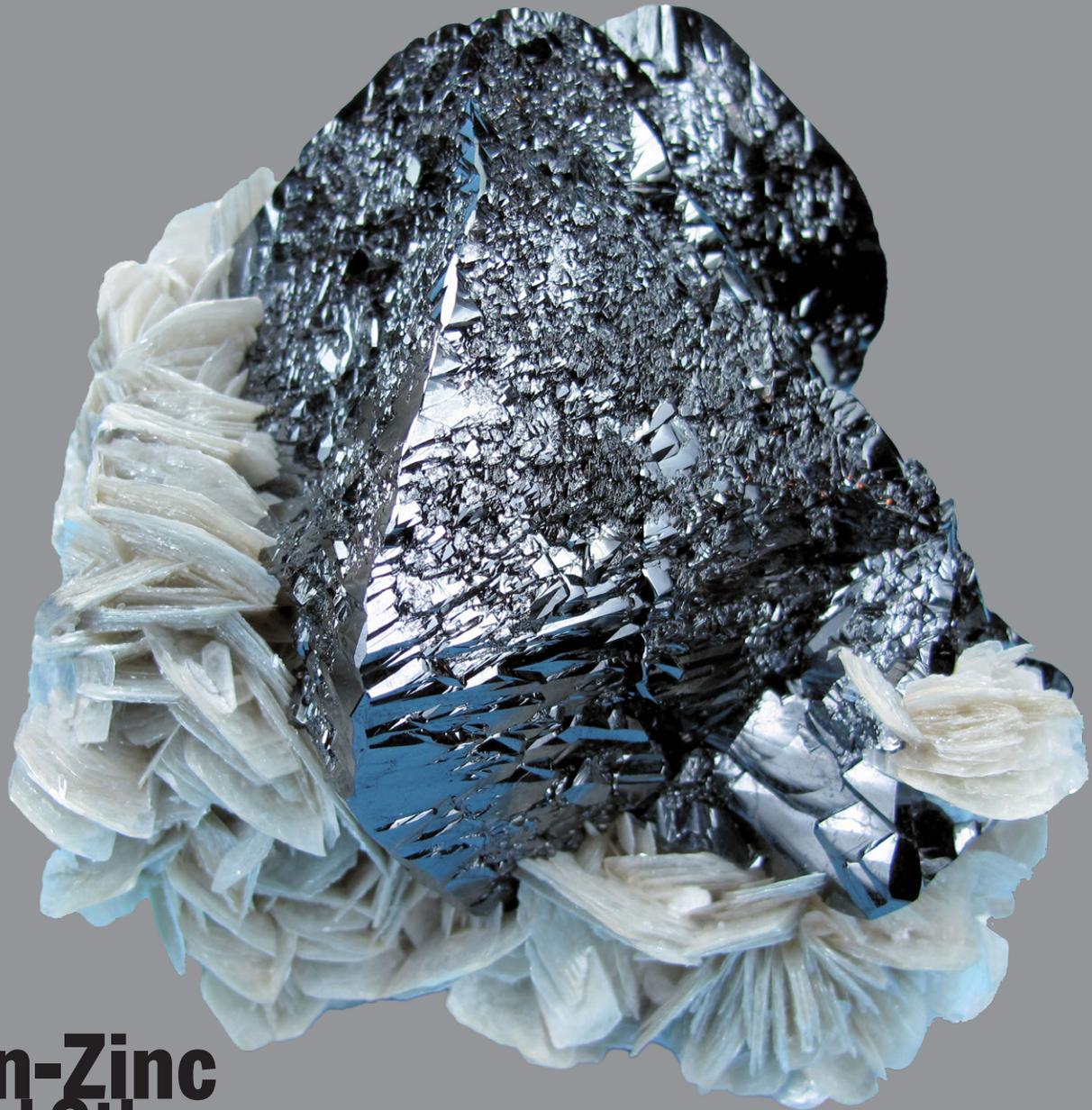


QwikConnect

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**Tin-Zinc
and Other
Glenair
Material
Innovations**



Tin-Zinc and Other Glenair Material Innovations



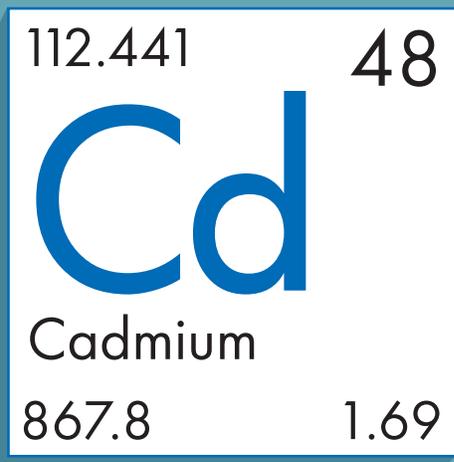
Corrosion Protection Treatments

Fighting corrosion is a perennial struggle in electrical interconnect systems. Glenair has developed a broad range of technologies and techniques to win the battle in even the harshest application environments. Our objective is always to build parts which meet industry standards and provide years of service. Corrosion-proof composite thermoplastic solutions, austenitic stainless steels, and durable finish platings are at the forefront of our efforts to solve corrosion problems before they can affect the safe operation of high-reliability interconnect systems.

Plating is the protective coating of materials, or combinations of materials subject to corrosion, with electro- and electroless-deposited metals and other substances. Certain plating systems, such as Nickel-fluorocarbon polymer, function as a cathodic barrier finish to protect vulnerable substrate materials. As long as the protective coating is unbroken, corrosion is held at bay. In real world applications however, parts get nicked, scratched and worn with use. The best plating systems therefore are “sacrificial,” meaning they halt corrosion by giving up their metals to interfere with the ionic current flow that would otherwise rust the part needing protection. Sacrificial plating systems continue to provide both corrosion protection and conductivity even when scratched or worn-down to the base material (typically aluminum alloy).

Because of its conductive and corrosion resistant qualities, electroplated cadmium has historically been applied to interconnect components on commercial and military land, sea and air systems. Cadmium provides up to 1000 hours of sacrificial corrosion protection and excellent lubricity and resistance to galling for threaded applications.

Cadmium, a chemical element with the symbol Cd and atomic number 48, is a silver-white metal with a melting temperature of 321°C. When heated above this temperature, for example in a vehicle fire, cadmium oxide fumes may be emitted. These fumes are considered to be dangerous to the environment and human health, which is why industry research and development has focused on finding a suitable replacement for Cadmium-based plating systems. While the reduction and eventual elimination of cadmium is a laudable goal, replacement materials must deliver equal or better levels of performance to be qualified by the DLA and other controlling agencies.



Connectors and accessories for mission-critical applications are subject to rigorous salt spray testing to ensure reliable performance in harsh environments



On the cover: Cassiterite (SnO₂) with muscovite (mica) crystals. Cassiterite is a tin oxide mineral, and is the most important source of tin ore.

Source: CarlesMillan, from Wikimedia Commons. Distributed under the Creative Commons Attribution-Share Alike 3.0 Unported license. The photo subject has been clipped from its background.

Controlling Specifications and the Move Away from Cadmium

As a result, military and related industry specs have been revised, including the “grand-daddy” of specifications for backshells and accessories, AS85049, controlled by the Society of Automotive Engineers (SAE). MIL-DTL-38999L, published in May 2008, and MIL-DTL-83513, published in October 2008, were among the first military connector specifications to specifically call for new non-cadmium plating options for connectors and accessories. These were among the most important mil-specs controlling circular and rectangular military interconnects to instigate the move away from Cad. MIL-DTL-28840, the controlling mil-spec for shipboard, high density circular interconnects, followed suit and was also revised to include both new barrier as well as sacrificial plating systems. Initially these specification revisions settled on the following new plating systems:

Code P: Pure electrodeposited aluminum, conductive, temperature rated -65°C to 175°C, in accordance with MIL-DTL-83488, Type II, to withstand 1000 hours of dynamic salt spray testing.

Code T: Nickel fluorocarbon polymer over a suitable underplate, conductive, temperature rated -65°C to 175°C, to withstand 500 hours of dynamic salt spray testing, and

Code Z: Zinc nickel in accordance with ASTM B841 over a suitable underplate, conductive, temperature rated -65°C to 175°C, to withstand 1000 hours of dynamic salt spray testing. Color shall be matte black.

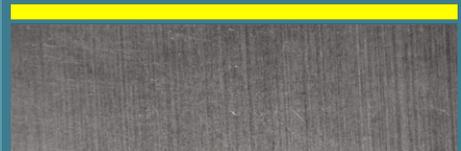
But shortcomings with the above choices led Glenair material scientists to pursue and qualify an additional new plating system, Tin-Zinc, that better matches the desirable properties of Cadmium. The Glenair process was the first to be qualified to MIL-DTL-28840 and the German Military VG specification. A sacrificial system, Tin-Zinc is arguably the first RoHS and REACH plating system that effectively replaces cadmium. Before we look at the particulars of the new Tin-Zinc process, it is worthwhile to discuss the nature of conductive plating systems in more detail.



Plating Types



Non-Conductive
Suitable for controlled to harsh environments
No EMI/RFI shielding
Extended corrosion resistance life



Barrier Finish
Controlled environments only
Continuous conductivity
Non-outgassing



Sacrificial Finish
Suitable for controlled to harsh environments
Best corrosion protection
Cadmium is the benchmark

Tin-Zinc and Other Glenair Material Innovations



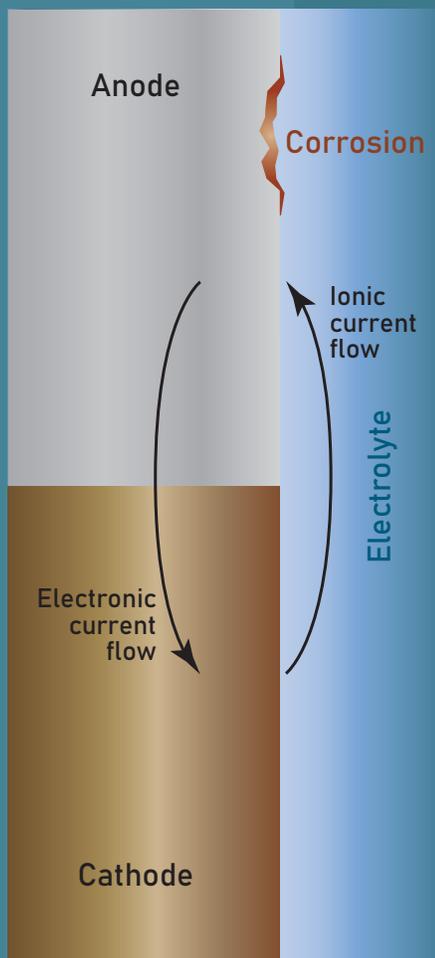
Plating for Conductivity

In our electrical interconnect industry, the problems associated with corrosion are compounded by the need to produce parts that are electrically conductive. As we all know, it is the conductive properties of plated connectors and backshells which prevent electromagnetic interference (EMI) from disrupting the flow of data throughout the interconnect system. To prevent EMI from permeating into the system, conductive cable shielding is grounded to plated connectors and accessories to take the unwelcome EMI harmlessly to ground. If metal connectors and accessories could be produced without the need for conductive surface platings, corrosion in interconnect systems would be a much easier problem to resolve. Conductive surface platings themselves significantly compound the difficulty of preventing interconnect system corrosion.



Cable shielding is grounded to conductively-plated connectors to prevent EMI

The Corrosion Process



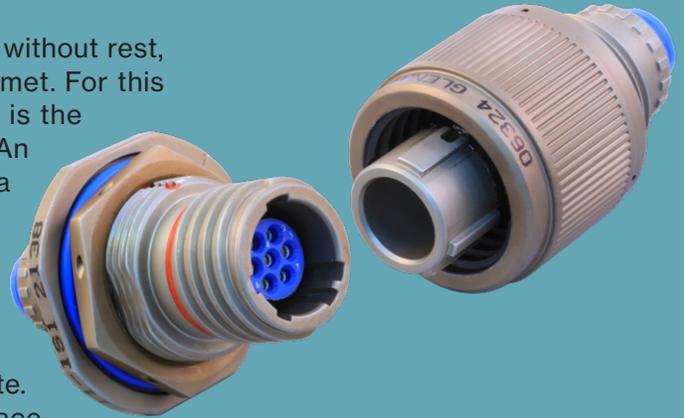
The electrochemical corrosion process: Electrons migrate along the metallic path from the Anode to the Cathode. Positively-charged atoms remain in the anode and combine with negatively-charged ions in the environment to form rust.

