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TECH SHEET

PEM® REF/ CHOOSING A FASTENER FINISH

SUBJECT: METAL FASTENERS IN CONTACT WITH METAL PANELS

Introduction – All PennEngineering catalog bulletins list a standard finish and some also list optional finishes. There are also a wide variety of special finishes available to meet customer requirements when the standard finish or catalog finish options will not suffice. This Tech Sheet gives guidance on choosing the most appropriate finish for self-clinching fasteners. It also lists factors to consider before deciding that a non-standard finish really is warranted.

The scope of this Tech Sheet is restricted to metal parts in intimate contact with metal panels. This Tech Sheet is applicable to the following types and Brands of PennEngineering fasteners.

- All PEM Brand self-clinching fasteners
- All PEM Brand broaching fasteners when used in metal panels
- All PEM Brand weld nuts
- All Atlas Brand Fasteners when used in metal panels

Standard Finishes

Advantages

Reliability - Standard finishes for the fasteners covered here are listed in Table I. Past sales reveal that most PEM cataloged fasteners are sold with these standard finishes. User history confirms that these finishes perform reliably in most applications.

Table I
Standard finished for selected PEM brand self-clinching fasteners

Fastener Material	Sub-Group	Fastener Types	Finish Description	Finish Specification	Finish Suffix
Aluminum	Plain Clinch	BSOA, CSA, CHA, CLA, FHA, SOA	Plain finish	N/A	none
Steel	Plain Clinch	AS, B, BSO,FH, FHL, HFE, HFH, TFH, S, SS, SSS, SO, TSO	Zinc and clear trivalent	Penn FIN-C20/C21	ZI
Steel	Projection Weld	WN	Copper flash	Penn internal spec	CU
Steel	All-metal & Nylon Locknuts	SL, PL	Zinc and clear trivalent	Penn FIN-C20/C21	ZI
Steel	All-metal Locknuts	HNL	Zinc plus lubricant	Penn internal spec	LZ
Steel	All-metal Locknuts	LK	Dry film lub over phosphate	Penn internal spec	MD
Stainless Steel	Plain Clinch	A4, AC, BSO4, BSOS, BS, CLS, CLSS, CHC, CSS, F, FEX, FEOX, FH4, FHP, FHS, FHLS, HFHS, MPP, MSO4, PLC, TFHS, SKC, SP, SO4, SOS, TSOS	Passivate and/or test	ASTM A380	none
Stainless Steel	Projection Weld	WNS	Passivate and/or test	ASTM A380	none
Stainless Steel	All-metal Locknuts	FE, FEO, LA4, LAS, LAC, LKS	Dry film lube	Penn internal spec	MD
Stainless Steel	All-metal Locknuts - small	UL	Carbowax	Penn internal spec	CW

Availability - Standard finishes are usually in stock and are always more available than optional or special finishes.

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Cost effectiveness – Standard finishes are almost always less expensive than optional or special finishes. The only way a non-standard finish can ever be less expensive is if it is less costly to apply (such as rust-preventative oil instead of electroplated zinc on steel) and if the quantities are high enough to negate any minimum lot charges.

Optional Finishes

It should also be noted that some PennEngineering catalog bulletins list optional finishes. One common optional finish for steel parts is zinc and yellow chromate denoted ZC. By specification, zinc and yellow offers 8 times the salt spray resistance to white corrosion as the standard ZI plating. That means, 96 hours for zinc, yellow and 12 hours for zinc clear finish.

Another common optional finish offered for many panel fasteners assemblies is black nitride designated BN. The black nitride finish provides a durable black color.

A third example of an optional finish is annealed matte tin designated DT offered on all solderable parts. The use of matte tin plating chemistry and the stress relief anneal of the plating deposit mitigate the risk of tin whisker growth.

When a non-standard finish is being considered, there are some advantages to using an optional finish if it meets requirements. Advantages include the potential for the optional finish to be available from stock and if not generally shorter lead time because the optional finish process is already defined and suppliers are already in place.

