

# PLATING

Finish	Description
<b>Electro-Zinc &amp; Clear</b>	Zinc is the most popular of all commercial platings because it is relatively economical and offers good corrosion resistance in environments not subject to excessive moisture. To avoid any reduction in the strength properties of screws with Class 2A thread allowances in sizes No. 8 or smaller, a thinner zinc coating is acceptable. A clear or blueish chromate finish is applied on top of the zinc to provide additional protection against white oxidation spots which can form due to moisture. Electroplating is the most common way of applying zinc coatings to fasteners. It is recommended by certain industry experts that case-hardened parts which are electro-plated should be baked after plating to minimize the risk of hydrogen embrittlement (see notes on baking on next page).
<b>Electro-Zinc &amp; Yellow</b>	Yellow chromate offers a greater degree of protection from white corrosion than does clear chromate. Electroplating is the most common way of applying zinc coatings to fasteners.
<b>Zinc Yellow to ASTM B633</b>	The ASTM B633 standard was revised in 2007. One of the changes concerned the amount of time certain fasteners are baked to reduce the effects of hydrogen embrittlement. Prior to this revision, plated Grade-BD cap screws were required to be baked for at least 4 hours at a temperature of 190°C to 220°C. That revised standard calls for these parts to be baked for at least 10 hours at 190°C to 220°C.
<b>Electrodeposited Coatings on Mechanical Fasteners to ASTM F1941</b>	For fasteners manufactured after October 2015, this standard replaces ASTM B633. It addresses the topics of (a) thickness of zinc coating, (b) various chromate coatings, (c) baking requirements for fasteners with a <b>core</b> hardness over Rockwell C 39, and (d) salt-spray performance, as well as other standards. For details re: the requirements this standard puts forth for the baking of through-hardened fasteners, see the following page.
<b>Electro Zinc &amp; Black</b>	Black chromate offers a similar appearance to black oxide but with greater degree of protection that black oxide lacks. Electroplating is the most common way of applying zinc coatings to fasteners.
<b>Electro-Zinc &amp; Wax</b>	A wax lubricant is added to the zinc coatings of certain fasteners to improve the ease of assembly. This is the standard plating for thread rolling screws including the Plastite® and Taptite® II, as well as two-way reversible center-lock nuts. Case-hardened parts are still recommended to be baked after plating (see below).
<b>Mechanical Zinc &amp; Clear</b>	Mechanically applying zinc to fasteners reduces the risk of hydrogen embrittlement forming within the parts. This minimizes the need for the precautionary practice of baking the parts soon after plating. A clear or bluish chromate finish is applied on top of the zinc to provide additional protection against white oxidation spots, which can form due to moisture. It is common for lock washers made from spring steel to be plated this way to avoid brittleness after baking.
<b>Mechanical Zinc &amp; Yellow</b>	This finish is identical to mechanical zinc but with a yellow chromate finish. This is the standard plating for high-alloy split lock washers and for tooth lock washers used with zinc yellow machine screws.
<b>Electro-Zinc &amp; Clear for Sockets</b>	Socket cap screws can receive a zinc plating of 0.0002 inches thickness. A clear chromate finish is applied on top of the zinc to provide additional protection against white corrosion. The manufacturer must be told prior to the thread rolling process that the parts are to be plated. The plated parts are then baked at 375°F for 24 hours within one hour of plating then subjected to a 72-hour stress test.
<b>Electro-Zinc &amp; Green</b>	Commercial zinc green is the finish applied to machine screws and thread-cutting screws that will be used as "grounding screws" in electrical applications.
<b>1,000 Hour Electro-Zinc/Nickel</b>	Zinc/Nickel is selected to achieve the highest resistance to corrosion with the smallest thickness of protective coating. Typically, the nickel content of the alloy finish is 12-15%. The finish will withstand a minimum 1,000 hour Salt Spray test.
<b>1,000 Hour Silver Ruspert®</b>	A three-layer coating consisting of (1) a metallic zinc layer, topped with a (2) chemical conversion film layer, which is finally covered by a (3) baked ceramic surface coating. The finished parts have a dull silver color and will withstand a minimum of 1,000 hour Salt Spray test.
<b>Nickel</b>	Nickel has more of a silver color to it than zinc and has similar corrosion resistant characteristics. It is the standard finish of cap nuts, countersunk finishing washers, brass spacers and standoffs, as well as other parts to achieve a more decorative appearance.
<b>Tin</b>	Tin plating is sometimes used on parts in the food handling industry because it resists organic acid. It improves the lubricity of steel and offers a high degree of corrosion resistance.
<b>Silver</b>	Silver is an excellent conductor of electricity. Its benefits are both decorative and protective as it resists thread galling when mated parts are under extreme pressure or exposed to extreme heat.