All matter is electrical by nature. Everything – from your body’s nervous system to the earth itself – has electrical properties since all matter is made up of atoms which in turn are composed of protons, neutrons, and electrons. The center, or nucleus of the atom, is composed of positively charged protons and neutral neutrons. The process of corrosion takes place at this most basic molecular level. To be a bit more exact, the corrosion process is electrochemical in nature; for the process to occur several specific conditions must be met, and not all are solely electrical:

- There must be a positive or anodic area, the “anode.”
- There must be a negative or cathodic area, the “cathode.”
- There must be a path for ionic current flow, the “electrolyte.”
- There must be a path for electronic current flow, which is normally a “metallic path.”

The electrical pressure between the anode and the cathode results in a migration of electrons from one to the other along the metallic path. With the loss of electrons, positively-charged atoms remain at the anode, combining with negatively-charged ions in the environment to form, in the case of steel parts, ferrous hydroxide, or rust. In most interconnect applications the role of the ionic current flow is played by the atmosphere, rain, or salt spray on ships. The rate at which metal is removed by the corrosive process is measured in Mass Loss per Unit Area, and is driven by current density (Microamp per Centimeter Square). In interconnect applications the conductor for this electrical current can be the mating point of the various subcomponents – such as fasteners, bands and braids – or the threaded interface between the backshell and connector. But the metallic path for the current flow can also be between the shell of the component and its own metallic surface plating.

The corrosion process described above will continue without rest, until one or more of the four conditions is no longer met. For this reason, the elimination of one of the four conditions is the very heart and soul of corrosion prevention efforts. An unbroken (perfect) protective coating on the surface of a metal part will, for example, prevent the electrolyte from connecting the cathode and anode and so eliminate the ionic current flow. Sacrificial anodes, to cite another example, can halt corrosion by integrating an alternative metal material into the metallic path (usually zinc) to halt corrosion of the more valuable, protected substrate. Perhaps the ultimate solution to corrosion is to replace the metallic materials with engineering plastics, essentially eliminating the anode from the equation altogether. Dissimilar metals are the most frequent cause of unexpected corrosion failures in marine environments, which is why Glenair’s composite components are of such value in systems subject to salt spray, stack gas and other corrosive electrolytes.



Glenair Tin-Zinc plated MIL-DTL-28840 qualified connectors. This new cadmium-free, RoHS finish is compatible with legacy finishes, and offers high conductivity and shielding performance, and robust corrosion resistance.

Tin-Zinc: a High-Performance Alternative

Tin-Zinc is a RoHS cadmium-free sacrificial finish that offers high conductivity and shielding performance, corrosion resistance, solderability, and proven compatibility with legacy cadmium and zinc-nickel finishes. The plating system, which is a chromate-conversion-coated tin-zinc alloy over an underplating of electroless nickel, performs well in SO₂ / salt spray qualification testing and has the following features and benefits:

Tin-Zinc, the new DLA-qualified replacement for Cadmium

- Now qualified as cadmium-free and compatible tin-zinc (TZ) plating for M28840 class code L and M (class T and TJ) navy land and maritime applications.
- High conductivity and shielding performance in harsh maritime conditions
- High corrosion resistance
- Compatibility with legacy cadmium-plated connectors and environmental shrink boots
- RoHS-compliant material

HIGH CONDUCTIVITY AND SHIELDING PERFORMANCE:	
High conductivity and shielding performance	VG95234 Code J Tin-Zinc plating shield connection average value: 0.5 mohm (VG95234 with legacy Cadmium plating shield connection average value: 1.5 mohm)
Shielding performance not degraded after:	Durability (500 mating cycles) + dry heat (16 hours at 125°C) + cold (16 hours at -55°C) + humidity (672 hours at 40°C 93%) Cycling Salt spray (5 days 2hrs salt spray + 22 hours humidity)
Compatibility with heat shrink boots of Cadmium plated connectors:	Tested with the following environmental heat shrink boots: VG95343T06 (without inner coating) VG95343T18 (with inner coating) VG95343T28 (without inner coating, halogen free) VG95343T29 (with inner coating, halogen free)
RoHS Compliance	Tin-Zinc is a Cadmium-free RoHS material
High Corrosion Resistance	Tested up to 2000 hrs. of salt spray

Galvanic Corrosion and the Case for Composites

Anyone who has ever worked on an old steel-frame road bike with aluminum parts knows the “dissimilar metals” effect. The mix of aluminum parts and chromoly-steel led to some monstrous galvanic corrosion – the electrochemical action of two dissimilar metals in the presence of an electrolyte (salt sweat) and an electron conductive path.

Such galvanic action is a principal corrosion problem in electrical interconnect systems. Specifically, the galvanic corrosion between the base metal of a part and its conductive plating. One way to solve this corrosion challenge is to specify composite thermoplastics for connectors and backshells. Composite thermoplastics offer unlimited corrosion resistance. Conversely, aluminum interconnect components

are always at risk from galvanic corrosion when their protective finish breaks down or gets damaged. Substituting composite plastic for the aluminum eliminates conditions required for this type of corrosion to occur.

Glenair has a responsibility to deliver interconnect systems and hardware without “built-in” corrosion problems. To prevent corrosion problems in backshells, for example, engineers use their thorough understanding of design and materials science to produce conductive, plated products which both prevent EMI and resist corrosion in harsh application environments. The simplest solution to this challenge by far is the specification of composite materials in place of metal.



Glenair innovative composite thermoplastics: a low-profile, split-shell banding backshell, 45° and 90° entry backshells for rectangular D-Sub connectors, and a cathodic-delamination-proof high-pressure underwater overmolded plug and receptacle.

Electro- and Electroless Plating

Electro-depositing, or “electroplating,” is the coating of an object with a thin layer of metal using electricity. The metals most often used are gold, silver, chromium, copper, nickel, tin, cadmium, and zinc. The object to be plated, called the “work,” is usually a different metal, but can be the same metal or even a nonmetal, such as a composite thermoplastic.

Electroplating usually takes place in a tank of solution containing the metal to be deposited on the work. When these electroplating chemicals dissolve, the atoms move freely, but lose one or more negatively-charged electrons and, as a result, become positively charged ions. Although ions are not visible to the naked eye, the solution may show some color; a nickel solution, for example, is emerald green.

The object to be plated is negatively charged by an electrical source and attracts the positive metal ions, which coat the object, regain their lost electrons and become metal once again.

Another process called electroless-deposited plating operates without using electricity. The action is purely chemical and, once started, is autocatalytic (it runs by itself). Electroless plating enables metal coating of other metals as well as nonconductive materials, such as plastics and ceramics. Composites and other non-conductive materials must be metalized in an electroless process before they can be electroplated.



Many effective protective coatings utilized in the interconnect industry employ a combination of two or more finish materials in order to create a physical barrier between joining parts and to prevent galvanic corrosion due to dissimilar metals. The approved U.S. Navy finish, chromated cadmium over electroless nickel, is the most common finish of this type provided by Glenair. Other choices include chromated zinc-nickel and tin-zinc

Passivation

Stainless steel parts require a special finish treatment known as “passivation.” The chromium content of stainless steel causes the natural formation of an invisible, corrosion-resisting chromium oxide film on the steel surface. If damaged mechanically or chemically, this film is self healing as long as oxygen is present. The protective quality of this oxide film layer can be enhanced by passivation.

According to ASTM A380, passivation is “the removal of exogenous iron or iron compounds from the surface of stainless steel by means of a chemical dissolution, most typically by a treatment with an acid that will remove the surface contamination, but will not significantly affect the stainless steel itself.” The ASTM spec goes on to describe passivation as “the chemical treatment of stainless steel with a mild oxidant, such as a nitric acid solution, for the purpose of enhancing the spontaneous formation of the protective passive film.” Passivation removes “free iron” contamination left behind on the surface of the stainless steel from casting, machining, and other secondary operations. These contaminants are potential corrosion sites if not removed.



Passivated stainless steel finish on a PowerLoad plug (top) and a pressure-boundary firewall feed-thru (bottom)

Anodization

Anodizing is an electrolytic process that places aluminum oxide films on aluminum. The resulting coating is uniform, much harder, and denser than natural oxidation. It is formed by converting the surface of the part with a simultaneous penetration and build-up of aluminum oxide. Unlike paint, which can flake off if not applied properly, anodized finishes are actually formed from the base material and cannot flake off. The aluminum oxide finish is very hard and exceptionally wear resistant. The aluminum can also be dyed at the end of the anodizing process for a colored finish. Anodized parts are non-conductive.

Electrodeposited Paint or Electroplating

Electrodeposited paint, also referred to as electrocoating, electrophoretic deposition, or electropainting, is an organic finishing process that uniformly applies thin-film primers and one-coat finishes to metallic substrates. Electrodeposited paint resembles electroplating by using electric current to deposit a coating onto substrates. However, electrocoating deposits waterborne paint onto substrates rather than metal ions.

Because of the uniformity of the applied coating, and excellent adhesion properties, corrosion protection offered by electrodeposited paint is quite high on both steel and aluminum substrates. Corrosion testing performed by the National Defense Center for Environmental Excellence (NDCEE) has demonstrated exceptional performance when used as a primer in combination with both aerospace and chemical agent resistant coating (CARC) topcoats. Electrodeposited paint also offers reduced environmental impact associated with hazardous solvents, and solid/hazardous waste generation and disposal.

Glenair offers black electrodeposited paint finish on signal and power connection products such as the ITS connector series, based on MIL-DTL-5015 with reverse bayonet and threaded coupling options, and the IPT-SE connector series based on MIL-C-26482. Electrodeposited paint can also be specified for other Glenair products.



A pair of ITS 500 single-pole high current connectors with black electrodeposited paint finish

ChatGPT Interview on the subject of Tin-Zinc Plating



Recent developments in artificial intelligence (AI) have changed the way we source technical content. QwikConnect readers may be interested to read along with a chat we had on the OpenAI platform, ChatGPT on the subject of Tin-Zinc plating. Note: this is a verbatim transcript and should be enjoyed for information purposes only.

QC *QwikConnect: Regulations on the use of hexavalent chromium and cadmium in finish plating are expanding. How have the latest restrictions impacted the aerospace industry?*

ChatGPT: The recent restrictions on cadmium and hexavalent chromium in finish plating have had significant impacts on the aerospace industry which heavily relies on these materials for various applications such as corrosion resistance, electrical conductivity and lubrication, making it difficult to find suitable replacements. This has resulted in increased research and development costs, production downtime and supply chain disruptions, as well as the need to modify processes and supply chains to conform to the new regulations. The aerospace industry is working to develop alternative technologies and materials to replace these substances, but this transition will take time and resources.

QC *What new plating (finish) materials have shown promise for replacement of Cadmium?*

ChatGPT: Several alternative materials have shown promise as replacements for cadmium in finish plating. Some of the most promising alternatives include:

- 1) Zinc-Nickel:** Zinc-nickel is a popular alternative to cadmium, offering good corrosion resistance and electrical conductivity.
- 2) Tin:** Tin-based coatings are also gaining popularity as a substitute for cadmium, offering good solderability and corrosion resistance.
- 3) Aluminum:** Aluminum is a good alternative to cadmium for applications where light weight is a concern, as it is lightweight and offers good corrosion resistance.
- 4) Zinc-Iron:** Zinc-iron alloys are also being explored as alternatives to cadmium, offering good corrosion resistance and cost effectiveness.
- 5) Zinc-Aluminum:** Zinc-aluminum alloys offer a good combination of corrosion resistance, electrical conductivity and cost effectiveness.

These alternatives are still being tested and evaluated for their long-term performance, and further research and development may be required before they can fully replace cadmium in finish plating applications.

QC *You did not mention Tin-Zinc. Has this material gained inroads in US military specifications?*

 Yes, tin-zinc is another alternative material that has gained traction as a replacement for cadmium in finish plating. It has been adopted by several US military specifications as a replacement for cadmium, due to its good corrosion resistance and compatibility with various base metals. Tin-zinc coatings can be deposited on various metal surfaces, including steel, aluminum, and magnesium, and can offer a viable solution for applications where high corrosion resistance, solderability and conductivity are required.

Overall, tin-zinc is considered to be a promising alternative to cadmium, and its use is expected to continue to grow in the aerospace and military industries, as well as other industries where high-performance coatings are required.

