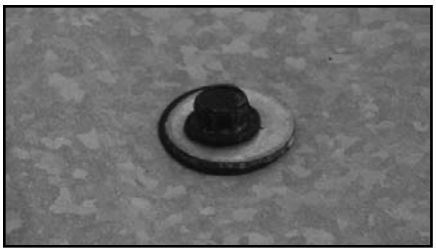

CORROSION PROTECTION INFORMATION

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SALT SPRAY RESULTS

The chart to the right provides general information with regard to corrosion resistance of various plating and coatings. Contact TFC for detailed information.

SALT SPRAY Per ASTM F1941 & B117 (0% red rust) Rev. 042111
Carbon steel and 410 stainless steel materials

Coating	Salt Spray
.00015” min. (3 um) zinc plating with clear chromate	15hrs
.0002” min. (6um) zinc plating with clear chromate	24hrs
Passivated 410 Stainless Steel	48hrs
.0003” min. (8 um) zinc plating with clear chromate	48hrs
.0003” min. (8 um) zinc plating with yellow di-chromate	120hrs
.0005” min. (12 um) zinc plating with clear chromate	72hrs
.0007” min. (14 um) mechanical zinc with clear chromate	72hrs
Epoxy (E-Coat) (ACQ Compatible)	100hrs
TRI-SEAL™ Long-life coating	1,000hrs

FASTENER COMPATIBILITY FOR METAL ROOFING AND WALL CLADDING

Table developed by the Metal Construction Association Members (Rev. by MCA 09.27.10)

	Fastener Material								
Metal Roof or Wall Cladding Material	Zinc Plated Steel Screws[2]	Organic Coated Steel Screws[2]	Hot-Dip Galvanized Steel Nails[3] and Screws	Zinc-Alloy Head Steel Screws	Stainless Capped Head Steel Screws	Aluminum	Copper and Copper Alloys	300 Series Stainless Steel	400 Series Stainless Steel
Unpainted Galvanized Steel	Yes[4]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Painted Galvanized Steel	Yes[4]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Unpainted Galvalume Steel	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Painted Galvalume Steel	Yes[4]	Yes	Yes	Yes	Yes	Yes	No	Yes[4]	Yes[4]
Aluminum	No	Yes	No	No	No	Yes	No	Yes	No
Copper & Copper Alloys	No	No	No	No	No	No	No	Yes	Yes4
Stainless Steel	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Zinc alloy	No	No	No	No	No	Yes	No	Yes	Yes

Note 1: Cautionary Guideline: This table serves as a guideline for the selection of fasteners used with metal roofing. The performance of compatible fasteners shown in this table matches the expected life of the metal roof or wall cladding materials. However, in highly corrosive environments such as heavy industrial, coastal marine, high airborne pollutants or salt spray, preservative treated lumber or fire-retardant lumber, the compatibility of certain fasteners with metal roofing or wall cladding materials may be affected. In those types of applications, the manufacturers of the fastener and metal panel will have specific and unique recommendations.

In addition, in the event that certain coating barriers are damaged or scratched through to the substrate there is increased potential for premature corrosion. Care should be taken during installation and during routine maintenance of the panels in order to protect the integrity of the coatings used for metal panels.
Note 2: Screws should be plated/coated per ASTM F1941
Note 3: Nails should be galvanized per ASTM A153
Note 4: Not recommended for coastal and heavy industrial environments

Special Note: Preservative-Treated Lumber Applications
ACQ, Penta, CA or CBA preservative-treated lumber can be incompatible with certain types of fasteners. In those cases where any type of metal roof or wall cladding materials are being attached to preservative treated lumber, the following fasteners are not compatible: zinc plated screws, zinc-alloy headed screws, stainless capped screws, aluminum, copper and copper alloy. When attaching metal panels to those types of preservative-treated lumber, a moisture barrier should be used between the lumber and the panel material. Metal panel fasteners that are compatible with preservative-treated lumber are stainless steel fasteners, or hot dip galvanized nails manufactured to ASTM A153 class D or heavier. Other types of fasteners coated with proprietary anti-corrosive technologies are also available for use with preservative-treated lumber. In addition, zinc-plated screws can be used in CCA and MCQ pressure-treated lumber.