# PLATING / BAKING / PASSIVATING

Finish	Description
<b>Cadmium &amp; Wax</b>	Cadmium plating results in a smoother surface and greater resistance to white oxidation spots than zinc plating. However, cadmium is a much more toxic metal than zinc, which makes the plating process more difficult and costly. The standard most commercial platers use when applying cadmium is a minimum thickness of .0002 inches. A supplemental wax coating is often added as a lubricant when cadmium is used on prevailing torque lock nuts.
<b>Hot-Dip Galvanized</b>	Hot dip galvanizing is generally the most effective way to apply a sufficient thickness of zinc to threaded fasteners for the zinc to serve as a corrosion protectant in harsh environments. During the galvanizing process, steel reacts with molten zinc, forming layers of zinc-iron alloy layers, which are metallurgical bonded to the steel surface. This hard barrier has a low corrosion rate and resists mechanical damage. Bolts and nuts 3/8 inch diameter and smaller shall have a zinc coating with an average thickness of 0.0017 inches with no individual both having a coating of less than 0.0014 inches. Bolts and nuts over 3/8 inches diameter and all sizes of washers shall have a zinc coating with an average thickness of 0.0021 inches with no individual both having a coating of less than 0.0017 inches.
<b>Black Phosphate</b>	This is the standard finish for most drywall screws, particle board screws and retaining rings. It can have either a dull or bright appearance. No additional oil treatment is required.
<b>Black Phosphate &amp; Oil</b>	The most common standard coating of black phosphate and oil is 1100mg per sq./ft., minimum. The oil serves as a rust inhibitor and a lubricant. Some fasteners with this plating are required to pass a salt-spray test, the duration and cost of which must be agreed upon between buyer and seller prior to the sale. Floorboard screws, frame bolts, Grade-GT locknuts and spring nuts are usually supplied with a black phosphate and oil finish.
<b>Black Oxide</b>	This is a "conversion coating" which means it is formed by a chemical reaction with the metal to form an integral surface, as opposed to an "applied coating" like zinc which bonds to the metal. An oil finish is applied as a rust inhibitor. For more information about black oxide, see next page.
<b>Chrome</b>	Chrome plating can be done in two ways: 1) A "hard chrome" finish deposits a thick layer of chrome on the part. This gives the fastener a very hard finish and superior wear resistance but does not offer much protection to corrosion; 2) A "nickel-chrome" finish is achieved by applying a flash of chrome on top of the nickel plating. This offers resistance to tarnishing and corrosion.
<b>EcoGuard™</b>	Provides a silver-gray color and an incredibly high level of corrosion resistance. Rated to withstand a minimum of 1,000-hour Salt Spray test. No risk for hydrogen embrittlement and is free of toxic metals.
<b>Dacro</b>	Dacro is a pollution-free ceramic coating for fasteners used with treated lumber. The coating offers corrosion protection comparable to hot-dip galvanizing without discoloring the wood. Screws with a proper dacro coating can typically withstand a 500-hour salt-spray test. A dacro finish minimizes greatly the risk of hydrogen embrittlement so baking the part is not required after the finish is applied.
<b>Blue Ruspert®</b>	Ruspert® metal finish is a high-quality corrosion-resistant coating that is comprised by three layers: (1) metallic zinc; (2) a chemical conversion film (to resist corrosion); and (3) a ceramic surface coating that is baked.
<b>Antique Brass</b>	This is a brass finish that has been chemically darkened to appear similar to aged brass—a moderate brown color with golden hues. It is common in cabinet hardware.
<b>Bright Brass</b>	Bright brass is strictly a decorative finish that is commonly used with cabinet hardware. It offers minimal resistance to corrosion but will not stain when used in acidic woods.
<b>Ceramic</b>	Ceramic finish is also a barrier coating used to offer corrosion resistance. It is used, though not exclusively, on certain types of construction fasteners and typically provides over 500 salt spray hours or more of protection. Green ceramic is a common finish for cement board screws. Flat head deck screws are available in multiple colors of ceramic finish including green, red and tan.