QC *Is Tin-zinc a sacrificial or barrier type of surface finish?*

 Tin-zinc plating is a sacrificial type of surface finish. In other words, it is a coating that corrodes preferentially to the substrate, thereby protecting the substrate from corrosion.

Tin-zinc plating works by corroding in a controlled manner, forming a protective layer of zinc oxide and tin oxide on the surface of the coating. This protective layer acts as a barrier to prevent further corrosion of the substrate, making tin-zinc an effective solution for improving corrosion resistance in harsh environments.



In comparison, barrier type finishes, such as anodizing or electroless nickel, work by forming a dense, impermeable layer on the surface of the substrate that acts as a barrier to prevent corrosion. These finishes do not corrode preferentially to the substrate, and therefore do not provide ongoing protection in the same way that a sacrificial finish does.

QC *We understand NAVSEA has qualified Tin-Zinc for use in M28840 series connectors. Do you have any information on this development?*

 Yes, the US Navy's Naval Sea Systems Command (NAVSEA) has indeed qualified tin-zinc for use in M28840 series connectors. This development is significant, as it demonstrates the confidence of the military in tin-zinc as a replacement for cadmium in high-performance applications.

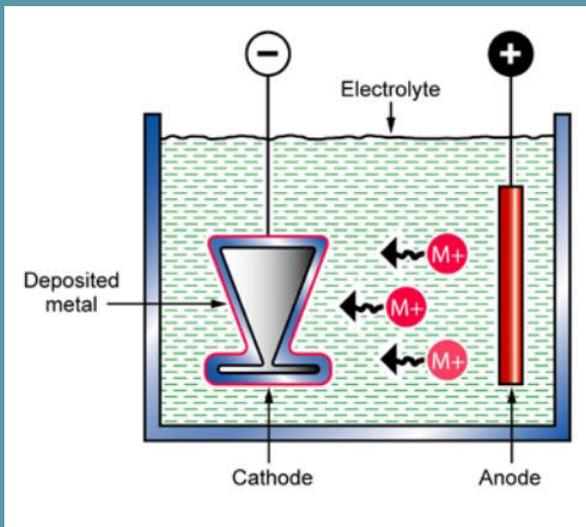
The qualification of tin-zinc for use in M28840 series connectors by NAVSEA indicates that the material has been thoroughly tested and meets the rigorous performance requirements of military specifications. This will likely result in increased adoption of tin-zinc in other military and aerospace applications where high-performance coatings are required.

Tin-zinc is considered to be a viable alternative to cadmium due to its good corrosion resistance and compatibility with various base metals. The qualification of tin-zinc by NAVSEA for use in M28840 series connectors confirms that it can provide the performance and durability required in high-stress military and aerospace applications.

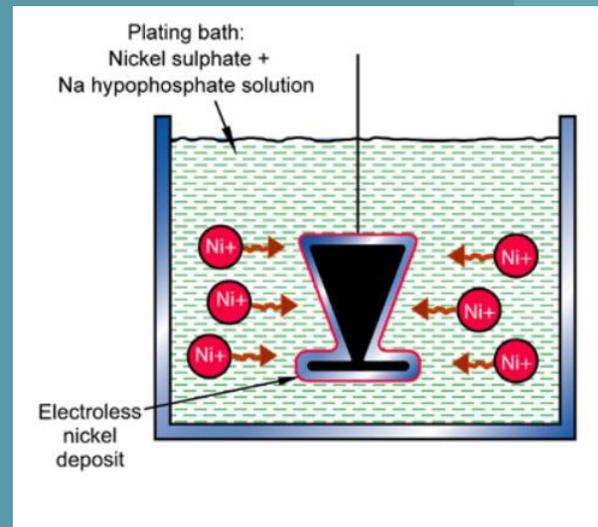
QC *Has the MIL-DTL-38999 connector specification also qualified Tin-Zinc as a suitable finish plating?*

 Yes, the MIL-DTL-38999 connector specification has also qualified tin-zinc as a suitable finish plating material, although the final release of the new specification listing Tin-Zinc has not yet been released. The MIL-DTL-38999 specification is a military standard for circular electrical connectors, and its qualification of tin-zinc as a finish plating material demonstrates its suitability for use in high-performance military applications.

The use of tin-zinc in MIL-DTL-38999 connectors provides several benefits, including good corrosion resistance, compatibility with other plating types, and improved solderability. Tin-zinc is considered to be a cost-effective alternative to cadmium, and its



Electroplating process schematic



Electroless nickel process schematic

qualification by the MIL-DTL-38999 specification is expected to result in increased adoption of tin-zinc in the aerospace and military industries, as well as other industries where high-performance coatings are required.

Overall, the qualification of tin-zinc by the MIL-DTL-38999 specification is a positive development for the aerospace and defense industries, and demonstrates the growing confidence in tin-zinc as a replacement for cadmium in high-performance applications.

QC *Is Tin-Zinc applied in an electroplating or electroless plating process?*

QC Tin-zinc is typically applied through an electroplating process. In this process, a layer of tin and zinc is deposited onto the surface of the substrate through the application of an electrical current.

The electroplating process for tin-zinc typically involves several stages, including surface preparation, activation, plating, and post-treatment. During the activation stage, the surface of the substrate is treated to increase its reactivity, allowing for better adhesion of the tin-zinc coating. In the plating stage, an electrical current is applied to the substrate, causing the tin and zinc to be deposited onto the surface. Finally, the post-treatment stage may involve processes such as passivation, to improve the corrosion resistance of the coating.

In comparison, electroless plating is a process in which a metal coating is deposited onto the surface of a substrate without the use of an electrical current. Electroless plating is typically used to deposit uniform, consistent coatings onto complex

or irregularly shaped surfaces, and is not commonly used for tin-zinc plating.

QC *You mentioned compatibility with other materials. Would a Tin-Zinc plated part be galvanically compatible for combined use with older cadmium-plated parts?*

QC Galvanic compatibility refers to the potential for corrosion between two dissimilar metals when they are in electrical contact with each other in the presence of an electrolyte (such as salt water). When two dissimilar metals are in electrical contact, a galvanic cell is formed, and the metal with the more negative electrode potential corrodes preferentially.

Tin-zinc and cadmium are dissimilar metals, but combining them in a galvanic couple does not necessarily result in corrosion of one of the metals, as the two sacrificial components (zinc and cad) are approximately next to each other on galvanic index tables. Depending on the electrolyte and the relative electrode potentials of the two parts, little or no dissimilar metal corrosion may occur.

Overall, the extent of galvanic corrosion between tin-zinc and cadmium depends on several factors, including the specific electrolyte, the temperature, the concentration of the electrolyte, and the relative surface areas of the two metals. To minimize the risk of galvanic corrosion, it is always important to use suitable corrosion-resistant materials and coatings, and to consider factors such as the design and construction of the components and the environment in which they will be used. Ultimately, it is the responsibility of SAE and other certification agencies to determine mating compatibility of dissimilar components.

QC *How would you rate Tin-Zinc, compared to other finishes such as electroless nickel, when it comes to conductivity?*

 Tin-zinc has good conductivity for a surface finish, but it is generally not as conductive as electroless nickel. Electroless nickel is known for its high conductivity and uniform deposition, which makes it a popular choice for applications that require good electrical conductivity.

In comparison, tin-zinc plating typically has lower conductivity compared to electroless nickel. However, tin-zinc plating provides better corrosion resistance, which can be important in certain applications.

The choice between tin-zinc and electroless nickel as a surface finish will depend on the specific requirements of the application, such as conductivity, corrosion resistance, and cost. For applications that require high conductivity alone, electroless nickel may be the better choice, while for applications that also require good corrosion resistance, tin-zinc may be more suitable.

QC *Can Tin-Zinc be used as a surface finish for composite plastics, such as PEEK?*

 Yes, tin-zinc can be used as a surface finish for composite plastics such as PEEK (Polyether Ether Ketone). PEEK is a high-performance thermoplastic that is used in a variety of aerospace, medical, and industrial applications due to its excellent mechanical and thermal properties. To enhance its corrosion resistance, PEEK parts can be plated with tin-zinc using a process such as electroplating.

It is important to note that the plating process for composite plastics can be more challenging than for metals, as the surface of the plastic must be properly prepared to ensure good adhesion of the plating. In addition, the compatibility of the plating with the plastic must be carefully evaluated, as some plating processes can lead to degradation of the plastic.

To determine the suitability of tin-zinc plating for a particular composite plastic application, it is important to consider factors such as the required corrosion resistance, conductivity, and temperature tolerance, as well as the specific conditions and environment in which the components will be used. It may also be necessary to evaluate the compatibility of the plating with the plastic and the specific requirements for the plating process.

QC *Aluminum plating (alumni plate) was once considered a possible replacement for cadmium. Ditto Nickel-PTFE and Zinc-Nickel. Is Tin-Zinc now the leading replacement for RoHS compliance?*

 Tin-zinc is considered one of the leading replacements for cadmium in terms of RoHS (Restriction of Hazardous Substances) compliance. The RoHS Directive restricts the use of certain hazardous substances in electrical and electronic equipment, including cadmium, which has been widely used in aerospace and other industrial applications for its corrosion resistance and conductivity.

Tin-zinc is considered a more environmentally friendly alternative to cadmium, as it does not contain hazardous substances and is considered safe for use in electrical and electronic equipment. As a result, tin-zinc has gained popularity as a surface finish for aerospace and industrial applications that require RoHS compliance.

Other alternatives to cadmium, such as aluminum plating, nickel-PTFE, and zinc-nickel, are also used as surface finishes in some aerospace and industrial applications. However, tin-zinc is now preferred due to its combination of good corrosion resistance, conductivity, and temperature tolerance, as well as its suitability for use with a wide range of metals and alloys. The specific requirements of each application will determine the most suitable surface finish, and a combination of factors, including cost, processability, and compatibility with other materials, should be considered.

QC *Thanks for the chat. May we share it with others?*

 Yes, you may share this chat with others. Just keep in mind that this information is not intended for professional advice and is provided for general information purposes only.



TECHNICAL WHITEPAPER

Anodic versus Cathodic Finishes for Corrosion Protection of Aluminum Substrates in Interconnect Applications

The following is a technical white paper from August 2022 authored for a DLA discussion on proposed new finish classes for 38999 and other connector specifications, written by Ty Geverink; Product Manager, member Senior Technical Staff, Glenair, Inc.

Abstract

Efforts to replace cadmium surface plating and other materials have been ongoing for over twenty years. Historically, chromate-conversion-coated-cadmium over an underplating of electroless nickel was the only available finish capable of meeting the conductivity and long-term corrosion protection requirements of aluminum alloy interconnect components – particularly the harsh-environment requirements defined in military and aerospace standards. A handful of alternatives to cadmium emerged in response to RoHS and REACH initiatives to eliminate (or at least reduce) the use of target materials – with nickel-fluorocarbon polymer and zinc-nickel alloy emerging as the most popular. In more recent years, additional alternatives have been developed that are being considered for adoption into various interconnect product specifications.

This paper will examine the fundamental differences between these cadmium-alternative finishes with a focus on how the respective processes achieve corrosion protection. Current testing methodology and pass/fail criteria will also be explored to evaluate theoretical shortcomings versus real-world conditions.

Background

Aluminum is the most widely used substrate material in military and aerospace connector applications for its relatively light weight, strength, electrical and thermal properties, low cost, abundant supply, and ease of manufacturing. Un-protected aluminum however is highly active (anodic) making it susceptible to loss of electrical conductivity due to oxidation and severe corrosion in harsh environments. The successful application of aluminum in Electrical Wire Interconnect Systems (EWIS) is owed in large part to the ability of applied conductive coating/plating processes to enable retention of Al conductivity, and dramatically improve the material's corrosion resistance – critical requirements for life-of-system survival in harsh application environments – such as aerospace and defense.

Typical testing to validate surface finish effectiveness in meeting these electrical conductivity and corrosion performance requirements includes:

- 1) Corrosion resistance:** Exposure to neutral salt-spray / salt fog (NSS) alone (static salt-spray), or in combination with mating cycle durability (dynamic salt-spray) for evaluation of corrosion resistance for durations of between 48 and 1,000 hours of exposure. Additional proposed testing may include a separate exposure to acidified salt-spray/fog (SO₂) for up to 336 hours.
- 2) Conductivity:** Measurement of (connector) shell-to-shell or backshell to connector voltage drop, both before and after corrosion resistance testing.