Interacting Influences

This brief look at the rusting of steel points up the interacting influences which initiate, and control, the mechanism of electrochemical corrosion.

First, there must be the possibility for any electrical current to flow. This means either the contacting of dissimilar metals with different electropotentials, or some measure of heterogeneity in the same base metal. The greater the differential, the stronger the current flow and the faster and more severe the corrosive action. Corrosion of the same metal, for example; the rusting of steel, normally results in a uniform corroding of the entire exposed surface When dissimilar metals contact, the attack is usually more localized.

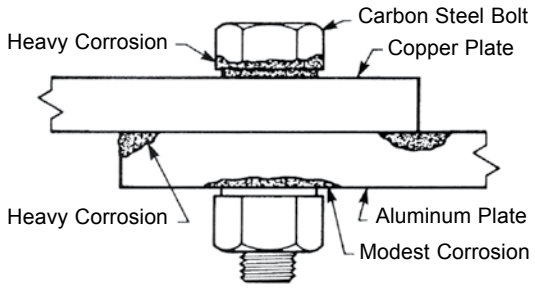
Second, there must be an electrolyte a medium through which the electrical current flows. Electrolytes occur naturally in our everyday environments - humidity, fog, dew, condensation, rain - and with a broad variation in their occurrence and intensity. For example, the corrosion survival expectancy of steel is shortened considerably when exposed in the high humidity Southern states as opposed to the ultra-dry desert climates of Nevada and Arizona. Similarly, structures and equipment survive longer in rural Midwestern states than in either ocean bordering states or in heavily industrialized areas with their high impurity atmospheres. Even in the home, storing articles in the dryness of an attic is more protective than in the dampness of a basement.

Distilled water is a poor conductor; tap water with its modest chemical content is better; industrial exposures with their pollutants and contaminants are even better; and salt water is exceptionally good. Whenever the electrolyte is agitated, such as flowing water, its conductivity is significantly magnified. The "dirtier" the electrolyte, the better its conductivity, and the faster the rate of corrosion.

Third, there must be oxygen. As most products of corrosion are oxides formed by the chemical reaction, the presence of oxygen is mandatory. Without oxygen, most forms of corrosion would be stalemated. However, its complete elimination is an engineering impracticality. Oxygen is the principal element of the air we breathe, and it is present, although to a lesser degree, underground and underwater

The importance of oxygen can be illustrated by considering an oceangoing steel-hulled ship. Without suitable protection of its exposed surfaces, the entire hull would corrode, but at three different rates. The plates at the water line would go first because of the concentrated aggressiveness of the sea water coupled with unlimited oxygen. The upper structure and decks would corrode more slowly because the electrolyte is now a spray which has lost some of its intensity although the oxygen supply is undiminished. The fully submerged bottom of the hull would survive the longest simply because of the meagerness of the oxygen supply.

Temperature, while not a direct contributor to corrosion, is definitely a factor in the rate at which it occurs. Generally, heat accelerates chemical reactions. All other conditions being equal, corrosion happens quicker and more markedly in southern climates than in those of the north. It also occurs more quickly in industrial plants where heat is inherent in the process as opposed to industries which conduct their operations at ambient temperatures or in the luxury of an air conditioned atmosphere.



Effects of Galvanic Corrosion

Galvanic Corrosion

Similar metals are compatible; dissimilar metals are not. When dissimilar metals contact in the presence of an electrolyte, a galvanic action occurs which causes one of the metals to corrode at a much faster than normal rate, while the other corrodes more slowly, if at all. The rate, location and extent of the corrosion depends on three factors:

- The difference in electrical potentials
- The conductivity strength of the corroding medium, and
- The relative sizes of the contacting areas.