<b>Baking of Case Hardened Parts</b>	Electroplated screws, which are case hardened, should be baked for a minimum of 4 hours within the temperature range of 375-450°F no later than 4 hours after the plating operations. However, this process does not guarantee that hydrogen embrittlement will not still be present after baking or that it will not occur at a later date while in service. Specialized testing or a substitute part may be required, depending on the application. This heat treatment practice is recommended for tapping screws, drywall screws, SEMS screws, clinch nuts and clinch studs.
<b>Baking of Through Hardened Parts</b>	Mechanical fasteners that are <u>through-hardened</u> with a core hardness above Rockwell C 39 and up to C 44 shall be baked for a minimum of 14 hours within a temperature range of 375-450°F. <u>Through-hardened</u> parts with a core hardness above Rockwell C 44 shall be baked for a minimum of 24 hours within a temperature range of 375-450°F. These requirements also apply to parts with hardened steel captive washers. These baking requirements are specified to offer relief from hydrogen embrittlement.
<b>Passivation of Stainless Fasteners</b>	This process enhances stainless steel's corrosion resistance. The fasteners are dipped in a solution, which removes surface imperfections and produces a slight film on the surface of the parts.

# PLATING / BLACK OXIDE FINISH

### **Black Oxide Finish**

Black oxide is a conversion coating (as opposed to an applied coating) because it results from a chemical reaction with the iron present in the metal fastener and forms an integral protective surface. It is a color of the base metal, which neither removes nor deposits metal; therefore it adds, at the most, 5 to 10 millionths of an inch to the fastener's dimensions. Likewise, it cannot chip, peel or rub off. Also, the item maintains 99% of its conductivity making black oxide a popular finish for electrical parts.

When a black oxide finish is specified, it is interpreted as "Black Oxide and Oil". Other supplementary coatings such as wax or lacquer may be ordered, but fasteners with those finishes are usually not available from a distributor's stock.

Typically, the oil after-finish is dry to the touch, which gives the part a lustrous appearance and improved lubricity without excessive residue. The color is a deep black rather than the grayish-black appearance of a black phosphate, and remains consistent at temperatures as high as 900°F. Black oxide also resists abrasions better than phosphate.

One of the most important advantages of black oxide is that there is almost no risk of hydrogen embrittlement because the process does not involve electro-plating nor does it require an acid-activation. Case hardened parts need not be baked after receiving a black oxide finish.

Black oxide neither enhances nor detracts from a fastener's resistance to corrosion. The post-treatment oil application offers good indoor corrosion protection, but a zinc-plated part is more resistant to rust. However, parts with a black oxide finish will not suffer from white corrosion, which can occur over time with electro-plated parts. To avoid the risk of white corrosive particles (which can cause electrical shorts) many in the electronics industry opt for black oxide instead of zinc-plated fasteners.

The popularity of black oxide stainless fasteners is also growing. In addition to being used for decorative purposes, the finish reduces light glare and reflection, and makes the surface of the fastener smoother. The automotive aftermarket utilizes them in tail-light assemblies, luggage racks, grills and windshield wiper assemblies, to name a few.

# HEAT TREATING

## Notes on Heat Treating Fasteners

Steel fasteners are heat treated to develop the fastening strengths their material structure is capable of reaching. The iron, carbon, manganese and other elements, which form the grains of steel, are transformed during heat-treating to a structure capable of greater load carrying. The as-heat treated hardness and tensile strength are two of several metallurgical measures of the finished heat-treated fastener.

Heat-treating is a “three box” process: *Harden-Quench-Temper*. The raw fasteners travel into the hardening furnace where a high temperature and an atmosphere with a metered amount

of carbon molecules alter the fasteners’ microstructure. Once “soaked” in and transformed in this environment, the fasteners are rapidly cooled, or “quenched” to shift the fastener metal into the martensitic microstructure right for fastening. To relieve the stresses from the rapid temperature changes needed to quench properly, the final step, tempering, draws the fastener back to their final hardness and tensile strength using a temperature lower than used in hardening. By hardening, quenching and tempering a steel fastener, the finished product develops the mechanical properties to provide fastening abilities

# **FASTENER THREAD FITS**

## **Comparing Fine Threaded with Coarse Threaded Fasteners**

Fastener threads provide both load holding when tightened and the ability to move during tightening and loosening. A fastener's pitch and lead, determined by whether it has a coarse or fine thread, is a factor in fastener performance. A coarse thread will move a larger distance with each rotation than a finer thread of the same diameter. If speed of assembly is a factor, a coarse thread may be preferred, as it will assemble faster. If adjustment is required, a fine thread will provide a less sensitive adjustment and a greater ability to control adjustment.

Each flank of thread carries a percentage of the clamping load. This load is not distributed equally among the thread pitches in most applications. It is generally thought that a fine pitch thread will have a more uniform load distribution among its engaged pitches when installed.