It should be noted that “accelerated” laboratory testing results may not adequately simulate actual field conditions that may include combinations of handling, minor physical damage, temperature extremes, or exposure to debris including ice or blowing dust/sand.

Characteristics of Anodic and Cathodic Finishes

Coating/plating systems can be described as either anodic (sacrificial) or cathodic (barrier) finishes. To understand the distinction, it is important to consider the materials galvanic potential in the most likely environmental medium. **Table 1** ranks commonly used materials according to a measured voltage in a medium of seawater. The corrosion tendency for materials listed towards the top is considered cathodic or “noble” and they are generally slower corroding. As the voltage potential decreases towards the bottom of the table, materials become increasingly more anodic or “active” and susceptible to oxidation and faster corroding. (e.g., Gold is cathodic while Zinc is anodic.)

Galvanic corrosion is one of the most pervasive and progressive types of corrosion. There are four fundamental components to form a galvanic electrochemical corrosion cell: an anode, a cathode, an electrolyte and an electrical connection between the anode and cathode for the flow of electrons. The basic concept for most methods of corrosion protection is to remove one or more of these cell components so that the pure metal or metal alloy of interest will not corrode⁽²⁾. It is important to take a closer look at the anodic or cathodic potential for materials of interest, applicable to this discussion

Anodic (sacrificial) finishes are also rather non-intuitively referred to as “cathodic protection” because the anodic finish protects the more cathodic substrate by sacrificial corrosion. Cathodic protection of the substrate by sacrificial corrosion of the coating.

For example, zinc and/or cadmium coatings are electronegative (or anodic) to steel⁽²⁾. The mechanics of this corrosion protection system are shown in **Figure 1**. The reaction in this process involves zinc

giving up electrons to the steel substrate and zinc leaving the matrix as an ion. The steel substrate then passes on the electrons gained from zinc to the hydrogen and therefore remains protected.

GROUP NUMBER	METALLURGICAL CATEGORY	EMF (V)	ANODIC INDEX (0.01 V)	COMPATIBLE COUPLES ¹
0	Inorganic carbon (carbon fibers, graphite, graphene, etc.) ²	+0.30	0	○
1	Gold, solid or plated; gold-platinum alloys; wrought platinum	+0.15	15	● ○
2	Rhodium plated on silver-plated copper	+0.05	25	● ○
3	Silver, solid or plated; high silver alloys	0	30	● ○
4	Nickel, solid or plated; Monel® metal; high nickel-copper alloys; Titanium and Titanium alloys, Inconel® alloys, Hastelloy® C276	-0.15	45	● ○
5	Copper, solid or plated; low brasses or bronzes; silver solder; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion-resistant steels	-0.20	50	● ○
6	Commercial yellow brasses and bronzes	-0.25	55	● ○
7	High brasses and bronzes; naval brass; Muntz metal	-0.30	60	● ○
8	18 percent chromium type corrosion-resistant steels	-0.35	65	● ○
9	Chromium plated; tin plated; 12 percent chromium-type corrosion-resistant steels	-0.45	75	● ○
10	Tin plate; terneplate; tin-lead solder	-0.50	80	● ○
11	Lead, solid or plated; high lead alloys	-0.55	85	● ○
12	Aluminum; wrought alloys of the 2000 series	-0.60	90	● ○
13	Iron, wrought, gray, or malleable; plain carbon and low-alloy steels; Armco® iron	-0.70	100	● ○
14	Aluminum, wrought alloys other than 2000 series aluminum; cast alloys of the silicon type	-0.75	105	● ○
15	Aluminum, cast alloys other than silicon type; cadmium, plated and chromated	-0.80	110	● ○
16	Hot-dip zinc plate; galvanized steel	-1.05	135	● ○
17	Zinc, wrought; zinc-base die-casting alloys; zinc, plated	-1.10	140	● ○
18	Magnesium and magnesium-base alloys, cast or wrought	-1.60	190	●

Notes:

1. ○ indicates the most cathodic member of the series, ● indicates an anodic member. Arrows indicate the anodic direction. All corrosion-resistant steel (CRES) in this table is passivated. 2. All conductive carbon forms, including structures and coatings comprised of carbon composites, carbon fibers, graphite, pitch carbons, carbon black, vitreous carbons, carbon/carbon, graphene, phenolic-impregnated carbon ablative (PICA) materials, etc.

Table 1: Metallurgical Category vs. Electro-Motive Force with Respect to SCE in Seawater(1) from NASA-STD-6012A

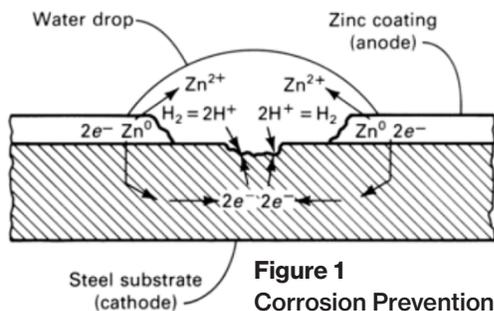


Figure 1
Corrosion Prevention of Sacrificial Protection ⁽²⁾

The corrosion penetration occurs parallel with the substrate. This protection remains effective even when voids, pores or defects are present in the coating.

Cathodic (barrier) finishes provide corrosion protection by providing a more corrosion-resistant cathodic barrier coating between the environment and the less corrosion-resistant anodic substrate. The success of this system in providing corrosion protection relies on effectively sealing the substrate so only the slower-corroding cathodic coating is exposed to the environment, and no galvanic action between the coating and substrate can occur. To accomplish this, the coating must be free of porosity or other defects.

In corrosive environments accelerated corrosion of the substrate occurs if cathodic coating fails to protect the substrate⁽³⁾. The corrosion mechanics of a breached barrier system can be seen in the example of a nickel coating over a steel substrate shown in **Figure 2**. The reaction in the process of this system includes the steel substrate giving up electrons to the more noble Nickel coating which passes these on to hydrogen, and results in steel leaving the matrix as an ion. As a result, the noble coating is protected, instead of the steel substrate and the corrosion penetration occurs perpendicular to the substrate and propagates laterally below the coating. Unlike sacrificial protection, any defects or damage introduced to the coating can result in catastrophic failure.

Application Considerations

Historically, interconnect product specifications have defined finish “classes” for aluminum material and corrosion performance requirements specific to those classes. In general, these performance requirements are representative of anticipated environments that include two categories: indoors or “protected environment” applications, and outdoors or “harsh environment” applications.

“Protected environment” applications include the interior of aircraft or Naval vessels which are typically not exposed to weather and associated corrosive

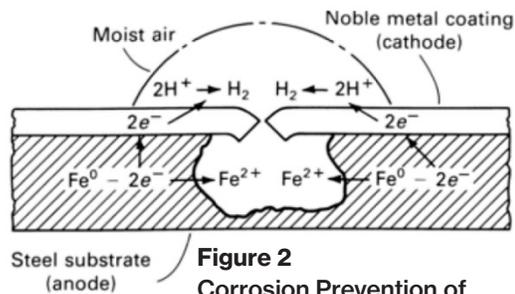


Figure 2
Corrosion Prevention of Barrier Protection ⁽²⁾

elements. For these applications, the predominant finish has been electroless Nickel, defined as finish class F in MIL-DTL-38999⁽⁴⁾ and finish class N in AS85049⁽⁵⁾. In this application environment, the cathodic barrier electroless Nickel finish protects the aluminum substrate from natural oxidation that could reduce electrical performance and provides resistance to 48 hours of static salt-spray testing to ensure limited corrosion protection. Consequences from aggressive handling or damage are not considered due to the generally limited exposure to electrolytes necessary for galvanic corrosion to occur.

“Harsh Environment” applications include locations such as the weather decks of Naval Vessels, external surfaces of military ground vehicles and equipment, and exposed (SWAMP zone) areas of aircraft. These frequently wet areas often include salt, chloride-sands, and other corrosive elements including exhaust gasses that can precipitate as acids. Harsh environments also anticipate rough treatment of interconnect components throughout the service life. For this reason, some military connector specifications for outdoors applications such as MIL-DTL-28840(8) or MIL-DTL-28876(9) have imposed testing for “Impact” among the qualification tests required for these connectors. Repeated exposure to impacts can chip or crack finishes, exposing the aluminum substrate. Far more corrosion protection is required to provide satisfactory performance over the anticipated service-life expectancy.

The predominant finish for this environment has been chromate-conversion-coated-cadmium over an underplating of electroless nickel, defined as finish class W in both MIL-DTL-38999⁽⁴⁾ and AS85049⁽⁵⁾. In this finish class, the aluminum substrate is first sealed with a cathodic undercoating of electroless nickel, followed by an outer layer finish of anodic, sacrificial, and Aluminum-compatible cadmium which is then passivated and sealed with a thin chromate-conversion coating. This system provides continued electrical performance and provides resistance to 500 hours of dynamic salt-spray testing that includes mating durability cycles to ensure continued corrosion resistance. The testing sequence currently does not

account for consequences from aggressive handling or damage; however, the anodic, sacrificial class W finish has proven to be satisfactorily immune from detrimental effects due to handling and damage.

The preferred condition for a harsh environment rated finish is where the outer finish is sacrificial to any undercoating(s) and if possible, to the base material. When considering aluminum as the base material, since it is highly reactive (anodic), an additional strategy is to more effectively seal the finish (to eliminate pores and/or micro-cracks) as a means of protecting the aluminum⁽⁷⁾. This may be accomplished by providing a durable cathodic barrier undercoating followed by an anodic sacrificial outer finish that is sacrificial to, or at least galvanically compatible within 0.15V to the Aluminum substrate.

Anodic and Cathodic Characteristics of Cadmium Alternative Finishes

Cadmium-alternative finishes first introduced in the early 2000s, that remain in active use today include Nickel-fluorocarbon polymer and black Zinc-Nickel alloy. More recently appearing in some interconnect product specifications is Tin-Zinc alloy. Intermateability testing between these alternatives and class W Cadmium finish is documented in AIR5919⁽⁶⁾. Pass/fail criteria to establish compatibility requires the different intermated connectors to meet the required performance testing. This is not necessarily indicative of actual galvanic compatibility; only that any galvanic potential between the finishes is not sufficient to cause a failure. These finishes have demonstrated the capability to meet requirements which do not include any tests that simulate damage to expose the Aluminum substrate which could be disastrous for a cathodic finish.

Nickel-fluorocarbon polymer, defined as finish class T in MIL-DTL-38999⁽⁴⁾ and finish class X in AS85049⁽⁵⁾. The outer layer coating of this finish is a co-deposit of electroless Nickel-Phosphorous alloy, and a fluorocarbon Polymer (PTFE). Nickel-Phosphorous alloy is quite cathodic compared to Aluminum with a galvanic potential differential of over 0.50V. This characteristic establishes Nickel-fluorocarbon polymer as a cathodic barrier finish.

Black zinc-nickel alloy, defined as class Z in both MIL-DTL-38999⁽⁴⁾ and AS85049⁽⁵⁾, provides an electroless nickel undercoating with an outer layer of chromated conversion coated zinc-nickel alloy, which has a galvanic potential within 0.15V of both aluminum and cadmium, meeting the criteria of an anodic sacrificial finish.

Similarly, Tin-Zinc alloy recently defined as class V in AS85049⁽⁵⁾ and class codes L and M (classes T and TJ) in MIL-DTL-28840⁽⁸⁾, consists of an outer layer

of chromated conversion coated Tin-Zinc alloy, with a galvanic potential within 0.15V of both aluminum and cadmium, also meets the criteria of an anodic sacrificial finish.

Conclusion

On aluminum substrates, anodic, sacrificial style finish systems, like cadmium, zinc-nickel, and tin-zinc are preferable for harsh environment applications. When damaged, aluminum material that is exposed to the corrosive atmosphere can receive continued protection from the surrounding galvanically-similar outer finish layer.

Cathodic barrier style finish systems such as electroless nickel or nickel-fluorocarbon polymer can deliver significant corrosion protection provided these finishes are not damaged. When damaged, exposed aluminum material becomes sacrificial to the cathodic outer finish layer. The cathodic finish remains protected, instead of the aluminum substrate, and galvanic corrosion will penetrate the aluminum propagating laterally beneath the coating, potentially leading to catastrophic failure. For this reason, cathodic barrier finish systems are better suited for protected environments, or harsh environments where the possibility of damage from rough handling is essentially eliminated.