All metals have electrical potentials. Through research, the potentials of different base metals and their alloys, when exposed to sea water, were measured and then ranked into a series. In an electrical couple, the metal of higher electrical potential is the cathode (-), that of the lower the anode (+). Current flows from the cathode to the anode, from the anode through the electrolyte (corroding medium), and back to the cathode. Corrosion occurs at the point the current leaves the anode to enter the electrolyte. When dissimilar metals contact, the anode corrodes, the cathode survives.

Galvanic Series

Table 1 presents the Galvanic Series of Metals and Alloys. The various metals are grouped. Those within the same group are reasonably compatible when used together; those from different groups cause a corrosion problem. Some metals, basically those with significant contents of nickel and chromium, are included in the Series both in their active and passive conditions. Passivation (surface cleaning and sealing) lowers the metal's electrical potential and improves its corrosion behavior.

Study of the Galvanic Series suggests that steel and aluminum are reasonably compatible; but, if titanium and aluminum contact, the aluminum, as the anode, will corrode Fig. 2 illustrates another example A copper plate is joined to an aluminum plate using a carbon steel bolt. If none of the contacting surfaces are protected, corrosion will occur. The bolt, where it touches the copper, will corrode severely. However, the bolt, where it contacts the aluminum, will not corrode, because it is now the cathode. The aluminum plate in contact with the bolt may corrode, but only slightly because of the minor difference in their electropotentials and the large anode-to-Cathode area ratio. The aluminum plate will corrode where its exposed exterior surfaces contact the copper plate The aluminum plate may also corrode on its interior surface, but not to the same degree, because the corroding medium and oxygen supply are largely sealed out due to the bolt's clamping action.

Galvanic Series of Metals and Alloys

+Corroded End (anodic, or least noble)
Magnesium, Magnesium alloys, Zinc
Aluminum 1100, Cadmium, Aluminum 2024-T4, Steel or Iron, Cast Iron, Chromium-iron (active), Ni-Resist cast iron
Type 304 Stainless (active), Type 316 Stainless (active)
Lead tin solders, Lead, Tin
Nickel (active), Inconel nickel-chromium alloy (active), Hastelloy Alloy c (active)
Brasses, Copper, Bronzes, Copper-nickel alloys, Monel nickel-copper alloy
Silver solder, Nickel (passive), Inconel nickel-chromium alloy (passive)
Chromium-iron (passive), Type 304 Stainless (passive), Type 316 Stainless (passive), Hastelloy Alloy C (passive)
Silver, Titanium, Graphite, Gold, Platinum
- Protected End (cathodic, or most noble)

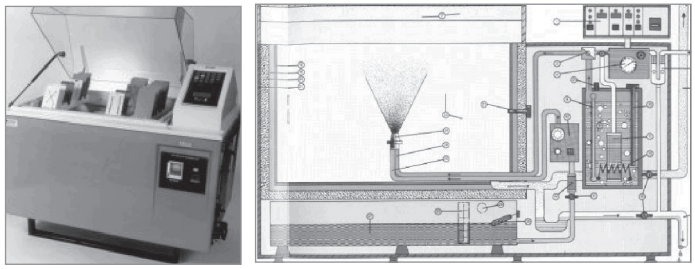
Taken from IFI Fastener Standards

General Corrosion Data for Fastener Finishes

There are two popular tests use on fasteners to compare their resistance to corrosion. These test are conduced using procedures that allow a specifier to compare various finishes and materials in a controlled environment. The results do not relate to years of service. Here is an explanation of the tests.

Salt Spray (ASTM B117)

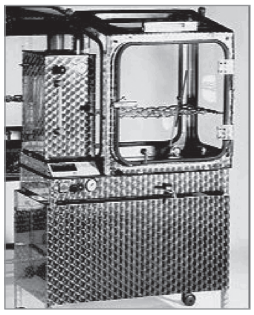
This test is used to compare performance of various finishes in a salt environment. This testing is conducted using a cabinet with a controlled environment consisting of fog with 5% salt solution at 95 degrees F. The test runs continuously with the specimens being visually judged every 24 hours for percent of total surface loss due to red rust along with the number of hours that have accumulated to that point.



