GUIDE TO CORROSION RESISTANCE FOR FASTENERS

FOREWORD

Corrosion is an inherent concern with every metal, with every metal coating, and in every environment. Since failure due to corrosion may have dramatic consequences, Grabber ensures our products meet corrosion resistance expectations.

This guide is intended to assist consumers in understanding the causes and types of corrosion, and the anticipated resistance effectiveness of different metals and coatings, so informed choices are available to our customers. However, the ultimate choice of the materials used, and the corrosion protection methods employed, remain the responsibility of the end user. Grabber strongly encourages consulting with local engineers for all corrosion resistance decisions.

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Section 1 - *Causes of Corrosion*

Corrosion is a natural occurrence caused by the interaction of metal and the environment in which the metal is exposed. Corrosion can change both the appearance and the functionality of the metal. Environmental variables that influence corrosion rate and extent include the presence of stress, oxygen, hydrogen, salts, temperature, and electrolytes. While some corrosion will always take place, steps can be taken to reduce how much corrosion will occur over time.

Section 2 - *Types of Corrosion*

CREVICE CORROSION – "Localized corrosion of a metal surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of close proximity of the metal to the surface of another material." (NACE *Corrosion Engineer's Reference Book*, 3rd Edition)

UNIFORM CORROSION – Refers to corrosion that takes place almost equally over a large area.

PITTING – Refers to localized corrosion that forms small holes or pits in the surface of the metal. Stainless steel is particularly vulnerable to pitting corrosion.

STRESS CORROSION CRACKING (SCC) – "Cracking of a material produced by the combined action of corrosion and tensile stress." (NACE *Corrosion Engineer's Reference Book*, 3rd Edition)

HYDROGEN EMBRITTLEMENT – "Loss of ductility of a metal resulting from absorption of hydrogen." (NACE *Corrosion Engineer's Reference Book*, 3rd Edition) See Section 3.

INERCRYSTALLINE CORROSION – Preferential corrosion that takes place along the grain boundaries in a metal structure that results in a loss of ductility in the metal (becomes more brittle).

ATMOSPHERIC CORROSION - Refers to corrosion created by environmental variables, such as the presence of heat and high humidity, sulfur dioxide or chlorides. Atmospheric corrosion typically only takes place when a moisture film is present on the surface of the metal. In the absence of high heat and humidity, most contaminants would create little or no corrosion.

GALVANIC CORROSION – "Accelerated corrosion of a metal because of an electrical contact with a more noble metal or nonmetallic conductor in a corrosive electrolyte." (NACE *Corrosion Engineer's Reference Book*, 3rd Edition) See Section 4.

Section 3 - *Hydrogen Embrittlement*

As the name implies, hydrogen embrittlement causes the material to become less ductile and more brittle. Three factors must be present at the same time and is typically most relevant for high-strength hardened steels. The three factors include: Tensile Stresses (applied or residual), Hardened Steel, and Hydrogen.

Hydrogen embrittlement susceptibility may be present for screws with zinc electroplated and chromium passivation finishes. When hydrogen embrittlement is a potential concern, Grabber's manufacturing plants conduct additional heating/baking processes in accordance with standard industry practices and tests for hydrogen embrittlement in accordance with ASTM F1940 and other relevant standards.

Section 4 - *Galvanic Corrosion*

Below is a galvanic corrosion chart for dissimilar metals.

Galvanic Corrosion Risk

= Lower Risk (green)

= Higher Risk (red)