Acknowledgements

The author would like to specifically acknowledge Mr. Greg Brown, Mr. Mehrdad "Mike" Ghara and Mr. Narongphon "Boyd" Changkaochai in support of this paper.

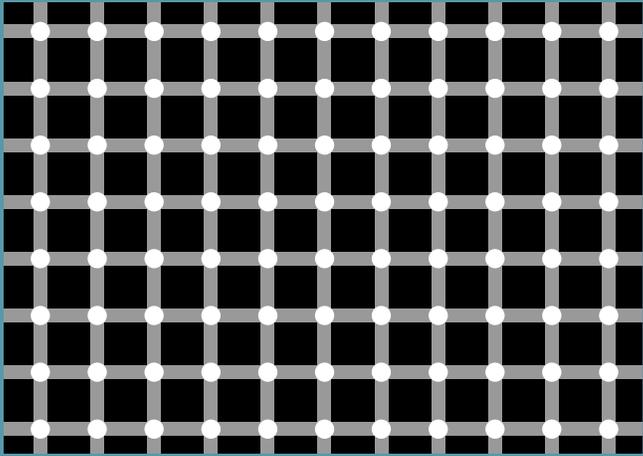
Background

Mr. Ty Geverink is Accessories Product Manager and Senior Technical Staff member at Glenair, Inc., located in Glendale, CA. Mr. Geverink has a BSCS (Associated Technical College) and has worked in the interconnect industry since 1981.

References:

- 1) MIL-STD-14072: Finishes for Ground Based Electronic Equipment
- 2) ASM HANDBOOK VOLUME 13A: Corrosion: Fundamentals, Testing, and Protection
- 3) <https://www.corrosionpedia.com/definition/226/cathodic-coating> - September 1, 2020
- 4) MIL-DTL-38999: Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded or Breech Coupling), Environment Resistant with Crimp Removable Contacts or Hermetically Sealed with Fixed, Solderable Contacts, General Specification for
- 5) SAE International; AS85049: Connector Accessories, Electrical, General Specification for
- 6) SAE International; AIR5919: Alternatives to Cadmium Plating
- 7) SAE International; AEISS 2009 Paper: Cad-Free Finishes for Interconnect Applications: Performance, Processing and Other Considerations by Greg Brown; VP Engineering, Glenair, Inc.
- 8) MIL-DTL-28840: Connectors, Electrical, Circular, Threaded, High Shock, High Density, Shipboard, Class D, General Specification For
- 9) MIL-PRF-28876: Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini, General Specification for.

If that technical whitepaper didn't get you dizzy... Here are some optical illusions to complete the process!



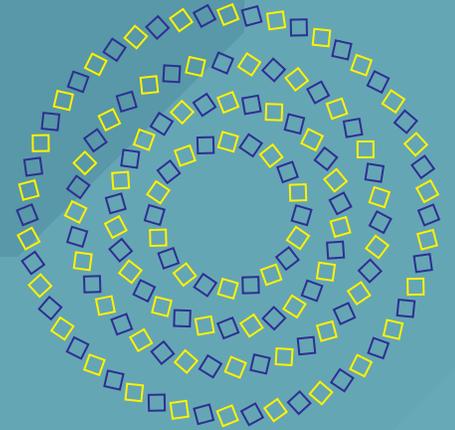
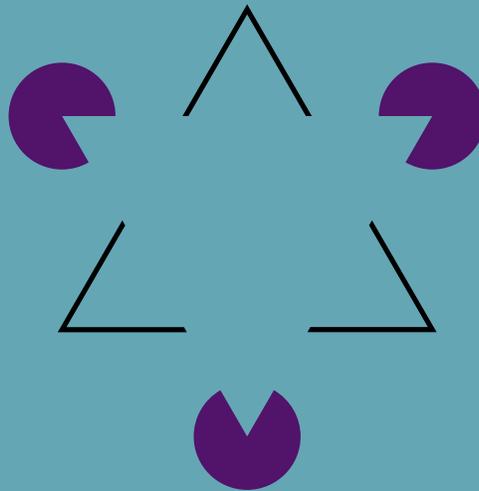
The Scintillating Grid (derived from the Hermann grid) is characterized by dark dots seeming to randomly appear and disappear on white discs at the intersections of a grey grid on a black background.

The **Rubin's Vase** illusion occurs when a two-dimensional image contains ambiguous (or bi-stable) forms which reverse with prolonged viewing.



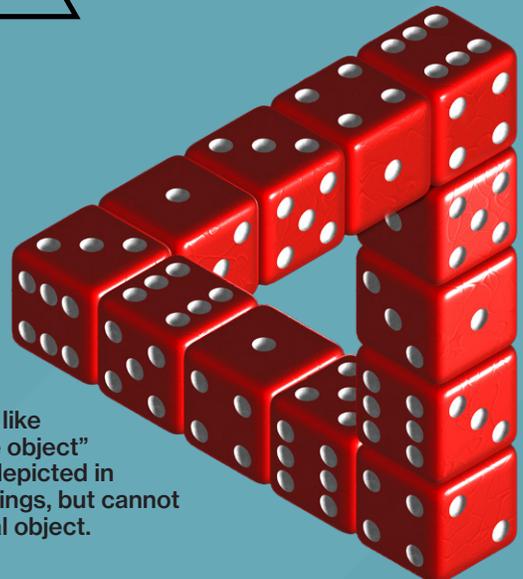
An **Impossible Object** is a two-dimensional image which instantly and naturally is interpreted by our brain as a three-dimensional object, with "impossible" results.

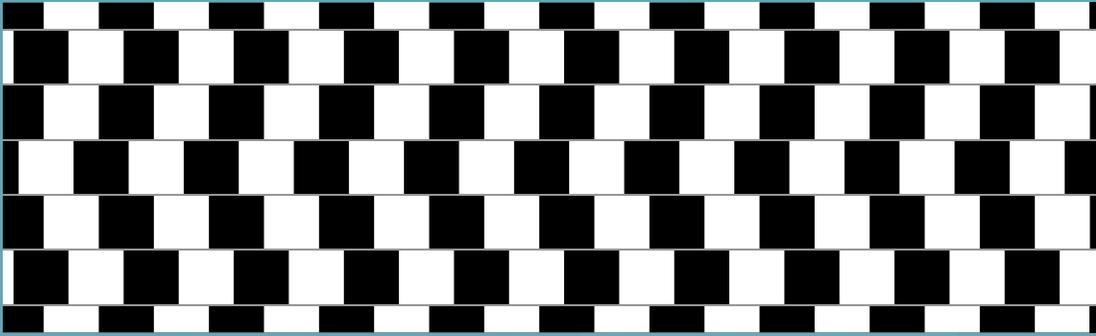
Kanizsa's Triangle depicts the "phantom edge phenomenon" in which the brain uses negative space to interpret a complete structure not actually there.



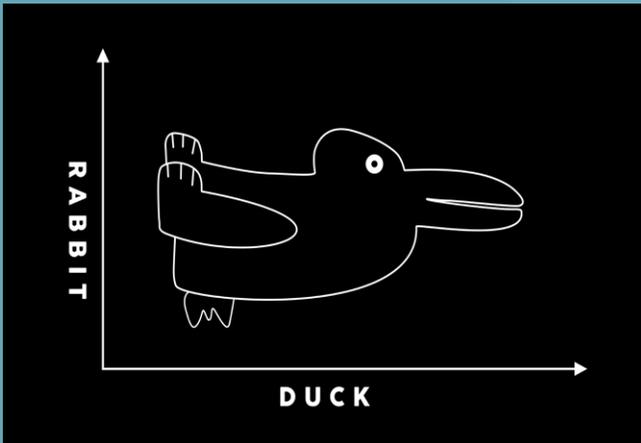
Pinna's Intertwining Effect: the image appears to be spiraling inward, when in fact the shapes are arranged on concentric circles.

The **Penrose Triangle**, or the impossible tribar, like other "impossible object" illusions, can be depicted in perspective drawings, but cannot exist as a physical object.



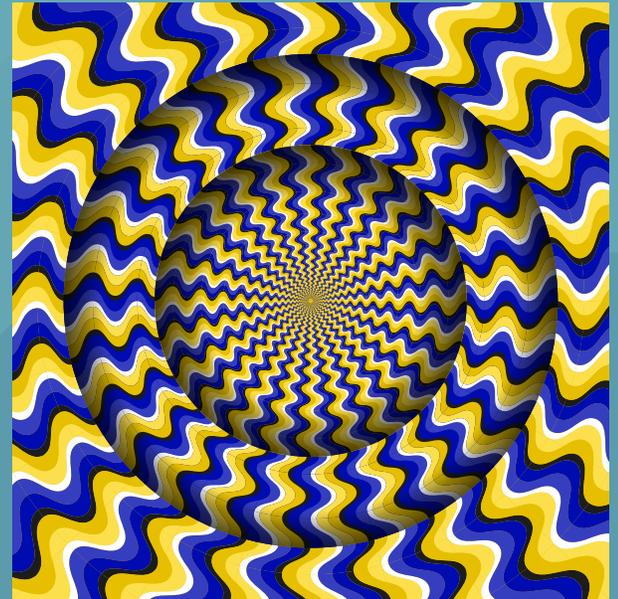


This **Zöllner Illusion** uses a contrasting angular pattern to make parallel lines appear to diverge. Has the added effect of causing nausea when viewed for prolonged periods.



An example of a **Literal Optical Illusion**. What you see in the moment is based on your current perception. Both images exist at all times.

This **Moving Image** is an example of the autokinetic effect in which the brain fabricates motion due to a pattern of shapes and colors. Stare at the center of the image to stop the movement, let your eyes track back and forth to enhance the motion.

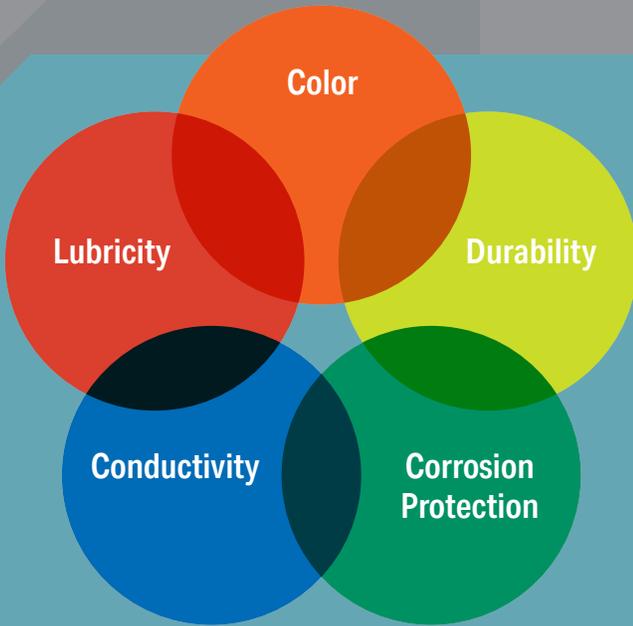


This illusion demonstrates the influence of the fall of a shadow on our interpretation of reality. Is the man blocked by a wall, or blithely crossing the street? The trajectory of the shadow determines your answer.

The **Ponzo Illusion** tricks the eye into seeing objects positioned along two converging lines as if the more “distant” object is larger than identically-sized objects positioned in the “foreground.” These two dudes are the same size!