Example of Salt Spray Test Cabinet

Kesternich (DIN 50018)

This test is used to compare performance of various finishes in an acidic environment. This testing is conducted using a cabinet with a controlled environment consisting of an injection of 0.2 liters of SO2 gas, moisture to a relative humidity of 100% at a temperature of 400 Centigrade. This atmosphere is held for 8-hours, then the door of the cabinet is opened and ambient air is allowed to circulate through the cabinet for 16 hours. This 24-hour period comprises one full cycle. The test runs continuously with the specimens being visually judged every 24 hours for percent of total surface loss due to red rust along with the number of cycles that have accumulated to that point.



Example of
Kesternich Cabinet

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SALT SPRAY RESULTS

The chart provides general information with regard to corrosion resistance of various plating and coatings. Contact TFC for detailed information.

SALT SPRAY Per ASTM F1941 & B117 (0% red rust) Rev. 042111
Carbon steel and 410 stainless steel materials

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Passivated 410 Stainless Steel	48hrs
.0003” min. (8 um) zinc plating with clear chromate	48hrs
.0003” min. (8 um) zinc plating with yellow di-chromate	120hrs
.0005” min. (12 um) zinc plating with clear chromate	72hrs
.0007” min. (14 um) mechanical zinc with clear chromate	72hrs
Epoxy (E-Coat) (ACQ Compatible)	100hrs
TRI-SEAL™ Long-life coating	1,000hrs

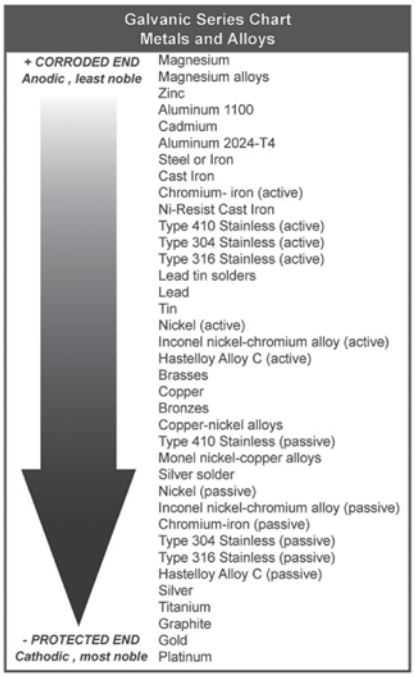
GALVANIC CORROSION - COMPATIBLE METALS CHARTS

To minimize galvanic corrosion, fasteners should be considered based on their material compatibility with the substrates.

Determine the materials being fastened and choose a fastener material that is close in proximity on the chart. The closer together the material are on the chart the less galvanic action will occur.

Metals listed on the top of the chart (anotic) will corrode faster than the metals on the bottom of the chart (cathodic).

Contact a corrosion specialist to determine the best material for your application.



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Painted Galvanized Steel	Yes[4]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Unpainted Galvalume Steel	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Painted Galvalume Steel	Yes[4]	Yes	Yes	Yes	Yes	Yes	No	Yes[4]	Yes[4]
Aluminum	No	Yes	No	No	No	Yes	No	Yes	No
Copper & Copper Alloys	No	No	No	No	No	No	No	Yes	Yes4
Stainless Steel	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Zinc alloy	No	No	No	No	No	Yes	No	Yes	Yes

Note 1: Cautionary Guideline: This table serves as a guideline for the selection of fasteners used with metal roofing. The performance of compatible fasteners shown in this table matches the expected life of the metal roof or wall cladding materials. However, in highly corrosive environments such as heavy industrial, coastal marine, high airborne pollutants or salt spray, preservative treated lumber or fire-retardant lumber, the compatibility of certain fasteners with metal roofing or wall cladding materials may be affected. In those types of applications, the manufacturers of the fastener and metal panel will have specific and unique recommendations.

