a fastener into molten zinc. The coating is pure zinc. HDG finish can be thick and threads need to be undersized to accommodate thickness.	<a href="#">ASTM A153</a> <a href="#">/ ASTM A153M</a>	

## MECHANICAL PLATING (or Mechanically Deposited Plating or Mechanical Galvanizing)


<b>Mechanical Zinc (Clear)</b>												
	Used on carbon steel fasteners - typically washers which are susceptible to HE and may stick together in Geomet coating process.  Typical call out : <i>Mechanically deposited zinc coating with clear trivalent chromate conversion treatment per ISO 12683 - Zn 8 M(Fe) Type 2A</i>	<a href="#">ASTM B695</a>	Fe/Zn, Class 8, Type II	8µm	Zinc		72 min	No	Yes	\$\$		Used on carbon steel fasteners - typically washers which are susceptible to HE and may stick together in Geomet coating process.
<b>Mechanical Zinc (Yellow)</b>	Used on carbon steel fasteners - typically washers which are susceptible to HE and may stick together in Geomet coating process.  Typical call out : <i>Mechanically deposited zinc coating with yellow trivalent chromate conversion treatment per ISO 12683 - Zn 8 M(Fe) Type 2C</i>	<a href="#">ISO 12683</a>	Fe/Zn 8A, Type 2	8µm	Zinc	Clear Trivalent (Cr3)	48 / 96	No	Yes	\$\$		Used on carbon steel fasteners - typically washers which are susceptible to HE and may stick together in Geomet coating process.
			Fe/Zn 8C, Type 2	8µm		Yellow Trivalent (Cr3)	48 / 96					

## ZINC FLAKE COATING (Zinc / Aluminum Flakes)


<b>GEOMET 321 (Example)</b>												
	Used on carbon steel fasteners, the GEOMET 321 is patented coating. Best specified on high hardness material (ex. case hardened parts and PC 12.9) due to HE risk mitigation due to permeable surface. PLUS ML top coat provides lubricity on case hardened tapping screws to ease assembly and avoid cold welding.  Typical call out : <i>Geomet 321 + ML Clear Sealer per ASTM F1136M-11, Grade 5, NC</i>	<a href="#">ASTM F1136</a>	GEOMET 321, Grade 5	6 - 12 mil	Zinc - Aluminum	Non - Chrome (NC)	720 min	No	Yes	\$\$\$\$		GEOMET 321 is a product of NOF Metal Coatings Group. It is RoHS complaint alternative to Dacromet. See NOF standards : GEOMET 500, GEOMET 321, GEOMET 720, GEOBLACK (GEOMET + PLUS ML BLACK).  GEOMET 321 can have topcoats for specific torque / tensions control : PLUS XL (CoF 0.06 - 0.09) ; PLUS VL (CoF 0.09 - 0.14) ; PLUS ML (CoF 0.10 - 0.16) ; PLUS 10 (CoF > 0.20)
<b>GEOBLACK (Example)</b>	Typical call out : <i>Geomet 321 + ML Black Sealer per ASTM F1136M-11, Grade 5, NC</i>	<a href="#">ASTM F1136</a>	GEOMET 321 + ML Black Sealer, Grade 5	6 - 12 mil	Zinc - Aluminum	Non - Chrome (NC)	720 min	No	Yes	\$\$\$\$		

Other zinc flake coatings include Magni Coatings, Doerken, Atotech, Zinctec, Armor Coat - all proprietary but all conform per ASTM F1136


### DIP SPIN ORGANIC COATING

	<p>Used on Stainless steel fasteners, the RIE 4037A is a proprietary coating. It is a dip or spin chrome free coating with excellent, corrosion and UV resistance.</p> <p>Typical call out : <i>RIE 4037A BLACK PLUS 5250 CLEAR TOPCOAT</i></p>	<p><a href="#">N/A</a></p>	<p>RIE 4037A Black Topcoat Plus 5250 Clear Topcoat</p>	<p>Chrome Free</p>	<p>500 min</p>	<p>No</p>	<p>Yes</p>	<p>\$\$</p>	<p>CoF : 0.09 - 0.15</p>
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### BLACK OXIDE