Corroding Metal \ Contact Metal	Magnesium and Alloys	Zinc and Alloys	Aluminum and Alloys	Cadmium	Carbon Steels	Cast Iron	Stainless Steel	Lead, Tin, and Alloys	Nickel	Brasses, Nickel-Silvers	Copper	Bronzes, Cupro-Nickels	Nickel Copper Alloys	Nickel-Chrome Alloys, Titanium, Silver, Graphite, Gold, and Platinum
Magnesium and Alloys	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Zinc and Alloys	Lower	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Aluminum and Alloys	Lower	Lower	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Cadmium	Lower	Lower	Lower	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Carbon Steel	Lower	Lower	Lower	Higher	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Cast Iron	Lower	Lower	Lower	Lower	Higher	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Stainless Steels	Lower	Lower	Lower	Lower	Higher	Higher	Lower	Higher	Higher	Higher	Higher	Higher	Higher	Higher
Lead, Tin, and Alloys	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Lower	Higher	Higher	Higher	Higher	Higher	Higher
Nickel	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Higher	Higher	Higher	Higher
Brasses, Nickel-Silvers	Lower	Lower	Lower	Lower	Lower	Higher	Higher	Higher	Higher	Lower	Higher	Higher	Higher	Higher
Copper	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Higher	Higher	Lower	Lower	Higher	Higher	Higher
Bronzes, Cupro-Nickels	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher	Higher
Nickel Copper Alloys	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Higher
Nickel-Chrome Alloys, Titanium, Silver, Graphite, Gold, and Platinum	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower	Lower

This chart is designed to assist in broadly assessing the risk of galvanic corrosion associated with a given metal coming into contact with another metal. To use the chart, align the metal to be assessed (for the risk of corrosion) in the left column with the Contact Metal listed in the upper row; green represents a lower risk and red represents a higher risk. For a more specific assessment of the risk of galvanic corrosion, please check with other sources.

CAUTION: Please understand that green represents "Lower risk" not "No risk." It should be noted that if sacrificial plating is incorporated in the fastener design, then a galvanic reaction can result in the deterioration of the sacrificial coating, rather than of the fastener. Fasteners for dissimilar-metal applications may also incorporate our GrabberGard® or NanoGard® coating to minimize the rate of corrosion. The barrier coating used to encapsulate our zinc and anti-corrosion chemical bonding agents minimize the opportunity for contact to occur, thereby further minimizing the risk of corrosion.

Section 5 - *Corrosion - Comparative Testing Methods*

The ASTM B117 standard for Salt Spray Testing (SST) is recognized industry-wide as an effective tool to compare different metals and different metal coatings in a tightly controlled corrosive environment for specific periods of time. SST results are not intended to predict corrosion resistance in real-world environments. Grabber goes to great lengths to ensure their products conform to expected corrosion resistance.

Section 6 - *Selecting the Right Corrosion Protection*

Three steps to selecting the right corrosion protection - ***Evaluate, Select, Check***:

Step 1 - Evaluate the exposure. Is it a dry environment, such as interior building construction, wet environment, such as exterior building construction, ocean or waterfront environment, such as coastal regions, lakes, rivers, etc., or a chemical treatment environment, such as exterior-grade treated lumber?

Step 2 - Select the most appropriate metal or coating using the following table as a general guide:

CORROSION RESISTANCE COMPARATIVE-TESTING RESULTS*			
Finish	**Test**	**Standard/Protocol**	**Results* (minimum)**
Phosphate	Salt Spray (SST)	ASTM B117	24 hours, no red rust
Clear Zinc	Salt Spray (SST)	ASTM B117	12 hours, no red rust
Yellow Zinc	Salt Spray (SST)	ASTM B117	24 hours, no red rust
GrabberGard®	Salt Spray (SST)	ASTM B117	1,000 hours, no red rust
GrabberGard® 15	Salt Spray (SST)	ASTM B117	1,500 hours, no red rust
NanoGard®	Salt Spray (SST)	ASTM B117	1,000 hours, no red rust

*NOTE: For comparative use ONLY. The results do not predict corrosion resistance in real-world environments (see Section 5 - *Corrosion - Comparative Testing Methods*).