Choosing an Non-Standard Finish

In situations where a non-standard finish is truly required, Table II below serves as a guide to the appropriate section of this Tech Sheet. Four considerations were selected for discussion:

- Corrosion Resistance
- Color
- Lubricity / Anti galling
- Panel Finishing after installation of fastener

These four criteria are the most common issues relating to customer applications. For each of these four considerations, common panel materials and fastener materials are discussed. For quick reference, use Table II to select the group of rows for the panel material and then select the row for the chosen fastener base material. Then select the column based on the major factor driving the fastener finish selection. The intersection point lists the section in which that combination is discussed. Sections begin below and arranged alphabetically.

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Table II
Directory to discussion sections on finish selection

Panel Material	Fastener Material	Major consideration for Fastener Finish Selection			
		Corrosion Resistance	Fastener Color	Lubricity or Anti-Galling	Panel Finishing After Installation
Aluminum	Aluminum	see Section A	see Section H	see Section K	see Section M
	300 Series Stainless Steel	see Section B	see Section I	see Section L	see Section N
	Steel	see Section C	see Section J	see Section L	see Section O
Steel	300 Series Stainless Steel	see Section D	see Section I	see Section L	see Section N
	Steel	see Section E	see Section J	see Section L	see Section O
300 Series Stainless Steel	400 Series Stainless Steel	see Section F	see Section I	see Section L	see Section N
	PH Stainless Steel	see Section G	see Section I	see Section L	see Section N

Corrosion Considerations (sections A through G)

Section A – Aluminum Panel and Aluminum Fasteners, Corrosion Considerations

Even when the panel material and fasteners are similar materials, galvanic corrosion may still be a factor. Detailed galvanic series show that the heat treatable alloys used to produce self-clinching fasteners are slightly more noble than the non-heat treatable 1000, 3000 and 5000 series alloys typically used for panel materials. Heat treatable alloys used for fasteners also have slightly lower corrosion resistance than typical (non-heat treatable) panel alloys which have lower alloy content. Higher corrosion resistance can be achieved in one of two basic ways; aluminum fasteners can be specified with chemical film finish or an anodized finish, or the entire assembly can be given a chemical film finish or be anodized after the fasteners are installed. For additional information on finishing any type of assembly with fasteners installed see PEM®Tech Sheet - Ref/Surface Finishing Sheet Metal Assemblies.

Section B – Aluminum Panel and 300 Series Stainless Steel Fasteners, Corrosion Considerations

In this situation there is a significant galvanic potential voltage difference between the panel and the fastener. Currently most of these applications are in non- corrosive environments and do not present a problem. However if an electrolyte is present, then this issue needs to be addressed. In this case the fasteners can be plated with a metal closer to aluminum on the galvanic series. If the application is aerospace or defense and does not require RoHS compliance and a REACH SVHC is permitted, cadmium plating provides the lowest potential difference. If RoHS compliance is required, zinc plating greatly reduces the potential difference and may be acceptable. For thread sizes of 1/4”/M6 and greater aluminum rich dip-spin coatings can also be considered. Stainless parts that will be plated or coated must be made as specials with adequate thread allowance. Nickel strike is required for good plating adhesion on stainless steel.

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Section C – Aluminum Panel and Steel Fasteners, Corrosion Considerations

If the steel fastener has the standard zinc finish, the potential galvanic difference is greatly reduced and may be acceptable. As with stainless steel base metal, cadmium provides lower potential difference than zinc plating, but can only be used if RoHS compliance is not required. For thread sizes of 1/4"/M6 and greater, aluminum rich coatings can also be considered.

Section D – Steel Panel and 300 Series Stainless Steel Fasteners, Corrosion Considerations

In this situation the stainless steel fasteners have higher inherent corrosion resistance than the panel and there is seldom a need to add a coating to improve corrosion resistance. More common are requests that the stainless steel fasteners be passivated as opposed to the standard finish of "passivated and/or tested per ASTM A380." To insure that every lot is passivated per ASTM A380 a "-07" suffix is added to the stainless steel part number. For example part number CLS-632-2 is passivated and/or tested, but part number CLS-632-2-07, available on special order is always passivated per ASTM A380.

