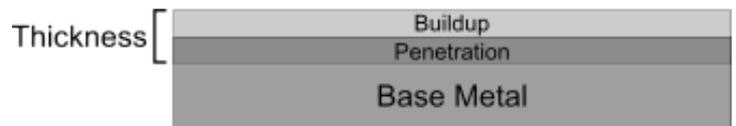


Metal Plating Guide

There are many options when it comes to finishing machined parts. Those options depend on the application of the component and the required material. Marvel Manufacturing has approved suppliers that can accommodate most finish and plating requirements. Below is a list of definitions of common finishing processes and terms that are used to describe them.

Terms

- **Buildup** – The amount plating that is deposited above the original surface of the material.
- **Penetration** – The amount plating that is deposited below the original surface of the material.
- **Thickness** – This is the total thickness of the plating (penetration + buildup).
- **Blind holes** – Holes that do not go completely through the part.
- **Distribution** – This refers to how uniform the thickness of the plating is over the surface of the part.
- **Electroplating** – Uses an electrical current to attract and bind the coating to the part surface. Only conductive materials can be electroplated.
- **Electroless Plating** – Coating is chemically bonded to the surface of the part. No electrical current is used; therefore, the material does not need to be conductive.
- **Racking** – This is the method that parts are held or fixtured during the plating process. Electroplating requires a contact point for the electrical current to flow through the part. This can sometimes leave a small “arc” point. It is suggested to specify on drawings where a suitable place to rack is, usually on a non-critical and non-visible position on the part.



***Plugging** – Used to plugged holes that should not be plated. Usually these are rubber cylinders placed in smaller holes but custom plugs can be made for specific applications. These are often used to prevent plating in threaded holes and small holes with tight tolerances.

***Masking** – Covers surfaces that should not be plated. Lacquer masking that is painted on or tape-like films are used to cover large or odd shaped surfaces.

***Note-** Plugging and masking are typically a manual process. This adds to the cost of plating depending on the number of holes or surface area that requires masking.

****The following information is for reference only.** See the latest version of the applicable plating standard to verify the most current specifications. Marvel Manufacturing consults with our plating vendors to ensure customer requirements are adhered to.

Process	Mil. Spec. Type Class	Thickness	Comments
Chromic Anodize	MIL-A-8625		
<p>Color will vary from light gray to dark gray depending on alloy. Not as readily dyed as sulfuric anodize.</p> <p>Because of thinness will scratch easily. Can be used for inspection of aluminum forgings or castings by noting evidence of chromic acid bleed out from taps, cracks, seams, etc.</p>	Type 1A	.00002" – .0003"	Conventional chromic coating produced from chromic acid bath.
	Type 1B	00002" – .0003"	Low voltage chromic acid anodizing 20V
	Class 1	Non-dyed. Natural color, including dichromate sealing.	
	Class 2	Dyed to specified color	
Sulfuric Anodize	MIL-A-8625		
<p>Color will vary with alloy. Aluminum with low alloying elements will show practically no color change. Can be dyed practically any color or shade. Sealing is required and gives good corrosion resistance.</p>	Type II	.00007" – .0010"	<p>Conventional coatings for all aluminum alloys, but do not use where solutions will entrap. Intended to improve surface corrosion protection under severe service conditions or as a base for paint systems.</p>
	Class 1	Non-dyed	
	Class 2	Dyed to specified color	
Hard Anodize	MIL-A-8625		
<p>Color will vary from light tan to black depending on alloy and thickness. Can be dyed in darker colors depending on thickness. Coating PENETRATES base metal as mush as builds up on the surface. The term THICKNESS includes both buildup and the penetration. Provides very</p>	Type III	Unless otherwise specified 0.002"	<p>Most aluminum alloys depending on process used. Where maximum serviceability or special properties are required, consult metal finisher for best alloy choice. Thick coatings (over .004") will tend to break down sharp edges. Typical applications, hydraulic cylinders, wear surfaces, actuating cams, etc. Can be used instead of conventional anodize for corrosion resistance and may be more</p>