Screws

Phosphate

Phosphate coatings are typically offered on drywall screws intended for interior applications only. The phosphate is a porous coating, which is usually applied in combination with light oil. It should be noted that Grabber® requires their mills to spin-dry phosphate-coated screws before packaging. While the phosphate coating offers some resistance against corrosion, the level of resistance is not sufficient for exterior applications. However, Grabber and Scorpion phosphate-coated drywall screws meet the corrosion resistance requirements outlined in ASTM C1002, *Standard Specifications for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs*, and ASTM C954, *Standard Specifications for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness.*

Clear Zinc and Yellow Zinc

Clear zinc and yellow zinc electrodeposited coatings are offered in many Grabber® and Scorpion® screw families intended for interior applications only. These coatings are applied in accordance with requirements outlined in ASTM F1941 - *Standard Specification for Electrodeposited Coatings on Mechanical Fasteners, Inch and Metric.* "Zinc-based coatings have the added advantage of providing a sacrificial or galvanic corrosions protection to steel. When base steel is exposed, such as at a cut edge or scratch, the steel is cathodically protected by the corrosion of the zinc coating adjacent to the steel. This occurs because the zinc is more electronegative (more reactive) than steel in the galvanic series" (CFSEI Technical Note - *Corrosion Protection of Fasteners*).

Our standard clear and yellow zinc coatings are Hexavalent Chromium, however Trivalent chromium is available upon request.

GrabberGard®

GrabberGard® for fasteners is a proprietary multi-layer coating that adds superior corrosion resistance to the fastener. GrabberGard® is suitable for use with ACQ/CCA and other preservative treatments in woods, composite and exotic lumbers, cement boards, high-density exterior sheathings, and tile-backers to wood or steel framing members in exterior environments. The preservative-treated wood supplier should provide all the pertinent information about fastener coating limitations. GrabberGard® is rated at 1,000 hours in ASTM B117 SST testing.

GrabberGard® 15

GrabberGard® 15 provides a thicker coating than our standard GrabberGard to further enhance corrosion resistance. GrabberGard® 15 is rated at 1,500 hours in ASTM B117 SST testing.

NanoGard®

NanoGard® is a proprietary double-layer coating that adds significant corrosion resistance. NanoGard® is rated at 1,000 hours in ASTM B117 SST testing.

Mechanical Galvanized

Mechanical galvanized coatings are offered in our Tie-Master® and Lag-Master® series. "Powdered zinc is applied to the fastener surface by tumbling the fasteners with water, a chemical catalyst and glass beads that pound the zinc onto the fastener surface." (CFSEI Technical Note - *Corrosion Protection of Fasteners)*. The thickness of zinc for Tie-Master and Lag-Master screws is classified as Class 55 in accordance with ASTM B695, *Standard Specifications of Coatings for Zinc Mechanically Deposited on Iron and Steel.*

410 Stainless steel

410 stainless steel screws are hardened so they can penetrate heavy-gauge steel while providing notable corrosion resistance.

302, 304, and 305 Stainless Steel

Grades 302, 304, and 305 stainless steel are the most common grades of stainless steel used in exterior applications. These grades are used in applications where GrabberGard and NanoGard-coated screws do not provide sufficient corrosion resistance.

316 Stainless Steel

316 stainless steel, sometimes referred to as marine grade stainless, is a nickel-chromium austenitic grade of stainless steel with 2–3% Molybdenum. The significance of this addition is that it provides "improved pitting and crevice corrosion resistant properties." 316 stainless steel is not hardened by heat treatment and is inherently non-magnetic. It provides a level of corrosion protection suitable for severe environments, especially environments with chlorides, such as coastal regions or near waste water plants. Pre-drilling is typically required in heavy-gauge steel applications.

Nails and Staples

Bright

Fasteners with a bright finish are not designed for exterior applications. The fasteners are raw polished steel with no added coating.

Blued

The "blue" finish on nails is achieved through a specific chemical and heat treatment set of operations in the manufacturing process that adds some added benefit for corrosion protection, but not sufficient for exterior applications. Blued drywall nails, for example, may be acceptable for the application of gypsum board in kitchens and bathrooms where higher concentrations of moisture may be present, depending on local code requirements.

Cement and Vinyl Coated

Both cement and vinyl coatings are added to provide stronger adhesion to wood. While both offer a small degree of corrosion protection, they are intended for interior use only.

Electro Galvanized (EG)

Similar to clear and yellow zinc coating, electro galvanization starts by submerging the manufactured nail into an electrolytic solution as an electrically charged anode composed of pure zinc is placed into the solution. Tiny particles of zinc bond to the surface of the metal resulting in the material having a thin coating of protection. This process provides corrosion resistance, but typically does not achieve as high of a level of protection as hot-dipped or thermal diffused galvanized coatings achieve.