In addition, in the event that certain coating barriers are damaged or scratched through to the substrate there is increased potential for premature corrosion. Care should be taken during installation and during routine maintenance of the panels in order to protect the integrity of the coatings used for metal panels.
Note 2: Screws should be plated/coated per ASTM F1941
Note 3: Nails should be galvanized per ASTM A153
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Characteristics of Platings, Coatings and Finishes

Plating, Coating or Finish	For Use On	Degree of Corrosion Resistance	Characteristics
Rust inhibitors	All metals	Varies with type	Oils, greases, etc. Vary in color and film thickness. Usually applied to black oxide finishes. Used to protect parts in transit and temporary storage.
Zinc, electroplated	All metals	Very good	Blue to blue-white gray color.
Cadmium, electroplated	Most metals	Excellent	Bright silver-gray, dull gray, or black finish. Particularly effective corrosion protection in marine applications. Used for decorative purposes. High lubricity.
Clear chromate finish	Zinc and cadmium plated parts	Very good to excellent	Clear bright or iridescent chemical conversion coating applied to plated parts to enhance corrosion protection, coloring, and paint bonding.
Dichromate	Zinc and cadmium plated parts	Very good to excellent	Yellow, brown, green or iridescent colored coating same as clear chromate.
Color chromate finish	Zinc and cadmium plated parts	Very good to excellent	Olive drab, blue, gold, bronze, etc. Same as clear chromate.
Zinc or Manganese Phosphate	Steel	Good	Black in color. Added protection when oiled with a non-drying petroleum oil containing corrosion inhibitors. Good lubricity.
Color phosphate coatings	Steel	Superior to regular phosphate and oiled surfaces	Chemically produced color coating. Available in blue, green, red, purple, etc.
Hot-dip zinc	All metals	Very good	Gives maximum corrosion protection. Dull grayish color Necessitates thread size adjustments to permit assembly.
Hot-dip aluminum	Steel	Very good	Gives maximum corrosion protection. Dull grayish color. Necessitates thread size adjustments to permit assemblably.
Mechanically deposited Zinc	Steel	Very good	Dull gray, smooth finish. Corrosion protection depends on coating thickness. Good coverage in recesses and thread roots.
Tin, electroplated	All metals		Silver-gray color. Excellent corrosion protection for parts in contact with food.
Hot-dip tin	All metals	Excellent	Same as electroplated but thickness is harder to control.
Lead-tin	Steel, usually	Fair to good	Silver-gray, dull coating. Applied by hot-dip method. Helps lubricity.
Silver, electroplated	All metals	Excellent	Decorative, expensive, excellent electrical conductor.
Chromium, electroplated	Most metals	Good (improves with copper and nickel undercoats)	Bright, blue-white, lustrous finish. Has relatively hard surface. Used for decorative purposes or to add wear resistance.
Copper, electroplated	Most metals	Fair	Used for nickel and chromium plate undercoat. Can be blackened and relieved to obtain Antique, Statuary, and Venetian finishes.
Brass, electroplated, lacquered	Steel, usually	Fair	Brass electroplated which is then lacquered. Recommended only for indoor decorative use.
Bronze, electroplated, lacquered	Steel, usually	Fair	Has color similar to 80% copper, 20% zinc alloy. Electroplated and then lacquered. Recommended only for indoor decorative use.
Copper, brass, bronze, miscellaneous finishes	Most metals	Indoor, very good	Decorative finishes. Applied to copper, brass,and bronze plated parts to match colors. Color and tone vary from black to almost the original color. Finish names are: Antique, Black Oxide, Statuary ,Old English, Venetian, Copper Oxidized.
Bright nickel	Most metals	Indoor excellent. Outdoor good if thickness at least 0.0005 in.	Electroplated silver-colored finish. Used for appliances, hardware, etc.
Dull nickel	Most metals	Same as bright nickel	Whitish cast. Can be obtained by mechanical surface finishing or a special satin bath.
Lacquering, clear or color-matched	All metals	Improves corrosion resistance. Some types designed for humid or other severe applications	Used for decorative finishes. Clear or colored to match mating color or luster
Anodizing	Aluminum	Excellent	Acid electrolytic treatment. Frosty-etched appearance. Hard oxide surface gives excellent protection.
Passivating	Stainless steel	Excellent	Chemical treatment. Removes iron particles and produces a passive surface.