	<p>Used on stainless steel fasteners. Salt Spray Test performance on stainless steel is reference only.</p> <p>Typical call out : <i>Black Oxide per MIL 13924D Class 4 Type Nova 34</i></p>	<p><a href="#">MIL-DTL-13924D</a></p>	<p>Class 4, Type NOVA 34</p>			<p>(100 min)</p>	<p>No</p>	<p>Yes</p>	
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### PASSIVATION ON STAINLESS STEEL

	<p>Process to remove free iron from the surface of stainless steel that are deposited during the manufacturing process to restore and enhance thin protective oxide film on surface.</p> <p>Salt Spray Test performance on stainless steel is reference only since stainless steel does not corrode predicatably like zinc or steel.</p> <p>Typical call out : <i>Passivation per ASTM A967-05 Nitric 1 OR Passivation per QQ-P-35C Type II</i></p>	<p><a href="#">ASTM A967</a></p>	<p>Nitric 1</p>				<p>No</p>	<p>Yes</p>	
		<p><a href="#">QQ-P-35C</a></p>	<p>Type II</p>						


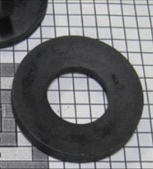
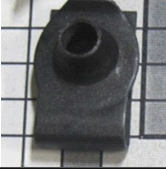

	<p>Electropolishing removes a uniform layer of surface material to create a uniform, burr free finish with reduced risk of galling and superior corrosion resistance.</p>								
	<p>Kolsterising of stainless steel is a post treatment to increase the surface hardness of stainless steel</p>								





<p><b>Wax Lube</b></p> 	<p>Wax over stainless steel provides lubricity and mitigates the risk of galling.</p>	
<p><b>Nickel Strike</b></p> 	<p>Also called Woods Nickel. The flash finish of zinc nickel over stainless steel can either provide lubricity to avoid galling or provide conductivity to allow the stainless steel to be electroplated.</p>	
<b>ALUMINUM</b>		
<p><b>Anodization (Clear)</b></p> 	<p>Electrolytic process to produce a wear and corrosion resistant aluminum oxide coating on aluminum. Available in different colors.</p>	
<p><b>Black Anodized</b></p> 	<p>...</p>	
<p><b>Alumina</b></p> 	<p>Alumina Coating applied by aerosol deposition is a cost-efficient high-performance ceramic coating for electrical insulation with very good adhesion, anti-wear purposes and encapsulation in high-temperature applications. Potential fields of application are Sensors, Batteries, Power-Electronics, Medical components, Vacuum technology</p>	







## CHROME







<b>Chrome</b>		
		
<b>Black Chrome</b>		
		

## PHOSPHATE

<b>Phosphate</b>		
		
<b>Black Phosphate and Dry</b>		
		
<b>Phos and Oil</b>		
		
<b>Black Zinc Phosphate</b>		
		

<p><b>Phosphare/Organic/Oil</b></p> 	<p>Black corrosion protective coating which is produced with a zinc phosphate treatment, chromic acid rinse or seal, organic coating, oven bake, wate and oil emulsion post treatment and air dry.</p>	<p><a href="#">GM6174M</a></p>	
<p><b>Phosphate/Electro-Organic</b></p> 	<p>Black corrosion protective coating which is produced by electrodepositionation of a black organic coating, oven bake, water/oil emulsion post treatment and air dry.</p>	<p><a href="#">GM6047M</a></p>	
<p><b>Flurocarbon Protective Coating</b></p> 	<p>Flurocarbon post treatment. Coating is applied to zinc phosphate, zinc</p>	<p><a href="#">GM6046M</a></p>	
<p><b>Phos and Metallic Paint</b></p> 	<p>...</p>		