Section E – Steel Panel and Steel Fasteners, Corrosion Considerations

Most steel panels and enclosures into which fasteners are installed are plated with zinc for corrosion protection. With sacrificial zinc plated fasteners in zinc plated panels there are no galvanic corrosion concerns. Therefore the standard fastener finish is adequate. In those cases where the zinc plating applied to the panel has superior corrosion resistance, it may be necessary to use a fastener finish with higher corrosion resistance. If the yellow color is acceptable, the optional zinc and yellow finish, designated by the ZC suffix, provides 96 hours of neutral salt spray resistance to white corrosion. If more corrosion resistance is required the first recommendation is to add a topcoat or sealant, which has not appreciable thickness and therefore will not require special thread sizing. If even more corrosion resistance is needed, zinc thickness can be increased to either .0003" (8 microns) min or .0005" (12 microns) min. The .0005" (12 micron) zinc thickness is not recommended on thread sizes below #10/M5.

When steel panels have a finish providing more corrosion resistance than zinc platings, zinc alloy plating such as zinc nickel should be considered first. Like zinc, zinc alloy platings protect sacrificially, but because they have a galvanic potential closer to steel than pure zinc, they corrode at a slower rate. Zinc-nickel plating on steel can provide up to 1000 hours of neutral salt spray to red rust at a thickness compatible with thread allowances typically in self clinching fasteners. Another option for larger thread sizes is a zinc rich or zinc/aluminum rich dip-spin coating. These coatings can provide up to 1000 hours of salt spray to red rust and have an added advantage of not being applied by the electroplating process and therefore not exposing the work to molecular hydrogen. If the pretreatment also does not use any acid, there is no exposure to hydrogen anywhere in the process and hence no chance of hydrogen embrittlement and no need to bake for hydrogen relief and test to confirm embrittlement relief. These coatings may be appropriate for high hardness, safety critical parts that require a high degree of corrosion resistance. The major disadvantage of these coating is a non-uniform thickness and the tendency of the finish to collect in small internal threads and small recesses. This finish require special rules relative to thread gaging after coating and should not be used on external threads under 1/4" (M6) or on internal threads under 5/16" (M8) or on screws with an internal recess drive. Trade names of these finishes include Dacromet®, Geomet® and Magni®.

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Some steel clinch fasteners, such as panel fastener and spring plunger assemblies use bright nickel over copper flash as their standard finish. Unlike zinc, nickel protects by serving as a barrier preventing corrosive substances from contacting the steel base metal. Nickel itself has very good corrosion resistance and experience has shown that it holds up very well on these types of fasteners which are frequently touched and sometimes contaminated with human sweat. Nickel is nobler than both steel and zinc, so when these fasteners are installed in zinc plated steel, any galvanic corrosion will attack the zinc first and then the steel panel. Internal drive recesses in panel screws are sometimes subject to mechanical damage which destroys the integrity of the nickel plating allowing base steel corrosion. If this is a concern, zinc alloy plating should be considered.

Section F – 300 Series Stainless Steel Panel and 400 Series Stainless Steel Fasteners, Corrosion Considerations

It is well known that 400 series stainless steels have lower corrosion resistance than 300 series stainless steels. If the corrosion resistance of 400 series fasteners is not adequate for the application, the first recommendation is to upgrade to a fastener made from a PH grade of stainless steel. For example, an FH4 stud could be upgraded to an FHP stud. Currently there is no standard upgrade for BSO4/SO4 standoffs, so electroless nickel plating should be considered for improved corrosion resistance.

Section G – 300 Series Stainless Steel Panel and PH (Precipitation Hardening) Stainless Steel Fasteners, Corrosion Considerations

The stainless steel grades used for PennEngineering Type SP, FHP and SFP fasteners have essentially the same corrosion resistance as type 304 which is the most common 300 series panel alloy. Therefore there is rarely a need to apply a finish to the fastener for increased corrosion resistance. Customers occasionally specify electroless nickel and it may provide slight benefit in some environments. Using electroless nickel requires special thread sizing not normally applied to these product types.