"TFC SPECIFIC" FASTENERS FOR USE IN ACQ TREATED LUMBER AND FIRE RATED LUMBER

Effective January 1, 2004, lumber treated with arsenic (CCA – Chromated Copper Arsenic) is no longer produced for residential applications, and a new treated lumber material known as ACQ (Alkaline Copper Quanternary) is being utilized.

From a fastener standpoint, it's important to know that ACQ has up to six (6) times more copper content than the wood it replaces. This condition can cause fasteners plated with electro-plated zinc to corrode at a very fast rate, leaving the bare steel to red rust.

As recommended by the Southern Pine Council (SPC); recognized by the NRCA and the MCA; required by the International Residential Code (R319.3) and the International Building Code (2304.9.5), the following fasteners are acceptable for use in ACQ pressure treated lumber and fire rated lumber;

- Hot-dipped galvanized complying with ASTM A153,
- or coated with proprietary anti-corrosion coatings.
- For maximum corrosion protection, fasteners made from 302, 304, 305 or 316 stainless steel (18-8) should be considered.

Below is a list of TFC brand fasteners that is acceptable for use in ACQ treated lumber or Fire Rated lumber.

1. BLAZER® Drill Screws for wood-to-metal applications coated with TRI-SEAL™ long-life ceramic topcoat.
2. CONCEALOR® Low Profile Pancake head screws coated with TRI-SEAL™ or TRI-ACQ™ long-life ceramic topcoat.
3. CONCEALOR® ULP Ultra Low Profile head screws coated with TRI-SEAL™ or TRI-ACQ™ long-life ceramic topcoat.
4. CONCEALOR® DP1 Low Profile Pancake head screws coated with epoxy coated (E-coat)long-life topcoat.
   NOTE: Approved for the attachment of treated wood to metal or concrete. Approved for the attachment of a prepunch roof clip to treated wood. Not approved for the attachment of metal panel, trim or siding to treated wood where the screw must penetrate the steel.
5. PANEL-TITE® Post Frame metal-to-wood screws coated with TRI-SEAL™ or TRI-ACQ™ long-life ceramic topcoat.
6. PANEL-TITE® SS Post Frame metal-to-wood screws made of 305 stainless steel.
7. SENTRY PLUS FIVE® Roofing Fasteners coated with an electro-coated epoxy (E-coat) topcoat.
   NOTE: Approved for the attachment of treated wood to metal or concrete. Approved for the attachment of a prepunch roof clip to treated wood. Not approved for the attachment of metal panel, trim or siding to treated wood where the screw must penetrate the steel.
8. TRACER® Drywall screws coated with TRI-SEAL™ or TRI-ACQ™ long-life ceramic topcoat.
9. TRI-SEAL™ Long-life coated screws.
10. Any fastener made from 300 series stainless steel.
11. Any fastener made from 410 stainless steel

Note: Estimating service life of fasteners in ACQ treated lumber cannot be determined due to variables uncontrollable by TFC. Stainless steel screws are recommended. It is important that if carbon steel fasteners are used, they are at the least coated with a finish that provides protection equal to or better than hot dipped galvanized like the ones listed above. Determining the proper fastener is the responsibility of the user or specifier, who assumes all risks and liabilities.

Date: 6.1.10