<p><b>Clear Iridite</b></p> 	<p>Iridite is a chemical process that creates a protective film on aluminum and aluminum alloys. It's also known as Alodine. The coating can be clear or have color, with darker shades providing greater corrosion protection. Iridite can be applied by dipping, brushing, swabbing, or spraying.</p>	
<p><b>Brass Nickel</b></p> 	<p>...</p>	
<p><b>Brass Bright Dip</b></p> 	<p>A bright dip for brass and copper alloys is an acid-based chromate conversion coating used to protect and add shelf life to the base material.</p>	
<p><b>Electrocoat Black</b></p> 	<p>Electrocoat utilizes electrical current to deposit the coating material onto the fastener. After application, the coating is oven cured. Electrocoat is intended for dry service, low-corrosion applications and is suitable for use with FRT in medium-corrosion, dry-service applications. Protective and aesthetic finish.</p>	
<p><b>Electroless nickel PTFE (Niflor)</b></p> 	<p>Electroless Nickel Plating (ENP) is the deposit of a nickel-alloy coating by chemical reduction - without the electric current that's used in electroplating processes.</p>	
<p><b>Gold</b></p> 	<p>...</p>	

<p><b>NiCoTef Coating</b></p> 	<p>Extremely low coefficient of friction. Submicron particles of teflon are dispersed in auto catalytically applied nickel/phosphorous matrix.</p>	
<p><b>Brass Tin</b></p> 	<p>...</p>	
<p><b>Nickel Brass</b></p> 	<p>...</p>	
<p><b>Fluorokote</b></p> 	<p>Proprietary non stick fluoropolymer coating that is formulated for high corrosion resistance and durability when used in severe environments.</p>	
<p><b>Xylan (PTFE)</b></p> 	<p>Xylan or PTFE (Polytetrafluoroethylene) coatings provide excellent corrosion resistance, head resistance and low co-efficient of friction. Available in different colors.</p>	
<p><b>Thermal Black Oxide</b></p> 	<p>An 'as produced' finish on carbon steel products having an oil residue which provides some shelf life but no real corrosion protection when in use.</p>	

## RoHS - Restriction of Hazardous Substances

### Commentary

RoHS, first instituted in the EU in 2006, restricts the use of Cadmium and Hexavalent chromium

## Neutral Salt Spray Performance

### Commentary

Salt spray testing is the most common form of testing coatings on fasteners. ASTM B117 defines an accelerated test to determine the protection afforded by both organic and inorganic coatings on the metal substrate of the fastener. Salt spray testing results offers a R&R (repeatable and reproducible) result that allows for easy comparison of different coatings in a controlled environment. However, the results from a B117 test are not directly predictable of performance in a real world environment or application.

## HYDROGEN EMBRITTLEMENT

### Commentary

Fasteners under stress may fail (time delayed after installation) well below their UTS without warning because of hydrogen embrittlement.

Hydrogen embrittlement may be the result of Internal Hydrogen Embrittlement which is typically the result of an acid cleaning in the plating process or Environmental Hydrogen Embrittlement which is the result of hydrogen absorption due to corrosion activity.

High tensile or hardened fasteners above PC 8.8 or SAE Grade 5 are susceptible to hydrogen embrittlement in the cleaning and coating process, particularly electroplating. They absorb hydrogen atoms which concentrate in areas of stress, causing minute cracks which can suddenly and violently fail in service. To avoid this potential, the hydrogen atoms can be diffused by baking the product immediately after plating, prior to chromating at a temperature of 190°C to 210°C for a period depending upon the grade and size of the product. For this reason, it is most inadvisable to plate PC 10 or SAE Grade 8 and higher products after purchase, unless the plater is also able to perform and guarantee the de-embrittlement process.

### Baking Recommendations

<b>Case Hardened Parts</b>	Should be baked for a minimum of 4 hours, within 2 hours of zinc electroplating. Baking mitigates the risk of IHE but does not guarantee its elimination.
<b>Thru Hardened Parts</b>	High hardness steels (>39HRC and <44HRC) should be baked for a minimum of 14 hours. 24 hours if >24 hours.