Color Considerations (sections H, I and J)

Section H – Aluminum Panels, Aluminum Fasteners, Fastener Color Considerations

There are two primary ways to color aluminum fasteners. The first, known by the trade name Alodine®, is a conversion coating and is available in clear and yellow. The yellow color can vary from light yellow to a deep dark yellow based on the chemistry used for the process.

The second way to color aluminum is to anodize. The process uses the porous surface of the anodized layer to hold a dye. While theoretically any color can be specified, anodizing dye tanks are expensive to maintain and most commercial anodizing facilities will therefore only maintain one tank of each color. If a specific color match is required, PennEngineering can check with a number of commercial anodizers and may be able to find a close color match.

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Section I – All Panels, Stainless Steel Fasteners, Fastener Color Considerations

Other than black, there are limited options for coloring stainless steel fasteners. For colors other than black, a metallic plating such as zinc can be applied and then various colors can be added to the conversion coating as discussed in section J below. Since stainless steel fasteners do not normally have an additive finish, this option requires special thread sizing.

There are two ways to blacken stainless steel that do not require special thread sizing. The first is chemical black oxide designated by the BO suffix. The second is black nitride designated by the BN suffix. This is actually a heat treat process which adds a very thin, hard case of ferritic carbo-nitride which as a characteristic dark-gray to black color. Each of these methods may present challenges for color consistency.

Section J – All Panels, Steel Fasteners, Fastener Color Considerations

The most common way to color zinc plated steel fasteners is to add a color to a conversion layer (known as a chromate or passivate) over the zinc. On the standard PEM® zinc plating (ZI) this chromate is clear with a very slight blue hue. Other available colors are zinc yellow (ZC), zinc black designated ZB, and blue designated BZ. Red, green and other colors are also available by this method, but do not currently have assigned PEM® designations.

In addition to zinc, colored chromates are also applicable to other plating metals that use a supplementary conversion process such as cadmium and zinc alloys.

Although the zinc rich coatings discussed in section E above are typically silver in color, some are also available in other colors. Many of these use a topcoat which can be dyed to achieve other colors.

Steel parts can also be blackened by the chemical black oxide process (BO designation) and the black nitride process (BN designation) both discussed in section I above.

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Lubricity and Anti-Galling Considerations (sections K and L)

Section K – Aluminum Panels, Aluminum Fasteners, Lubricity and Anti-Galling Considerations

Although not as well-known as stainless steel thread galling, mating aluminum threads can also gall under certain conditions. A simple way to prevent aluminum thread galling is to apply one of the commercially available lithium-based aluminum thread lubricants to one of the mating threads prior to assembly. A less labor intensive solution is to anodize one or both of the mating components. Optimum protection from thread galling can be obtained with hard coat anodizing plus a lubricant applied as an integral part of the outer portion of the anodize layer.

Section L – All Panels, Steel and Stainless Steel Fasteners, Lubricity and Anti-Galling Considerations

There are three common reasons for adding a lubricating finish to a threaded fastener. These include:

- Improving prevailing torque performance of locknuts.
- Improving torque-tension performance.
- To prevent galling.

Most lubricating finishes offer some benefit in each of these areas. The standard finish on all of PennEngineering's steel and stainless steel all-metal (as opposed to nylon element) 15 cycle locknuts is a dry film lubricant containing molybdenum disulfide and antimony trioxide. Dry film lubricants can also be applied to non-locking threaded fasteners to prevent galling or improve torque-tension performance. Accommodations for film thickness may have to be made using nonstandard thread sizing and even with special thread sizing not all parts will gage freely. A noteworthy disadvantage of dry film lubricants is the possibility of conductive debris being generated from repeated assembly and disassembly.