Sacrificial Plating with Tin-Zinc (TZ) in a Nutshell

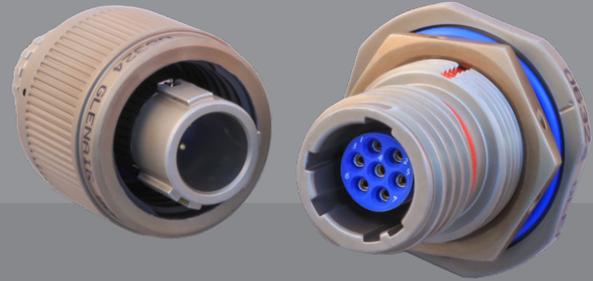


Why We Plate

Desirable characteristics of an ideal connector finish

- Increased conductivity and EMI shielding effectiveness
- Increased corrosion protection, galvanic compatibility, and extended field service life
- Increased durability and wear resistance
- Improved color and non-reflectivity
- Increased surface lubricity to prevent galling or seizing

Key TZ Facts



- Latest sacrificial-finish alternative to Cadmium to be approved by SAE and DLA
- 70/30 Tin-Zinc alloy with green/gold chromate over electroless Nickel
- Excellent conductivity, remaining conductive after 2,000+ salt-spray hours.
- Base metal corrosion protection to 4,000+ hours.
- Galvanically similar and compatible to Cadmium
- Alloy hardness comparable to Cadmium
- Thoroughly tested and ultimately recommended by NAVSEA over Nickel-PTFE and Zinc Nickel
- Qualified to VG95234 class J (5015 reverse bayonet)
- Qualified to MIL-DTL-28840 plating code TZ for classes L and M

Surface Plating Operating Environments



Sheltered

- Temperature/humidity stable
- No exposure to liquids
- Common materials and simple finishes are sufficient such as electroless nickel (M)
- Galvanic potential of dissimilar material ~0.50V



Ambient

- Varying temperature and humidity
- Limited exposure to liquids, vapors or fumes
- Higher performance materials required such as heavy electroless nickel (ME) or Nickel-PTFE (MT)
- Galvanic potential of dissimilar material ~0.25 V



Harsh

- High humidity/temperature fluctuations
- High exposure to liquids and/or corrosive elements
- Highest-performance finishes required such as Cadmium (NF) Zinc-Nickel (ZR), or Tin-Zinc (TZ)
- Galvanic potential of dissimilar material ~0.15 V

NAVSEA Performed TZ Corrosion Testing

GLENAIR
QwikConnect

- Brutal test plan. Sequentially tested.
- Fewer groups than MIL-DTL-38999 with as many tests, some far more difficult
- Outperformed Zinc-Nickel and others
- Retained functionality including conductivity after all tests
- Included Electromagnetic Effects testing per MIL-PRF-28876
- Will be the **ONLY** approved conductive finish for MIL-PRF-28876 receptacles.
- NAVSEA sent letters of recommendation to SAE and DLA for inclusion into all shipboard electrical connector specs



Tin-Zinc: Gold Standard of the Future!



- Tested and Approved by NAVSEA
- AIR5919 Tested/Passed (GT-17-120)
- Tested/Passed VG95234 Glenair Italia (RDP 382-18)
- Replaced Ni-PTFE in MIL-DTL-28840.
- AS85049 draft proposed class V
- Most compatible with Cadmium
- More conductive than Zinc-Nickel



Tin-Zinc vs. Cadmium

- RoHS Compliant
- Same corrosion resistance, conductivity, operating temperature, and solderability
- Improved resistance to SO2 and mixed gasses.



Tin-Zinc vs. Zinc Nickel

- Contains less Zinc, produces less Zinc Oxide and Carbonate corrosion by product. Functionality remains after corrosion.
- Higher Electrical conductivity
- Better interoperability with Cadmium plated parts

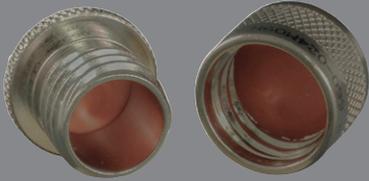


Tin-Zinc vs. Ni-PTFE

- Sacrificial plating protects base material if surface is damaged
- Better Corrosion protection
- Better interoperability with Cadmium plated parts

Cadmium and Cadmium-Alternative Finishes go Head-to-Head

Plating	Operating Temperature	RoHS	Conductivity	Corrosion	Wear	Cadmium Compatibility
Cadmium (Cd)	-65° to +175°C	✗	★★★★★	★★★★★	★★★☆☆	★★★★★
Tin-Zinc (SnZn)	-65° to +175°C	✓	★★★★★	★★★★★	★★★☆☆	★★★★★
Zinc-Nickel (ZnNi)	-65° to +175°C	✓	★★★★☆	★★★★★	★★★☆☆	★★★★☆
Nickel-PTFE (NiPTFE)	-65° to +175°C	✓	★★★★★	★★★★☆	★★★★★	★★★☆☆
Anodic Coating	-65° to +175°C	✓	☆☆☆☆☆	★★★★★	★★★★★	★★★☆☆



Tin-Zinc

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **TZ**



Glenair code TZ is a 70/30 Tin-Zinc alloy sacrificial plating with green / gold chromate over electroless nickel. Tin-Zinc is the most recent and best alternative to cadmium to be approved by both SAE and the DLA, and offers base metal corrosion protection to 4000+ hours, and remains conductive after 2000+ hours of exposure to salt spray. Tin-Zinc is galvanically similar and compatible to cadmium, and may be used interchangeably with this older (non-RoHS compliant) material.

Thoroughly tested and recommended by NAVSEA over nickel-PTFE and zinc-nickel. Glenair TZ is qualified to VG95234 and M28840, and has completed all qualification testing for the yet-to-be-released MIL-DTL-38999 Tin-Zinc specification.

Glenair Tin-Zinc alloy—also recently defined as class V in AS85049(5) and class codes L and M (classes T and TJ) in MIL-DTL-28840(8)—consists of an outer layer of chromated conversion coated Tin-Zinc alloy, with a galvanic potential within 0.15V of both aluminum and cadmium, meeting the criteria of an anodic sacrificial finish which makes the material the most viable across-the-board replacement for cadmium.

Glenair TZ plating is a RoHS and REACH compliant material and demonstrates improved resistance to SO2 and mixed gases—a critical requirement for the material's use in naval and armored vehicle applications.

Abrasive wear or galling is a critical concern in thread-mating components, and is usually defined as the undesired removal of material from contacting surfaces by mechanical action. Abrasive wear can damage surface plating leading to unwanted corrosion of substrate materials. Glenair Tin-Zinc (TZ) has demonstrated outstanding lubricity and resistance to both adhesive and abrasive wear and has passed all mating cycle durability requirements for connectors and backshells.



Cadmium

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **NE, LF, JF**



Cadmium plated aluminum is still in broad use and demand in the defense/aerospace industry. Offering up to 1000 hours of salt spray protection when deposited over electroless nickel, cadmium is highly conductive, and provides good lubricity and resistance to galling. As plated, cadmium has a silvery appearance. A subsequent chromic acid passivation bath creates a chromate topcoat over the cadmium, enhancing corrosion protection. Olive drab chromate is widely used, followed by gold chromate and clear chromate.



Electroless Nickel

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +200°C

Glenair Code **M, ME**



Aluminum plated with electroless nickel offers excellent conductivity, wear resistance, and adequate corrosion resistance. Typically specified on electrical connectors and accessories used in avionics boxes, exoatmospheric equipment, and missiles, electroless nickel is a good choice when exposure to marine or corrosive atmospheres is not a primary concern. The plating process is purely chemical, and once started, is autocatalytic (it runs by itself). Code M delivers 48 hours salt spray protection, Code ME is higher-durability with 96 hours salt spray.



Black Zinc Nickel

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **ZR, ZNU**



RoHS-compliant black zinc-nickel is approved for MIL-DTL-38999, AS85049 and other major military specifications as a replacement for cadmium and hexavalent chromium platings. The non-reflective finish and adequate conductivity make the Glenair ZNU finish a reasonable choice for cadmium-free tactical systems. Corrosion resistance is comparable to cadmium.



Zinc-Nickel

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **ZN**



Zinc-nickel plated aluminum was developed as a cost-effective alternative to cad over nickel. Supplied with an olive drab chromate conversion coatings, zinc-nickel plated aluminum may be specified for military airframe and other applications that need to remove non-compliant cad materials but want to maintain the olive drab appearance of interconnect components.



Nickel-PTFE

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **MT, XMT, ZMT**



Now approved for MIL-DTL-38999 and MIL-DTL-83513, Glenair's Nickel-PTFE meets the need for a barrier plating cadmium replacement with excellent conductivity, wear resistance and corrosion protection. This extremely durable finish is gun-metal gray. A proprietary preliminary undercoat is followed with a composite coating of electroless nickel phosphorus and polytetrafluoroethylene (PTFE). Ni-PTFE is approved for the Joint Strike Fighter and offers excellent lubricity.



Black Anodize (Type II)

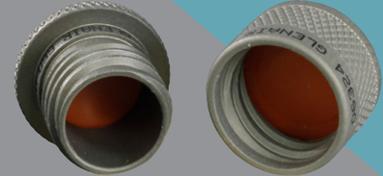
Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **C**



Black anodized aluminum is an option for electrical connectors and accessories that do not require conductivity. Black anodized aluminum offers a modicum of corrosion protection and is relatively inexpensive. Anodizing is an electrolytic process that creates aluminum oxide films by oxidizing the base metal. While the resulting coating is neither harder nor denser than natural oxidation, it may be preferred due to its uniform color qualities. The parts are immersed in a sulfuric acid solution at room temperature. After anodizing, the parts are dyed black.



Hardcoat Anodize (Type III)

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +200°C

Glenair Code **G**



Hardcoat anodized aluminum offers greater wear resistance and better corrosion resistance compared to conventional anodizing. Typically employed when conductivity is not required, hardcoat aluminum offers good corrosion protection for marine and tactical applications. The resulting finish is a matte greenish-gray color. Hardcoat anodizing is an electrolytic process that creates aluminum oxide films by oxidizing the base metal in a sulfuric acid solution. The parts are immersed in a high-concentration sulfuric acid solution at 35°C. After anodizing, the parts can be dyed black (code GB).



Passivated Stainless Steel

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +200°C

Glenair Code **Z1, ZL, ZW**



Stainless steel offers unbeatable strength and protection from environmental stress if durability and corrosion resistance are more important than cost and weight. Typically found on aircraft engines, landing gear, geophysical equipment, armored vehicles and marine applications, passivated stainless steel is widely specified in throughout the interconnect industry. Also offered with nickel and cadmium plating for improved conductivity, stainless steel is an obvious alternative to cadmium if cost and weight are not an issue.



Plated Composite

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +200°C

Glenair Code **XM, XW, XMT**



Plated composite connectors and accessories provide unsurpassed corrosion protection and excellent conductivity. Glass-reinforced or carbon-reinforced thermoplastic is metallized and plated with electroless nickel (olive drab cadmium is another popular finish). Plated composite connectors and accessories have become the first choice for aerospace programs seeking to increase corrosion resistance and reduce weight.



Unplated Composite

Cost	\$	\$	\$	\$	\$
Conductivity	+	+	+	+	+
Corrosion Resistance	⌚	⌚	⌚	⌚	⌚

-65° to +175°C

Glenair Code **XB, XO**



If conductivity and EMI shielding are not required, unplated composites provide the best solution to corrosion protection. Glenair's composite connector accessories are ideally suited for use in harsh environments where even stainless steel parts can be attacked by corrosive fluids. Available in black (code XB) and brown (code XO).



Material and Finish Table

This chart presents a selection of the broad range of base materials, plating options, specifications and codes available for Glenair connectors and accessories.