Finally, starting can be a factor. Fine threads can be more susceptible to cross threading if assembly conditions are not controlled. In general, both coarse and fine threads have advantages depending on the fastening output required.

## **Differences in Thread Classes 1B, 2B, 3B; and 1A, 2A and 3A**

A thread's class is an arbitrary but well-established set of precision measurements established by the United States, The United Kingdom and Canada in the late 1940's. It is universally used, accepted and maintained more than sixty years later. Its success is testimony to its sound engineering. In general, each diameter and pitch combination have been assigned a set of measurements within which it is to be manufactured for each of the three classes. The B denotes an internal thread such as that found on a nut. A 1A class

would be slightly smaller on average than a 2A, which is in turn easier to make than a 3A. Similarly, a 1B would provide a looser fit than a 2B, which in turn, would not be as precise as a 3B. With three external and three internal classes, a total of nine combinations are possible in theory. In practice, only a few are in general application. A 2A/2B is popular for general fastening. 3A/2B finds application in more precision assemblies and 3A/3B serves where high precision is warranted.

## EFFECTS OF TEMPERATURE CHANGES ON FASTENERS

### Fastener Effects Due to Temperature Changes, Both Elevated and Cryogenic

Out of the box, fasteners come with a set of static and dynamic strengths, which are determined by their grade, material and size. In application, the availability of these strengths are affected by a range of factors. Among these factors, temperature variations can reduce available fastening power in an installed fastener to a large degree. Metal fasteners are made of “building blocks” of steel grains, which are molecules of metallic and other elements. Tensile, yield, impact and the other fastener strength properties are the result of these molecular bonds. As temperatures at an application site rise, these bonds weaken. Fastener

strength drops as temperatures rise above ambient levels. At 300° Fahrenheit, an alloy steel fastener’s strength is lower. And with continued time at an elevated temperature, a tensile fastener under load will progressively lose its ability to fasten at room temperature strength levels.

At very cold temperatures, these same molecular bonds lose their ability to “flex” or relieve fastening stresses under application load. As a result, fasteners can become brittle at low temperature levels and also provide less than room temperature fastening performance.



**ANSI** – American National Standards Institute

**ASME** – American Society of Mechanical Engineers

**ASTM** – American Society of Testing and Materials

**Aircraft Quality** – In the fastener industry, this refers to parts that are made to more stringent specifications, and tested more thoroughly, than commercial fasteners because they are used in high-risk and/or high-stress applications requiring near-zero defects.

**Alloy Steel** – A variety of steel, which includes elements in addition to carbon, giving the material the ability to retain its strength at higher temperatures. Additionally, alloy steel has greater tensile and yield strength than medium carbon steel.

**Annealed** – The condition of a fastener when it has been heated, then cooled to make it soft or less brittle.

**Bolt** – An externally threaded rod, headed at one end, designed to pass through an oversized hole and mate with a nut so as to hold two or more objects together.

**Carbon Steel** – A steel whose only significant alloying material is carbon.

**Case Depth** – That area of a fastener, measured from the surface inward, which has a different hardness requirement than its core.

**Case Hardening** – The process performed on quenched, tempered, ferrous fasteners which makes the surface of those parts harder than the inner core. Case hardness is measured in the threaded section of the fastener.

**Core Hardness** – The resistance a fastener material has to being permanently deformed, measured at a spot deeper than the case depth.

**Ductility** – The ability of material to be permanently bent or stretched without breaking.

**Elongation** – the lengthening of a fastener caused by a tensile force.

**Embedment, minimum** – The minimum depth an anchor must be installed to meet the minimum pull-out values. It is the distance measured from the concrete surface to the bottom of the anchor.

**Ferrous** – That which contains iron; usually refers to fasteners containing more iron than any other element.

**Fillet** – The concavely curved Section at the angle formed at two intersecting surfaces of a fastener.

**Galvanizing:**

**Hot-Dip Galvanizing** - The process of coating iron or steel with zinc by means of hot-dipping.

**Electro-Galvanizing** - The process of coating iron or steel with zinc through an electric current. This results in a somewhat smoother, shinier finish than hot-dipping.

**Mechanical-Galvanizing** - The process of coating iron or steel with zinc at room temperature where the zinc powder becomes cold welded to the metal parts. It results in a more uniform finish than hot-dipping and greatly reduces the chance of hydrogen embrittlement which can occur in electro-galvanizing.