A second way to apply a lubricating finish to steel and stainless steel is to plate with a metal that has inherent lubricity. Cadmium is most widely known for its lubricity, but is increasingly limited by environmental regulations such as RoHS and REACH. Interestingly, although not known for lubricity, thick zinc plating on one of the threaded members has proven effective in preventing galling of mating stainless steel threads. In most cases stainless steel must have a nickel strike applied prior to plating it with one on the above metals. Tin plating also provides lubricity.

A third way to add lubricity is to apply one of many specially formulated topcoats designed to provide specific torque-tension characteristics. Topcoats are common for zinc-rich coatings such as Dacromet® and Geomet®. They are also common for electroplated finishes which protect sacrificially such as cadmium, zinc and zinc alloy.

For finishes using a conversion coating (chromate or passivation), the lubricating topcoat is either integral with the conversion coating or is applied after it. The designated LZ finish used on type HNL locknuts and type SFW fasteners is zinc with an integral lubricant. The LZ finish should be considered for zinc plated parts used in applications where additional lubricity is needed. In many cases a topcoat can be used in conjunction with a plating which has inherent lubricity.

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Although not the topic of this Tech Sheet, it should be noted that galling of mating stainless steel threads can also be addressed by mating different grades of stainless with different hardness and/or by using certain stainless alloys which are specifically designed to be anti-galling.

Finishing after Fastener Installation Considerations (sections M, N and O)

Note: Sections O, M and N only address fastener finish selection issues related to finishing an assembly of a metal panel with self clinching fasteners installed. There are other important issues to consider, please see Tech Sheet PEM® - REF/Surface Finishing Sheet Metal Assemblies (http://www.pemnet.com/design_info/techsheets/Surface_Finish.pdf) for a complete discussion of all major issues.

Section M – Aluminum Panels, Aluminum Fasteners, and Panel Finishing after Fastener Installation Considerations

There are two major finishing methods for aluminum panels with aluminum fasteners installed. These include a conversion coating (aka Alodine® or chem film) and anodizing. For both of these processes it is recommended that the fasteners have a plain finish. This gives the assembly the best chance for optimal final appearance. However, because the fastener is typically a different alloy than the panel, final appearance of the fastener may be slightly different from the panel after being processed as an assembly.

Section N – All Panels, Steel Fasteners, Panel Finishing after Fastener Installation Considerations

The most common finishing process for installed steel fasteners is to zinc plate them along with a steel panel. For this process there is a slight advantage to purchase them without plating. This way the plating does not need to be stripped from the fasteners before plating the assembly.

However there are several disadvantages of unplated steel fasteners. These include reduced shelf life and difficulty feeding in automatic installation equipment.

When unplated steel fasteners are provided, a rust preventative oil is typically applied. However since too much or too little oil can present problems with automatic feeding or shelf life respectively, a copper flash plating is the better alternative. The copper flash provides better corrosion protection during storage than rust preventative oil and unlike zinc plating, does not need to be completely stripped prior to plating. In most panel plating processes the pre-treatment process for the steel panel will activate the copper so that it will accept plating.

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Section O – All Panels, Stainless Steel Fasteners, Panel Finishing after Fastener Installation Considerations

The most common finishing process for stainless steel panels is passivation. If the panel has welds there may need to be a pickling process prior to passivation to remove oxides from the welds. If the panel will be passivated or pickled and passivated with stainless steel fasteners installed, the stainless steel fasteners must have our standard finish of passivated and/or tested. Stainless steel locknuts with dry film lubricant or any stainless steel fastener with a black finish cannot be installed prior to passivation of a stainless steel panel. These finishes will be severely damaged by the passivation process.

Summary - The standard finish will provide adequate protection in most applications and should be the first consideration. Standard finishes are more cost effective and generally available from your PEM® authorized distributor. Non-standard finishes are then available if the standard finish will not provide the protection for your specialized application.

This Tech Sheet provides guidance for choosing these and other finishes that may be required. For practical reasons, not all potential situations can be covered in a Tech Sheet. It is understood that there may be other considerations in choosing a fastener finish. For design considerations or materials not covered here, please contact techsupport@pemnet.com.