hard ceramic type coating. Abrasion resistance will vary with alloy and thickness of coating. Good dielectric properties. Corrosion resistance is good, but recommend seal hard anodize in 5% dichromate solution where increased corrosion resistance is required. Where extreme abrasion resistance is required do not seal as some softening is encountered.			economical in conjunction with other hard anodized areas.
	Class 1	Non-dyed	
	Class 2	Dyed	
Black Chrome	MIL-C-14538		
The Black Chrome surface may be waxed or oiled to darken the surface.		As specified on drawing	Color is a dull gray, approaching black.
Black Oxide Coating	MIL-C13924		
A uniform black coating for ferrous metals. Mostly a decorative coating. Only very limited corrosion protection under mild corrosion conditions. Black oxide coatings should normally be given a supplemental treatment (i.e. oil displacement per MIL-C-16173 Grade 3 or protection treatments of MIL-C-16173).	Class 1	No dimensional range	For moving parts which cannot tolerate the dimensional change of a more corrosion resistant finish. For decorative applications and can be used to decrease light reflection.
	Class 2		Alkaline oxidizing. For wrought iron, cast and malleable irons, plain carbon and low alloy steels.
	Class 3		Fused salt oxidizing. For corrosion resistant steel alloys which are tempered at 900°F (482°C) or higher.
	Class 4		Alkaline oxidizing. For 300 series corrosion resistant steel alloys only.
Cadmium	QQ-P-416		
Bright silvery white. Supplementary treatment for Type II can be golden,	Type I		No Supplementary treatment (as plated)
	Type II		Supplementary chromate treatment. Type II is best for corrosion resistance.
			Supplementary phosphate treatment. Type

iridescent, amber, black, olive drab. Corrosion resistance is very good, especially with Type II finish.	Type III		III is used as a paint base. Excellent for plating stainless steels that are to be used in conjunction with aluminum to prevent galvanic corrosion.
	Class 1	.0005" min	
	Class 2	.0003" min	
	Class 3	.0002" min	
Chemical Films	MIL-DTL-5541		
Materials qualified produce coatings that range in color from clear to iridescent yellow or brown. Inspection difficulties may arise with clear coatings because visual inspection does not reveal the presence of a coating.	Class 1A		Class 1A is used as a corrosion preventative film or to improve adhesion of paint finish systems on aluminum and aluminum alloys.
	Class 3		Class 3 is used as a corrosion preventative film for electrical and electronic applications, where low-resistance contacts are required.
Chemical Finish: Black	MIL-C-495		
A uniform black corrosion retardant for copper. Coating has no abrasion resistance.			
Chrome	QQ-C-320		
Excellent hardness (Rc 68-74), wear resistant and erosion resistance. Has low coefficient of friction, and is resistant to heat. In addition to above properties, can be rendered porous for lubrication purposes	Type I		Bright.
	Type II		Satin.
	Class 1	.00001" min on all visible surfaces	Corrosion protection plating
	Class 2	Unless otherwise specified .002" min	Engineering plating
Copper	MIL-C-14550		
		Unless	

Copper in color and matte to a very shiny finish. Good corrosion resistance when used as undercoat. A number of copper processes are available, each designed for a specific purpose. Brightness (to eliminate the need for buffing); High speed (for electroforming); fine grain (to prevent case hardening); etc.		otherwise specified	For heat treatment stop-off
	Class 0	.001 - .005" min	Supplementary chromate treatment
	Class 1	.001" min	For carburizing and decarburizing shield, also plated through printed circuit boards.
	Class 2	.0005" min	As an undercoat for nickel and other plating's.
	Class 3	.0002" min	To prevent basis metal migration into tin (prevents poisoning solderability).
	Class 4	.0001" min	
Electroless Nickel	MIL-C-26074		
Similar to stainless steel in color. Plates uniformly in recesses and cavities (does not build upon edges) Corrosion resistance is good for coating over .001" thickness. Electroless nickel is used extensively in salvage of mis-machines parts. Also, for inside dimensions and irregular shapes (where assembly tolerances need uniformity provided by 'electroless" process).	Class A	.001" min	Unless otherwise specified, minimum thickness on aluminum alloys.
	Class B	.0005" min	Unless otherwise specified, minimum thickness on copper, nickel, cobalt, titanium, or beryllium alloys.
	Class C	.0015"	Unless otherwise specified, minimum thickness on iron based alloys.
	Class 1		As plated, no subsequent heat treatment
	Class 2		Steel and other base metals heat treatable to improve hardness
	Class 3		Aluminum and other base metals not heat treatable
	Class 4		Aluminum alloy , heat treatable, processed to improve adhesion of the nickel deposit
Gold	MIL-G-45204		
		Unless otherwise specified	
	Type I		99.7% gold min (Grade A, B, or C)
	Type II		99.0% gold min (Grade B, C, or D)