Code	Material	Finish	Finish Specification
AB	Marine Bronze	Unplated	AMS4640 alloy, unplated
C	Aluminum	Anodize, Black	MIL-PRF-8625, Type II, Class 2
E	Aluminum	Chem Film, Gold	MIL-DTL-5541, Type I, Class 3
ER	Aluminum	Chem Film, Clear	MIL-DTL-5541, Type II, Class 3
G	Aluminum	Hard Anodize, Natural	MIL-PRF-8625, Type III, Class 1
GB4	Aluminum	Hard Anodize, Black, w/ PTFE	MIL-PRF-8625, Type III, Class 2, Black, with PTFE coating
JF	Aluminum	Cadmium, Yellow-Gold	AMS-QQ-P-416, Type II, Class 2, over electroless Nickel
LF	Aluminum	Cadmium, Clear	AMS-QQ-P-416, Type II, Class 2, over electroless Nickel
M	Aluminum	Electroless Nickel	AMS-C-26074, Grade B; ASTM B733, SC 2
MA	Aluminum	Electroless Nickel, Matte	AMS-C-26074, Grade A; ASTM B733, SC 3
ME	Aluminum	Electroless Nickel	AMS-C-26074, Grade A; ASTM B733, SC 3
MT	Aluminum	Nickel-PTFE	AMS2454
NC	Aluminum	Zinc-Cobalt, Olive Drab	ASTM B840, over electroless Nickel
NF	Aluminum	Cadmium, Olive Drab	AMS-QQ-P-416, Type II, Class 2, over electroless Nickel
TP2	Titanium	Electrodeposited Nickel	AMS-QQ-N-290, Class 1, Grade G
TZ	Aluminum	Tin-Zinc, Green-Gold	AMS2434, Type 2, over electroless Nickel
UF	Aluminum	Cadmium, Black	AMS-QQ-P-416, Type II, Class 2, over electroless Nickel
XB	Composite	Unplated, Black	[N/A]
XM	Composite	Electroless Nickel	AMS-C-26074, Grade B; ASTM B733, SC 2
XMT	Composite	Nickel-PTFE	AMS2454
XW	Composite	Cadmium, Olive Drab	AMS-QQ-P-416, Type II, Class 3, over electroless Nickel
XZN	Composite	Zinc-Nickel, Black	ASTM B841, over electroless Nickel
Z1	Stainless Steel	Passivate	AMS2700
Z2	Aluminum	Gold	MIL-DTL-45204, Class 1, over electroless Nickel
ZL	Stainless Steel	Electrodeposited Nickel	AMS-QQ-N-290, Class 2
ZM	Stainless Steel	Electroless Nickel	AMS-C-26074, Grade A
ZMT	Stainless Steel	Nickel-PTFE	AMS2454
ZN	Aluminum	Zinc-Nickel, Olive Drab	ASTM B841, over electroless Nickel
ZR	Aluminum	Zinc-Nickel, Black	ASTM B841, over electroless Nickel
ZU	Stainless Steel	Cadmium, Black	AMS-QQ-P-416, Type II, Class 2
ZW	Stainless Steel	Cadmium, Olive Drab	AMS-QQ-P-416, Type II, Class 2, over electroless Nickel
ZZR	Stainless Steel	Zinc-Nickel, Black	ASTM B841, over electroless Nickel

Salt Spray Hours	Electrical Conductivity	Operating Temp. Range	RoHS MATERIALS	Notes
1000	Conductive	-65° to +200°C	✓	Marine and geo-physical applications.
336	Non-Conductive	-65° to +200°C	✓	Glenair's standard black anodize finish.
168	Conductive	-65° to +125°C		Glenair's standard chem film finish.
168	Conductive	-65° to +125°C	✓	Glenair's RoHS compliant chem film finish.
500	Non-Conductive	-65° to +200°C	✓	Glenair's standard hard anodize finish.
500	Non-Conductive	-65° to +200°C	✓	MIL-PRF-28876 standard non-conductive finish
500	Conductive	-65° to +175°C		Glenair's standard yellow-gold Cadmium finish.
500	Conductive	-65° to +175°C		Glenair's standard clear Cadmium finish.
48	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel finish.
96	Conductive	-65° to +200°C	✓	Glenair's standard high-build matte electroless Nickel finish.
96	Conductive	-65° to +200°C	✓	Glenair's standard high-durability electroless Nickel finish.
500	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel-PTFE finish.
240	Conductive	-65° to +175°C	✓	Not recommended for new projects. ZN is preferred.
500	Conductive	-65° to +175°C		Glenair's standard olive drab Cadmium finish.
96	Conductive	-65° to +200°C	✓	Glenair's standard electrodeposited Nickel over Titanium.
500	Conductive	-65° to +175°C	✓	Glenair's recommended Cadmium-compatible replacement
500	Conductive	-65° to +175°C		Glenair's standard black Cadmium finish.
2000	Non-Conductive	-65° to +175°C	✓	Glenair's standard unplated composite.
2000	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel over composite.
2000	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel-PTFE over composite.
2000	Conductive	-65° to +175°C		Glenair's standard olive drab Cadmium over composite.
2000	Conductive	-65° to +175°C		Glenair's standard black Zinc-Nickel over composite.
500	Conductive	-65° to +200°C	✓	Glenair's standard passivated stainless steel.
48	Conductive	-65° to +200°C	✓	Glenair's standard Gold finish.
500	Conductive	-65° to +200°C	✓	Glenair's standard electrodeposited Nickel over SST
1000	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel over stainless steel.
1000	Conductive	-65° to +200°C	✓	Glenair's standard electroless Nickel-PTFE over SST.
500	Conductive	-65° to +175°C	✓	Glenair's standard olive drab Zinc-Nickel.
500	Conductive	-65° to +175°C	✓	Glenair's standard black Zinc-Nickel finish.
500	Conductive	-65° to +175°C		Glenair's standard black Cadmium over stainless steel.
500	Conductive	-65° to +175°C		Glenair's standard olive drab Cadmium over stainless steel.
500	Conductive	-65° to +175°C	✓	Glenair's standard black Zinc-Nickel over stainless steel.



Material and Finish Cross-Reference Tables

AS85049 Material and Finish Codes

AS85049 Class	Glenair Code	Material	Finish
A	C (G)	Aluminum	Anodize
B	ZU	Stainless Steel	Cadmium, Black
G	MA	Aluminum	Electroless Nickel, Matte
J	XW	Composite	Cadmium, Olive Drab
L	XX	Composite	Cadmium, Olive Drab (sel.)
M	XM	Composite	Electroless Nickel
N	M	Aluminum	Electroless Nickel
P	NFP	Aluminum	Cadmium, Olive Drab (sel.)
S	Z1	Stainless Steel	Passivated
T	XO	Composite	No Plating
V	TZ	Aluminum	Tin-Zinc
VC	XTZ	Composite	Tin-Zinc
VL	XTS	Composite	Tin-Zinc, Selective
VP	TS	Aluminum	Tin-Zinc, Selective
VS	ZTZ	Stainless Steel	Tin-Zinc
W	NF	Aluminum	Cadmium, Olive Drab
X	MT	Aluminum	Nickel-PTFE
XC	XMT	Composite	Nickel-PTFE
XS	ZMT	Stainless Steel	Nickel-PTFE
Y	AL	Aluminum	Alumiplate
YC	XAL	Composite	Alumiplate
YL	XAP	Composite	Alumiplate (selective)
YP	ALP	Aluminum	Alumiplate (selective)
YS	ZAL	Stainless Steel	Alumiplate
Z	ZR	Aluminum	Zinc-Nickel, Black
ZC	XZR	Composite	Zinc-Nickel, Black
ZL	XZS	Composite	Zinc-Nickel, Black (selective)
ZP	ZS	Aluminum	Zinc-Nickel, Black (selective)
ZS	ZZR	Stainless Steel	Zinc-Nickel, Black

MIL-DTL-28840 Material and Finish Codes

M28840 Class	Glenair Code	Material	Finish
A	NF	Alum.	Cadmium, Olive Drab
B	ZU	316 SST	Cadmium, Black
C	NF	Alum.	Cadmium, Olive Drab
E	ZU	316 SST	Cadmium, Black
F	AL	Alum.	Alumiplate
G	AL	Alum.	Alumiplate
L	TZ	Alum.	Tin-Zinc
M	TZ	Alum.	Tin-Zinc
S	ZR	Alum.	Zinc-Nickel, Black
U	ZR	Alum.	Zinc-Nickel, Black

MIL-DTL-38999 Material and Finish Codes

M38999 Class	Glenair Code	Material	Finish
A	JF, LF	Aluminum	Cadmium, Clear Chromate
B	NF	Aluminum	Cadmium, Olive Drab
C	G	Aluminum	Hardcoat Anodize
D	FT	Steel	Fused Tin
E	Z1	Stainless Steel	Passivated
F	M	Aluminum	Electroless Nickel
G	MA	Aluminum	Electroless Nickel, Matte
H	Z1	Stainless Steel	Passivated
J	XW	Composite	Cadmium, Olive Drab
K	Z1	Stainless Steel	Passivated
L	ZL	Stainless Steel	Electrodeposited Nickel
M	XM	Composite	Nickel
N	ZL	Stainless Steel	Electrodeposited Nickel
R	ME	Aluminum	Electroless Nickel
S	ZL	Stainless Steel	Electrodeposited Nickel
T	MT	Aluminum	Nickel-PTFE
V	TZ	Aluminum	Tin-Zinc
U	JF	Aluminum	Cadmium, Clear Chromate
W	NF	Aluminum	Cadmium, Olive Drab
Y	Z1	Stainless Steel	Passivated
Z	ZR	Aluminum	Zinc-Nickel, Black

MIL-DTL-83723 Material and Finish Codes

M83723 Class	Glenair Code	Material	Finish
A	G	Aluminum	Hardcoat Anodize
G	Z1	Stainless Steel	Passivated
H	FT	Steel	Tin
J	FT	Steel	Tin
K	Z1	Stainless Steel	Passivated
L	ZL	Stainless Steel	Electrodeposited Nickel
M	AL	Aluminum	Alumiplate
N	ZL	Stainless Steel	Electrodeposited Nickel
P	Z1	Stainless Steel	Passivated
R	M	Aluminum	Electroless Nickel
S	Z1	Stainless Steel	Passivated
T	MT	Aluminum	Nickel-PTFE
W	NF	Aluminum	Cadmium, Olive Drab
Y	Z1	Stainless Steel	Passivated
Z	ZR	Aluminum	Zinc-Nickel, Black

AS50151
Material and Finish Codes

AS50151 Class	Glenair Code	Material	Finish
A	NF	Aluminum	Cadmium, Olive Drab
B	NF	Aluminum	Cadmium, Olive Drab
C	NF	Aluminum	Cadmium, Olive Drab
D	NF	Aluminum	Cadmium, Olive Drab
DJ	NF	Aluminum	Cadmium, Olive Drab
DJ	ZU	Stainless Steel	Cadmium, Black
DJS	ZU	Stainless Steel	Cadmium, Black
DSN	ZL	Stainless Steel	Electrodeposited Nickel
DT	MT	Aluminum	Nickel-PTFE
DV	TZ	Aluminum	Tin-Zinc
DY	AL	Aluminum	Alumiplate
DZ	ZR	Aluminum	Zinc-Nickel, Black
E	NF	Aluminum	Cadmium, Olive Drab
F	NF	Aluminum	Cadmium, Olive Drab
H	SM	Steel	Electroless Nickel
HT	FT	Steel	Fused Tin
K (Solder)	SN	Steel	Cadmium, Olive Drab
K (Crimp)	SM	Steel	Electroless Nickel
KT	SN	Steel	Cadmium, Olive Drab
L	M	Aluminum	Electroless Nickel
P	NF	Aluminum	Cadmium, Olive Drab
R	NF	Aluminum	Cadmium, Olive Drab
U	M	Aluminum	Electroless Nickel
W	NF	Aluminum	Cadmium, Olive Drab
WT	MT	Aluminum	Nickel-PTFE
WY	AL	Aluminum	Alumiplate
WZ	ZR	Aluminum	Zinc-Nickel, Black
X	NF	Aluminum	Cadmium, Olive Drab

EN 2997
Material and Finish Codes

EN 2997 Class	Glenair Code	Material	Finish
K	Z1	Stainless Steel	Passivated
KE	Z1	Stainless Steel	Passivated
KV	Z1	Stainless Steel	Passivated
R	M	Aluminum	Electroless Nickel
RS	M	Aluminum	Electroless Nickel
S	Z1	Stainless Steel	Passivated
SE	Z1	Stainless Steel	Passivated
SV	Z1	Stainless Steel	Passivated
W	NF	Aluminum	Cadmium, Olive Drab
WS	NF	Aluminum	Cadmium, Olive Drab
Y	Z1	Stainless Steel	Passivated
YE	Z1	Stainless Steel	Passivated

AS81703
Material and Finish Codes

AS81703 Class	Glenair Code	Material	Finish
E	M	Aluminum	Electroless Nickel
H	FT	Steel	Tin
L	M	Aluminum	Electroless Nickel

MIL-DTL-26482
Material and Finish Codes

M24682 Class	Glenair Code	Material	Finish
A	G	Aluminum	Hardcoat Anodize
H	FT	Steel	Fused Tin
K	MT	Aluminum	Zinc-Nickel, Black
L	M	Aluminum	Electroless Nickel
N	FT	Steel	Fused Tin
T	MT	Aluminum	Nickel-PTFE
V	TZ	Aluminum	Tin-Zinc
W	NF	Aluminum	Cadmium, Olive Drab

MIL-DTL-24308
Accessory Finish Codes

M24308 Finish	Glenair Code	Material	Finish
A	AL	Aluminum	Alumiplate
F	JF	Aluminum	Cadmium, Yellow Chromate
K	ZR	Aluminum	Zinc-Nickel, Black
T	MT	Aluminum	Nickel-PTFE
P	Z1	Stainless Steel	Passivated
Z	Y2	Aluminum	Zinc, Yellow Chromate

MIL-DTL-83513
Accessory Finish Codes

M83513 Finish	Glenair Code	Material	Finish
A	AL	Aluminum	Alumiplate
C	JF	Aluminum	Cadmium, Yellow Chromate
K	ZR	Aluminum	Zinc-Nickel, Black
N	M	Aluminum	Electroless Nickel
P	Z1	Stainless Steel	Passivated
T	MT	Aluminum	Nickel-PTFE

Step-by-Step Electroplating Process

STEP 1: A technician formulates solutions for use in the electroplating process by combining acids and aqueous metals to form an electrolytic bath. The constituent solutions contain free metal ions that will be deposited onto the “work” (the material being plated) via electrical current.