Hot-Dip Galvanized

Hot-dip galvanized (HDG) coatings are offered on many Grabber pneumatic nails and staples. The nails and staples have been dipped into a molten zinc bath to prevent corrosion and rust. Directly related to the coating thickness and environmental conditions, hot-dipped galvanized screws can provide a superior level of corrosion resistance. HDG has long been the corrosion resistance performance standard from which other coatings are measured against.

Phosphate

Phosphate coatings are typically offered on drywall nails intended for interior applications only. The phosphate is a porous coating, which is usually applied in combination with light oil. While the phosphate coating offers some resistance against corrosion, the level of resistance is not sufficient for exterior applications.

Thermal Diffused Galvanized (TDG)

Thermal diffused galvanized (TDG) coatings reduces the potential for hydrogen embrittlement while providing a more even coating than HDG coatings. The ASTM standard for TDG coatings does not allow any finish/appearance imperfections, while the ASTM standard for HDG only limits "Gross dross inclusions" imperfections. The coating forms by thermal diffusion of the Zn powder onto the steel parts. Similar to HDG, TDG corrosion resistance depends heavily of the coating thickness. For TDG, the achievable coating thickness ranges up to 45 microns; while for HDG, the achievable coating thickness ranges up to 127 microns.

Select the best fastener based on the material being fastened and the environmental conditions of the project location. For example, while GrabberGard-coated fasteners may be appropriate for installing a deck in a residential neighborhood, if the deck is located next to a swimming pool, grade 316 stainless steel fasteners should be considered for the best resistance against corrosion.

Step 3 - Check with local building officials to determine applicable code requirements. If additional information is needed, consult with a qualified engineer that understands the local corrosion protection needs in your community, especially in coastal regions, and near lakes, rivers, streams, canals, swimming pools, etc. For clarification of corrosion resistance of Grabber products, please contact a Grabber engineer at (801) 492-3880, EXT 222.

IN CONCLUSION

Kevin Garrity, former President of *NACE International, the Corrosion Society* – the world's largest authority on corrosion with 30,000 members worldwide – has spent most of his 38-year career in the field of corrosion engineering. "I started out as an electrical engineer but became intrigued by the fact that corrosion takes in so many different facets of engineering – stress, electrical components, chemical and biological reactions." Mr. Garrity emphasizes, "Corrosion has been a problem since man started to use steel in applications."

DISCLAIMER

For any Grabber-sold product, the ultimate choice of the materials and the corrosion protection methods needed for a given application remain the responsibility of the end user. This guide provides general information only. Grabber shall remain harmless and accepts no liability for any damage or injury resulting from the use of the information provided in this guide. Specific circumstances and environments must be fully assessed by qualified professionals to assure adequate materials and corrosion protection methods are in place.

APPENDIX A - Corrosion Categories

The term "Corrosion Category" used herein is defined in EN 1090-2 and the 12944 series. The latest edition of EN 12944-2 describes corrosion categories ranging from C1 to CX (CX is covered by ISO 12944-9 and is replacing the offshore aging test from ISO 203402). These are related to the thickness loss of low-carbon steel in various environments. Table 1 provides a general overview of corrosion categories and environments. For additional examples of appropriate service conditions and descriptions of service conditions, see ASTM B633 - *Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel* - Appendix X2.

Table 1

Severity	Corrosion Category	Environment	
		Exterior	Interior
Low	C1		Heated buildings with clean atmospheres, e.g. offices, shops, school, and hotels.
Medium	C2	Atmospheres with low level of pollution. Most rural areas.	Unheated buildings where condensation may occur, e.g. depots and sports halls.
High	C3	Urban and industrial atmospheres, moderate Sulfur dioxide pollution	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, and diaries.
Severe	C4	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal ships, boatyards.
	C5	Industrial areas with high humidity and aggressive atmosphere. Coastal areas with high salinity.	Buildings or areas with almost permanent condensation and high pollution.
	CX	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere. Subropical and tropical atmospheres.	Building or areas with extreme huminity and aggressive atmosphere.