<p>Yellow to orange color depending on proprietary process used. Will range from matte to bright finish depending on basis metal. Good corrosion resistance, and has high tarnish resistance. Provides a low contact resistance, and is a good conductor. Has excellent solderability</p>	Type III		99.9% gold min (Grade A only)
	Class 00	.00002" min	<p>Grade A 90 Knoop max Grade B 91-129 Knoop Grade C 130-200 Knoop Grade D 201 Knoop and over</p>
	Class 0	.00003" min	
	Class 1	.00005" min	
	Class 2	.00010" min	
	Class 3	.00020" min	
	Class 4	.00030" min	
	Class 5	.00050" min	
	Class 6	.00150" min	
Nickel	QQ-N-290		
<p>There is a nickel finish for almost any need. Nickel can be deposited soft or hard – dull or bright, depending on process used and conditions employed in plating. Thus hardness can range from 15-500 Vickers. Can be similar to stainless steel in color, or can be a dull gray or light gray (almost white) color. Corrosion resistance is a function of thickness. Has a low coefficient of thermal expansion- is magnetic.</p>	Class 1		For Corrosion protection.
	Class 2		For engineering applications
	Grade A	.0016"	<p>NOTE: All steel parts having a tensile strength of 220,000 or greater shall not be nickel plated without specific approval of procuring agency.</p>
	Grade B	.0012"	
	Grade C	.0010"	
	Grade D	.0008"	
	Grade E	.0006"	
	Grade F	.0004"	
	Grade G	.0002"	
Passivate	MIL-S-5002		
<p>A process designed to remove foreign metals from the surface of stainless and corrosion resistant steels and to promote natural tendency to surface to oxide. Does not change the appearance of the</p>	Type I	No dimensional change	Low temperature
	Type II		Medium temperature
	Type III		High temperature
	Type IV		For steels containing large amounts(0.15 percent) of sulfur or selenium.

base metal. Process purifies surface and therefore improves corrosion resistance.	Type V		Anodic – For high carbon martensitic (440) steels	
	Type VI		Low temperature (optional)	
Phosphate Coating - Light	TT-C-490			
<p>Specification covers cleaning methods and pretreatment processes.</p> <p>Type I - Intended as a general all purpose pretreatment prior to painting.</p> <p>Type II - Intended primarily for use where metal parts are to be formed after painting.</p> <p>Type III - Intended for use where size and shape preclude using Type I and Type II, metal components are assembled prior to treatment.</p>	Cleaning Methods		Light coating for use as a paint base.	
	Method I		Mechanical or abrasive cleaning	
	Method II		Solvent cleaning	
	Method III		Hot alkaline	
	Method IV		Emulsion	
	Method V		Alkaline de-rusting	
	Method VI		Phosphoric acid	
	Coatings			
	Type I		Zinc phosphate	
	Type II		Iron phosphate	
	Type III		Organic pre-treatment coating (wash primer)	
	Type IV		Non-aqueous iron phosphate	
	Type V		Zinc phosphate (heavy)	
Phosphate Coating - Heavy	DOD-P-16232			
A coating for medium and low alloy steels. Gray to black in color. Type M is more resistant than Type Z to alkaline environments. Type M can be			Heavy coating for corrosion and wear resist.	
	Type M	.0002" – .0004"	Manganese phosphate base coating (min 16g/sq m or 11g/sq m).	
	Type Z	0002" – .0006"	Zinc phosphate base coating (min 11g/sq m)	
			Supplementary preservative treatment or	

<p>used up to 250 F. Provides moderate corrosion resistant and prevents wear.</p> <p>Type Z can be used up to 200° F to prevent galling in extrusion and deep drawing. Class 2 is good for corrosion resistance.</p>	Class 1		coating, as specified.
	Class 2		Supplementary treatment with lubricating oil conforming to MIL-L-3150 or MIL-C-16173.
	Class 3		No supplementary treatment
	Class 4		Chemically converted (may be dyed to color as specified). With no supplementary coating or supplementary coating as specified.
Silver	QQ-S-365		
<p>White matte to very bright in appearance. Good corrosion resistance, depending on base metal. Will tarnish easily. Hardness varies from about 90 Brinnell to about 135 Brinnell depending on process and plating conditions. Solderability is excellent, but decreases with age. Best electrical conductor. Has excellent lubricity and smear characteristics for anti-galling uses on static seals, bushings, etc.</p>		Unless otherwise specified .0005" min	
	Type I		Matte
	Type II		Semi-bright
	Type III		Bright
	Grade A		Chromate post-treatment to improve tarnish resistance
	Grade B		No chromate treatment
Sulfamate Nickel	MIL-P-27418		
<p>The plating conforming to this specification is intended to facilitate the formation of a seal between two metallic surfaces. PLATING HARDNESS not to exceed 150 Knoop hardness (500gm. Load) after annealing.</p>		<p>Unless otherwise specified .0020" +/- .0003"</p>	<p>The nickel plating shall have columnar crystalline structure before annealing.</p>
Tin	MIL-T-10727		
		As specified on drawing.	

