

STANLEY[®]
Engineered Fastening

HELI-COIL[®]
Corrosion Screw Threads
and Methods

Technical Bulletin 68-1

HeliCoil[®]

CORROSION

The purpose of this bulletin is to provide useful information regarding the corrosion of fasteners in general and screw threads in particular. The choice of fastening techniques to minimize the effect of corrosion is dependent on a multitude of considerations such as environment, types of metals to be used, cost, lifetime expectancy, strength of assembly, and degree of reliability.

Corrosion is a natural phenomenon in which certain refined metals strive to revert to their natural state. The main concern is to prevent or significantly retard this action while maintaining serviceability and integrity of the fastener assembly. Especially significant is the fact that these problems become increasingly important with the increased use of light metals which are, by their very nature, more active and reactive to environmental conditions. Corrosion engineers have made significant strides in corrosion abatement. Through both research and practical experience, a realistic program for "elimination" of corrosion is now available for the designer.

While corrosion is a natural phenomenon, it is also a complex one, usually being categorized into the following types: Chemical Attack (Oxidation): Intergranular Corrosion; Concentration Cell and Galvanic Corrosion. Specific factors affecting the extent and rapidity of the corrosion reaction are: temperature, cycle of exposure to moisture, contaminants, velocity, presence and concentration of an electrolyte, etc.

The four types of corrosion and appropriate methods of avoiding or minimizing their occurrence, particularly in the case of threaded assemblies, are discussed in greater detail in the following pages.

1. CHEMICAL ATTACK (oxidation)

The most common form of corrosion or attack on metals is by specific chemicals or atmospheric conditions. Most metals are subject to some surface deterioration (often erroneously referred to as "rust" which, strictly speaking, applies to iron oxide only) because of their environment.

Whether the application involves simple exposure to the atmosphere (which itself contains moisture borne contaminants such as salt, sulfur dioxide, sulfuric acid, chlorine, alkalies, acid vapors, etc.) or whether it requires contact with severe corrosive elements such as acids, alkalies or seawater, the choice of metal is all important. The designer should select the metal, or combination of metals, which are resistant to attack by these elements. As an example, in seawater applications, the use of light metals such as aluminum or magnesium is normally restricted to those applications where weight is of prime importance, and where every means to provide a protective coating can be applied. Stainless steels are not normally recommended for use under immersed conditions, or in seawater, because of liability to pitting attack, and they should never be used under any immersed conditions unless oxygen can reach all surfaces. Metals (alloys) such as phosphor bronze, beryllium copper and Monel, have extremely low corrosion by salt water, and these materials are presently being used extensively in seawater applications.

2. INTERGRANULAR CORROSION

Austenitic grades of stainless steel (AISI types 200 and 300 series) are susceptible to a form of corrosion called intergranular corrosion. This corrosion occurs as a result of exposure for an extended period of time to temperatures in excess of 800° F (426° C). In this case, the chromium combines with the carbon in the metal and precipitates, at the grain boundaries, as chromium carbide. As a result of the chromium loss, the areas at the grain boundaries become depleted of chromium and are no longer stainless, and are readily attacked, even by mild corrodents. It should be noted that this can also occur as a result of welding or brazing if the metal heats or cools slowly through the critical temperature range (2). Corrective action, or proper design, clearly dictates that austenitic stainless steel hardware should not be exposed to temperatures beyond 800°F (426° C) even though the physical properties (tensile strength and hardness, etc.) may not be significantly reduced until exposed to temperatures well above this level.

3. CONCENTRATION CELL

This type of corrosion is a result of either a lack or imbalance of oxygen. Areas lacking oxygen become active because oxygen is replenished to the entrapped moisture by the surrounding metal in an active-passive cell. The primary technique to eliminate this problem is to prevent the entrance of moisture into the threads. This can be achieved by using blind tapped holes, rather than through holes, using screw lengths which project the full length into the female threads, using washers under the screw head, and lastly, tightening the screw. Of course, it is good practice, when parts are disassembled and exposed to the atmosphere, that the female threads be protected by reinstalling the screw into the threads. This is extremely important if the component is to be removed for any length of time or if the atmosphere is contaminated (especially if near the sea).

4. GALVANIC CORROSION

When dissimilar metals are coupled in the presence of an electrolyte (a solution that is an electrical conductor), electrons will leave the anodic metal and be attracted to the cathodic metal. The metal particles of the anodic metal are transformed into ions which then combine chemically with the nonmetallic ions in the electrolyte and form the corrosion products. The anodic metal proceeds to disintegrate while the cathodic metal remains relatively unaffected. This particular type of corrosion is called galvanic corrosion, and poses the most concern, because structural integrity can be severely compromised without necessarily being apparent upon visual examination.

As in the other types of corrosion, minimizing the possibility of moisture entering the threads is the main line of prevention. However, the designer should also anticipate that moisture will enter the threads and that a second line of defense is necessary. In order to bring this defense to bear, it is necessary to fully understand the comparative activity between metals when exposed to moisture.

Table I shows this relative activity or susceptibility to galvanic corrosion, and further explains the mechanism of this type of corrosion.