**Gimlet Point** – a conically shaped, threaded point having an angle of 45-50°. Lag screws, wood screws, Type A & AB tapping screws all have gimlet points.

**Grip Range** – The minimum and maximum thicknesses of materials a rivet can join together.

**Header Point** – A blunt point with chamfered edges. Machine screws typically have header points.

**Hydrogen Embrittlement** – The condition of a fastener, which had hydrogen introduced into its steel, causing it to be substantially less ductile and prone to sudden and premature failure.

# GLOSSARY

**Key engagement** – The distance from the head surface of a socket to that depth to which the hex wrench will penetrate.

**Locknut** – A nut constructed to resist loosening when subjected to vibration or axial load. A prevailing torque type locknut achieves its locking action without being against another nut or a bearing surface, but by a controlled distortion in its threads or by means of another locking element (e.g. a nylon ring) built into the nut. A free-spinning locknut achieves its locking action when tightened against another surface.

**Mandrel Break Load** – The axially applied load required to break the mandrel while a rivet is being set.

**Milled from Bar** – A description of fasteners made from bar stock on a screw machine or a lathe.

**Passivating** – The process performed on stainless fasteners of removing surface imperfections and producing a slight film on the surface which enhances the parts' resistance to corrosion.

**Penetration Gauge Depth** – A range of measurements, which determine the acceptability of a recess in the head of a screw. It is measured from a plane where the edge of the recess wings meet the top of the head's surface, downward into the recess.

**Pilot Hole Size** – An opening of sufficient size for a specific fastener to be properly installed.

## Pitch:

**Thread Pitch** – The distance between corresponding points on adjacent threads in the same plane parallel to the part's axis and on the same side of the axis.

**Pitch Cylinder** – An imaginary cylinder, which sharing the same axis as a fastener, would cut through the threaded portion of that fastener in a way that made the widths of the thread ridge and groove equal, or half way between the major and minor diameters.

**Pitch Diameter** – The diameter of the pitch cylinder.

**Plating** – The application of a metallic deposit on the surface of a fastener for protective and/or decorative purposes.

**Point Taper Length** – The length of the pointed portion of the fastener measured parallel to the axis, from the end of the point to the first full form thread.

**Proof Load** – The tension applied force a fastener must support without any permanent change in size or shape.

**Recess Depth** – The distance measured, axially, from the plane where the edge of the recess wings meet the top of the head's surface to the bottom of the recess.

**Reduction of Area** – One of the tests performed on a cap screw or bolt when determining its tensile and yield strengths. After a test specimen has been broken in a tensile tester, the original diameter of the specimen (d) is compared to its smallest diameter after fracture (t). The formula for determining reduction of area is:  

$$[1.000 - (.5 \times t)^2 / (.5 \times d)^2] \times 100 = \% \text{ area reduction.}$$

**Rockwell Hardness** – A test performed on fasteners to determine the resistance a fastener material has to being permanently deformed by a specifically shaped object under a specific amount of weight. The test measures how deep an indentation is made in the fastener. That measurement is converted to a reading on the Rockwell hardness scale.

**Runout of Thread** – A threaded portion with incomplete profile generated by chamfering part or leading part of tool. The incomplete threads are generated at the boundary between body and complete thread and also at thread-end portion as for an external threaded fastener with body.

The same are generated at under-head portion and thread end portion as for an external threaded fastener with continuous thread.

**SAE** – Society of Automotive Engineers



**Screw** - An externally threaded fastener designed to be tightened or loosened by torquing the head.

**Shear Load, Ultimate** – A minimum amount of force, applied transversely, which a blind rivet must withstand without failing.

**Stud** – A headless fastener with threads at both ends of the shank.

**Tensile Strength** – The greatest longitudinal stress a fastener can withstand prior to, or at the time of breaking apart.

**Tolerance** – The difference between the lower and upper limits between which a fastener's size(s) must be measured.

**Torque:**

**Drive Torque** – A screw shall form a mating internal thread in a test plate, without damaging its own thread with the application of a rotational force not in excess of the drive torque.

**Minimum Torsional Strength** – The amount of rotational force a fastener must endure before failure occurs. This presumes the screw is driven into a proper size hole.

**Tightening Torque** – The amount of rotational force which is approximately midway between a fastener's "drive torque" and "ultimate torque".

**UNC** – Unified National Coarse Threads

**UNF** – Unified National Fine Threads

**Washer Face** – A circular boss on the bearing surface of a screw, bolt or nut.

**Yield Strength** – The tension-applied stress at which a fastener, under strain, is deformed a measurable amount.