<p>Color is gray-white in a plated condition. Has very high luster in fused conditions. Soft, but is very ductile. Corrosion resistance is good. (Coated items should meet 24 hour 5% salt spray requirements.) Solderability is excellent. Tin is not good for low temperature applications (changes structure and loses adhesion when exposed to temperature below 40 C). Customer to specify bright or dull.</p>		Thickness guide not part of Spec.	Electrodeposited. Use ASTM-B 545
	Type I		Standard specification
	Type II		Hot dipped
		.0001" – .00025"	Flash for soldering
		.0002" – .0004"	To prevent galling and seizing
	.0003" min	Where corrosion resistance is important	
	.0002" – .0006"	To prevent formation of case during nitriding	
Tin Lead	MIL-P-81728		
<p>Excellent solderability. Either a matte or bright luster is acceptable. For electronic components use only parts with a matte or flow brightened finish.</p>	60/40 90/10	Unless otherwise specified .0003" - .0005"	Tin 50 to 70% by weight Lead remainder (Unless otherwise specified).
Zinc	ASTM-B633		
<p>Either a bright or dull finish is acceptable. Bright Zinc plating closely resembles bright chromium. However, bright zinc does not have the permanence of surface appearance. Zinc coated steel will not rust even when exposed by scratches because of the galvanic protection of the zinc. On weathering, zinc turns to a drab color. Zinc should be deposited directly on the base metal (Nickel is permissible undercoat if base metal is a corrosion resisting steel).Parts having a hardness</p>	Fe/Zn25 SC4	.0010"	The primary use of chromate finishes on zinc is to retard or prevent formation of white corrosion products on zinc surfaces
	Fe/Zn13 SC3	.00050"	
	Fe/Zn8 SC2	.00030"	The primary purpose of phosphate coating on zinc is to provide a paint base
	Fe/Zn5 SC1	.00020"	
	Type I		Without supplementary treatments (as plated)
	Type II		With colored chromate treatment
	Type III		With colorless chromate treatment

greater than Rc-40 must be given a heat treatment prior to plating. Springs having a hardness over Rc-40 must be given an after plating baking of 375° +/- 25°F for 3 hours.	Type IV		With phosphate conversion treatment
Zinc Nickel	AMS-2417 BAC-5637		
Dull matte gray or green iridescent. Type II acid or alkaline process. Excellent alternative for cadmium plate requirements. Meets and exceeds 96 hours salt spray test.		.0005" min	No supplementary treatment or supplementary chromate treatment.
		.0003" min	
		.0002" min	
Powder Coating	MIL-DTL-53072 MIL-PRF-32348		
<p>Powder coating is a type of coating that is applied as a free-flowing, dry powder. Unlike conventional liquid paint, which is delivered via an evaporating solvent, powder coating is typically applied electrostatically and then cured under heat or with ultraviolet light. The powder may be a thermoplastic or a thermosetting polymer. It is usually used to create a thick, tough finish that is more durable than conventional paint. Powder coating is mainly used for coating of metal objects, particularly those subject to rough use. Advancements in powder coating technology like UV-curable powder coatings allow for other materials such as plastics, composites, carbon fiber, and medium-density fiberboard (MDF) to be powder coated, as little heat or oven dwell time is required to process them.</p>			
Ferritic Nitrocarburize			
Salt Bath Ferritic Nitrocarburizing	AMS-2753		
<p>Nitriding is a heat treating process that allows nitrogen onto the surface of a metal to create a case hardened surface. Salt bath nitriding, also referred to as liquid salt bath ferritic nitrocarburizing is a surface treatment for most ferrous metal components and is designed to improve certain engineering properties to enhance wear resistance, lubricity, fatigue strength and corrosion resistance. The nitriding process will also lower the coefficient of friction.</p> <p>The simplest form of this process is encompassed by the trademarked "Melonite" process, also known as "Meli 1". It is most commonly used on steels, sintered irons, and cast irons to lower friction and improve wear and corrosion resistance</p>			

Gaseous Nitrocarburizing	AMS-2757		
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Gaseous ferritic nitrocarburizing is also known as controlled nitrocarburizing, soft nitriding, and vacuum nitrocarburizing or by the tradenames "UltraOx", "Nitrotec", "Nitemper", "Deganit", "Triniding", "Corr-I-Dur", "Nitroc", "Nitreg-C", "Nitrowear", and "Nitroneg". The process works to achieve the same result as the salt bath process, except gaseous mixtures are used to diffuse the nitrogen and carbon into the workpiece.

The parts are first cleaned, usually with a vapor degreasing process, and then nitrocarburized around 570 °C (1,058 °F), with a processing time that ranges from one to four hours. The actual gas mixtures are proprietary, but they usually contain ammonia and an endothermic gas.

In comparison to a standard nitriding process, ferritic nitrocarburizing or FNC in a vacuum furnace takes less time to achieve case depth requirements - mainly in part due to the addition of carbon to achieve faster diffusion.