STEP 2: Pre-mixed batches of plating solution are augmented with ingots of sacrificial metals (in this case copper – located in hanging baskets) to provide an abundant source of free-metal ions for an initial “underflash” deposit onto the work.

Glenair Certified Electroplating: Three fully-redundant World-Class Facilities



STEP 5: After the zincate process, the work receives an “underplating” in an electroless nickel solution and is rinsed thoroughly three times.



STEP 6: Parts are then immersed in an electrolytic bath of sulfuric acid and surface-metal plating material. Electricity is applied. The acid activates the surface of the parts, creating an ionic path for plating. The submerged metal ingots act as anodes (by giving up ions), while the work functions as a cathode (by taking on ions).



STEP 3: Meanwhile, raw parts are wired for electrical current flow, cleaned with an alkaline solution and an acid bath, and then finished with a sodium hydroxide “etch” to create a clean, adhesive surface upon which initial platings can be applied.

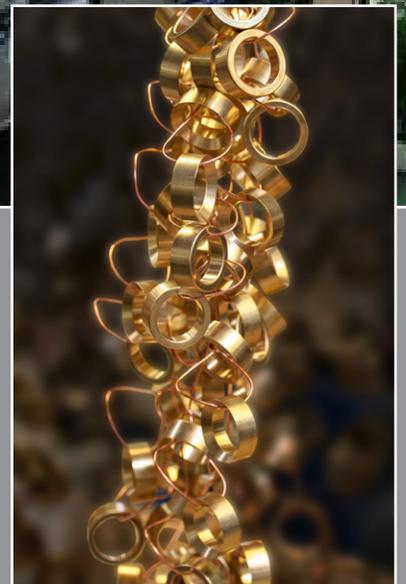


STEP 4: Etched parts are stripped of all oxide buildup in a nitric acid bath, then “flash-plated” in the prepared electroless zincate solution. This process protects the work from oxidation and augments conductivity.



STEP 7: Colorization of the work is achieved by submersion in a chromic acid bath containing dye. The chromate solution reacts with the plating to yield colors such as olive drab, black, or green/gold.

STEP 8: Plated parts receive a final rinsing in hot deionized water, after which they are dried and cured in an oven. Lastly, parts are sorted and examined by inspectors to ensure there have been no flaws in the plating process.





VG-Qualified J-Class Tin-Zinc Plated Connectors

VG95234 · VG95328 · VG96929

Glenair rugged VG series VG95234, VG95328, and VG96929 with Tin-Zinc J Class plating are now qualified by The Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support. Tin-Zinc is a RoHS cadmium-free galvanic finish that offers high conductivity and shielding performance, corrosion resistance, and proven compatibility with legacy Cadmium, Zinc-Nickel, and Nickel-PTFE finishes.



- High conductivity and shielding performance in harsh environment conditions
- High corrosion resistance
- Compatibility with legacy cadmium-plated connectors and environmental shrink boots
- RoHS-compliant material
- Test reports available upon request



Available finishes:
Standard Cadmium
Code B Marine Bronze
Code J Qualified Tin-Zinc

High conductivity and shielding performance:	
High conductivity and shielding performance	VG95234 Code J Tin-Zinc plating shield connection average value: 0.5 mohm (VG95234 with legacy Cadmium plating shield connection average value: 1.5 mohm)
Shielding performance not degraded after:	Durability (500 mating cycles) + dry heat (16 hours at 125°C) + cold (16 hours at -55°C) + humidity (672 hours at 40°C 93%) Cycling Salt spray (5 days 2hrs salt spray + 22 hours humidity)
Compatibility with heat shrink boots of Cadmium plated connectors:	Tested with the following environmental heat shrink boots: VG95343T06 (without inner coating) VG95343T18 (with inner coating) VG95343T28 (without inner coating, halogen free) VG95343T29 (with inner coating, halogen free)
RoHS Compliance	Tin-Zinc is a Cadmium-free RoHS material
High Corrosion Resistance	Tested up to 2000 hrs. of salt spray

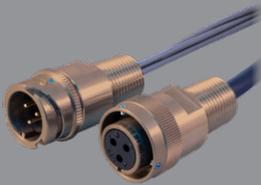
REVERSE-BAYONET

Industry-Standard 5015-Type Power and Signal Connector Series

VG-qualified and Glenair Signature solutions

GLENAIR QwikConnect

HIGH-PERFORMANCE RUGGED POWER CONNECTOR SERIES AVAILABLE WITH TIN-ZINC PLATING



Series ITS and FR-ITS (Fire-Resistant) Reverse-Bayonet



Series ITH Rigid Insert



Series ITK High-Temp Firewall: Stainless Steel / Ceramic Insert



VG95234 Reverse-Bayonet and VG96929 Single-Pole (Glenair Series IGE)



VG95328 Bayonet-Lock IAW MIL-C-26482: IPT and IPT-SE



Threaded Coupling Series Connectors: IT and ITZ



Super ITS - 921 High-Temp, High-Ampacity Power



Super ITS - ITH Octabyte High-Speed Quadrax / Octax

GLENAIR ITALIA BLQ: MANUFACTURING CENTER OF EXCELLENCE FOR HARSH-ENVIRONMENT MILITARY, NUCLEAR, RAIL, AND INDUSTRIAL INTERCONNECTS



High-capacity CNC Machining centers

allow Glenair BLQ to provide lightning-fast turnaround on small and custom orders as well as large production runs, all with superior surface finishes and better part quality.



Advanced plating line

Capabilities include VG95328-qualified Marine Bronze and J Class Tin-Zinc plating—VG95211 and VG95212 qualified cadmium alternative for corrosion-resistant interconnects.



QUALIFIED MIL-DTL-28840

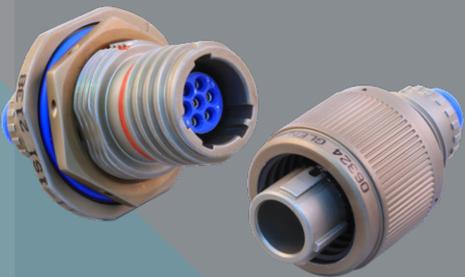
Connectors and accessories: every slash sheet, no gaps

- All sizes and platings in-stock and ready for immediate shipment
- High density, scoop proof contact arrangements
- Flange mount, box mount, jam-nut and in-line receptacles
- Straight, 45° and 90° strain reliefs and backshell assemblies
- Sav-Con® connector savers and bulkhead feedthrus
- Contact and connector assembly tools



MIL-DTL-28840 qualified connectors and accessories. Splined connector-to-backshell interface is ideally suited for heavy backshells and cables

QUALIFIED CADMIUM-FREE AND COMPATIBLE TIN-ZINC (TZ) PLATING FOR CLASS CODE L AND M (CLASS T AND TJ) NAVY LAND AND MARITIME APPLICATIONS.



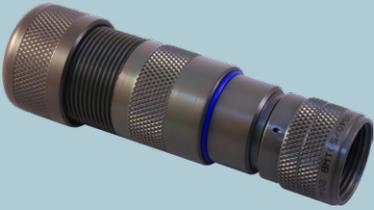
- New DLA-qualified replacement for Cadmium
- High conductivity and shielding performance in harsh maritime conditions
- High corrosion resistance
- Compatibility with legacy cadmium-plated connectors and environmental shrink boots
- RoHS-compliant material
- Test reports available upon request

L - Class T: Aluminum, Tin-Zinc Plate over Electroless Nickel, Non-Reflective



QUALIFIED
MIL-DTL-28840
Connectors and Accessories

MIL-DTL-28840 • FULLY-QUALIFIED • EVERY SLASH SHEET • NO GAPS • IN-STOCK AVAILABILITY

 <p>Contacts M39029/83 pin and /84 socket</p>	 <p>Clamps M28840/1 straight M28840/2 90° M28840/3 45°</p>	 <p>Conduit M28840/4 Metal-Core</p>
 <p>Conduit Fittings M28840/5 Backshell for Metal Core Conduit M28840/6 EMI/RFI Environmental Backshell M28840/25 90° EMI Conduit Adapter M28840/27 45° EMI Conduit Adapter M28840/30 Metal Conduit Coupler, Styles A and B M28840/22 Metal Conduit Bushing M28840/23 "E Nut"</p>	 <p>Backshells M28840/8 90° EMI/RFI Environmental M28840/ 45° EMI/RFI Environmental Backshell</p>	 <p>Connectors M28840/10 Wall Mount Receptacle Connector M28840/11 In-Line Receptacle Connector M28840/12 Box Mount Receptacle Connector M28840/14 Jam Nut Mount Receptacle Connector M28840/16 Plug Connector</p>
 <p>Connector / Backshell Assemblies M28840/17 Plug Connector / Straight Strain Relief M28840/18 Plug Connector with 90° Strain Relief M28840/19 Plug Connector with 45° Strain Relief M28840/20 Recept., Straight EMI/RFI Backshell M28840/21 In-Line Recept., St. EMI/RFI Backshell M28840/26 Plug, with Straight EMI/RFI Backshell M28840/28 90° Adapter Assembly Plug M28840/29 Plug with 45° EMI/RFI Backshell</p>	 <p>Protective Covers M28840/13 Protective Receptacle Cover M28840/15 Protective Plug Cover</p>	 <p>Tools and Accessories M28840/7 Dummy Stowage Receptacle M28840/24 Mounting Gasket</p>

Outlook

Life Expectancy

I recently had to replace the dishwasher in my kitchen at home. If you think there isn't much difference between the major brands when it comes to kitchen appliances, get ready to learn more than you might expect—or perhaps ever want to hear—from an aerospace executive. Happily, in this household drama there are only two combatants which should speed things along. The first is the company whose product I've just had to replace (I won't mention their name, but it rhymes with KitchenAid). And in the other corner we have Miele, the brand I should have bought in the first place.

What is your expectation when you purchase an appliance? Mine is that it will last a reasonable length of time before “end-of-life” kicks in and it starts leaking on the floor—say ten years or so. Now don't get me wrong, I appreciate just how harsh an environment the inside of a dishwasher can be—steaming hot water, mineral salts, detergents—and that its electronics and wiring are all packaged in tight quarters immediately adjacent to all the action. But four years? Come on.

Here is the point. The same thermal, mechanical, and electrical aging that sent my dishwasher to the scrap heap impacts the Electrical Wire Interconnect Systems (EWIS) our customers rely on for durable, life-of-system performance. Further, that material science (the business of selecting the right material for every component part—from contacts to insulators to connector shells to shields) is one of the biggest factors impacting durability and product life expectancy.

In our industry, critical systems are subject to a process the FAA and others describe as a “reliability assessment.” When products are qualified for use, a power connector for example, certain key variables such as the Dielectric Withstanding Voltage of its insulator or Thermal Aging Factor of its environmental sealing are tested and analyzed to determine their suitability for use in the target environment. This issue of *QwikConnect* explores one of the most critical material types subject to this kind of assessment (plating). But of course, many dozens of other materials and processes must be exactly selected and qualified for use in the range of harsh environments—from outer space to subsea—where our products are used.

My “reliability assessment” of my erstwhile dishwasher is that the plastic material used in component parts throughout the machine became prematurely brittle and cracked due to exposure to hard water and high heat. Ditto the many O-ring seals and gaskets. I guess when all is said and done, I might have saved a few hundred dollars on the initial purchase price of the appliance but ended up with a far more expensive “cost-of-ownership” given the product's woefully short life span.

At Glenair, we believe we have a responsibility to design and produce interconnect hardware that delivers reliable and durable service. We do this—in large part—by using only those materials, processes, and designs that have been painstakingly tested and qualified for use in mission-critical application environments by the regulators that govern our industry. Not to beat a dead horse, but it seems to me that the folks producing products for consumer markets are playing by a different set of rules. Thank God they don't make airplane parts.

Chris Toomey

QwikConnect

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