TABLE I

ELECTRO-CHEMICAL SERIES
ANODIC – LEAST NOBLE – CORRODED – ACTIVE

Magnesium
Zinc
Beryllium
Aluminum
Cadmium
Steel, Iron, Cast Iron
18-8 Stainless (Active)*
Lead – Tin Solder
Lead
Tin
Nickel
Inconel
Hastelloy A & B
Brasses, Copper Bronzes
Cupro Nickel Alloys
Monel
Silver Solder
Nickel (Passive)
Inconel (Passive)
Chromium Steel (Passive)
18-8 Stainless (Passive)*
Silver
Titanium
Graphite
Gold
Platinum

(*) Note: 18-8 Stainless (Active) is much closer to aluminum and magnesium than the Passive stainless. The conclusion is logically made that using passivated stainless steel will accelerate the corrosion of all metals above it. This is one reason why Stainless Steel Heli-Coil® Inserts are not passivated.

CATHODIC – MOST NOBLE – PROTECTED – PASSIVE

The farther apart two metals are, the greater is the potential for corrosion when they are coupled. The higher metal becomes anodic (corroded) to the one below it.

There are various combinations of metals which can, under service conditions, be coupled without fear of significant galvanic attack. Several military standards have grouped these metals as follows:

TABLE II

GROUP I	Magnesium alloys; Aluminum alloys 5052, 5056, 5356, 6061 and 6063
GROUP II	Aluminum; Aluminum Alloys; Zinc; Cadmium; Tin; Stainless Steel
GROUP III	Zinc, Cadmium; Steel; Lead; Tin; Stainless Steel; Nickel and its alloys
GROUP IV	Copper and its alloys; Nickel and its alloys; Chromium; Stainless Steel; Gold; Silver

Contact between a member of any one group and another member of the same group shall be considered as similar with no added protection needed. Contact between a member of one group and a member of any other group shall be considered as dissimilar, except for zinc, tin and cadmium, as listed in Groups II and III, and for Stainless steel, as listed in Groups II, III and IV. When it is necessary to combine two dissimilar metals, an interposing material compatible to each, shall be used (5).

There are three (3) basic steps in providing protection against galvanic corrosion:

1. Chemically treat the parent material. For aluminum, the Alodine, Anodize, Iridite, Hardcoat, or similar processes, for a protective oxide coating. It is recommended that Iridite 14 or 14-2 (MIL-C-5541) be substituted for anodizing on critical aluminum parts. Their substitution is permitted by specification MIL-S-5002, and will prevent dimensional changes which may occur when anodizing. For magnesium, Iridite 15 or dichromate surface treatments are recommended. When using HAE finishes, tapped holes should be plugged before the finish is applied.

An important point to be considered when using chemical oxide coatings is that, if the coating is chipped, concentrated corrosion or pitting will occur at that point. This explains why Step 1 is not singularly effective for medium or normal service conditions.

2. Coat the insert or fastener with a metal near the parent material in the galvanic series. Coatings commonly applied are zinc plating, .0001 inch thick, with Type II (supplementary chromate treatment) or Cadmium plating, .0001 inch thick, with Type II (supplementary chromate treatment). For many fasteners other than Heli-Coil® Inserts, a coating thickness requirement of .0002 inch is specified for zinc (QQ-A-325) and cadmium (QQ-P-416) coatings. For the wire insert, tests have shown that .0001 inch thick coatings are more than adequate under the most severe conditions (6). The supplementary chromate treatment to the cadmium plating is more effective in reducing corrosion.

3. Separate the metals by an insulating barrier, using:

- a) Liquid Zinc Chromate Primer per MIL-P-8585
- b) Sealants such as PR 1422 or EC 1675 per MIL-S-8802
- c) Dry Film lubricant AS5272 coating applied to insert prior to installation

Recommendations for various types of service are:

1. FOR EXTREMELY SEVERE SERVICE:

- a. When the screw is out of the assembly frequently.
- b. Assembly is exposed to salt water, corrosion atmospheres in continuous service; typically marine applications.

USE ALL THREE STEPS LISTED ABOVE WHEN COUPLING STAINLESS STEEL INSERTS AND THE LIGHT METAL.

The most frequently selected combination is Alodine for Aluminum, Dichromate for Magnesium, Cadmium Plating for the Insert, and Zinc Chromate Primer for the Tapped Threads. Increasing usage of sealants in place of Zinc Chromate Primer has been evidenced and is not recommended for wire inserts because it is difficult to handle, interferes with assembly of the screw and reduces insert retention in the tapped hole.

2. FOR SEVERE SERVICE:

- a. When screw may be left out of the insert for extended periods and blind hole traps significant amounts of water.
- b. Assembly is subject to an occasional exposure to salt air, sea spray, etc.

FOR ALUMINUM, USE STEP 2 OR 3. FOR MAGNESIUM, USE BOTH STEPS 2 AND 3.

3. OR NORMAL SERVICE:

- c. When a screw is always assembled in the insert.
- d. Assembly is rarely subject to moisture due to condensation, rain, or immersion in water (not salt water).

FOR ALUMINUM, NONE OF THE STEPS ARE REQUIRED. FOR MAGNESIUM, STEPS 2 OR 3.

CONCLUSION

Corrosion is the effort of refined metals to revert to their natural state. A reasonable program to minimize the effects of corrosion to an acceptable level is available. To ignore the effects of corrosion can be very expensive in terms of money, loss of reputation, or even loss of life. To be sure, there is an extra cost to design in adequate corrosion protection, but the cost is small compared to the potential loss. Also, with the increased usage of the light metals, corrosion problems have become more acute.

The methods described above will provide the means to “prevent” corrosion for the vast majority of applications. For special cases, the designer may find it helpful to seek the advice of corrosion experts.

In the final analysis, corrosion protection must be incorporated in the initial stage of product design and material selection. It is estimated that the total annual cost of corrosion is in excess of 10 billion dollars. Who can afford not to provide adequate protection against corrosion?

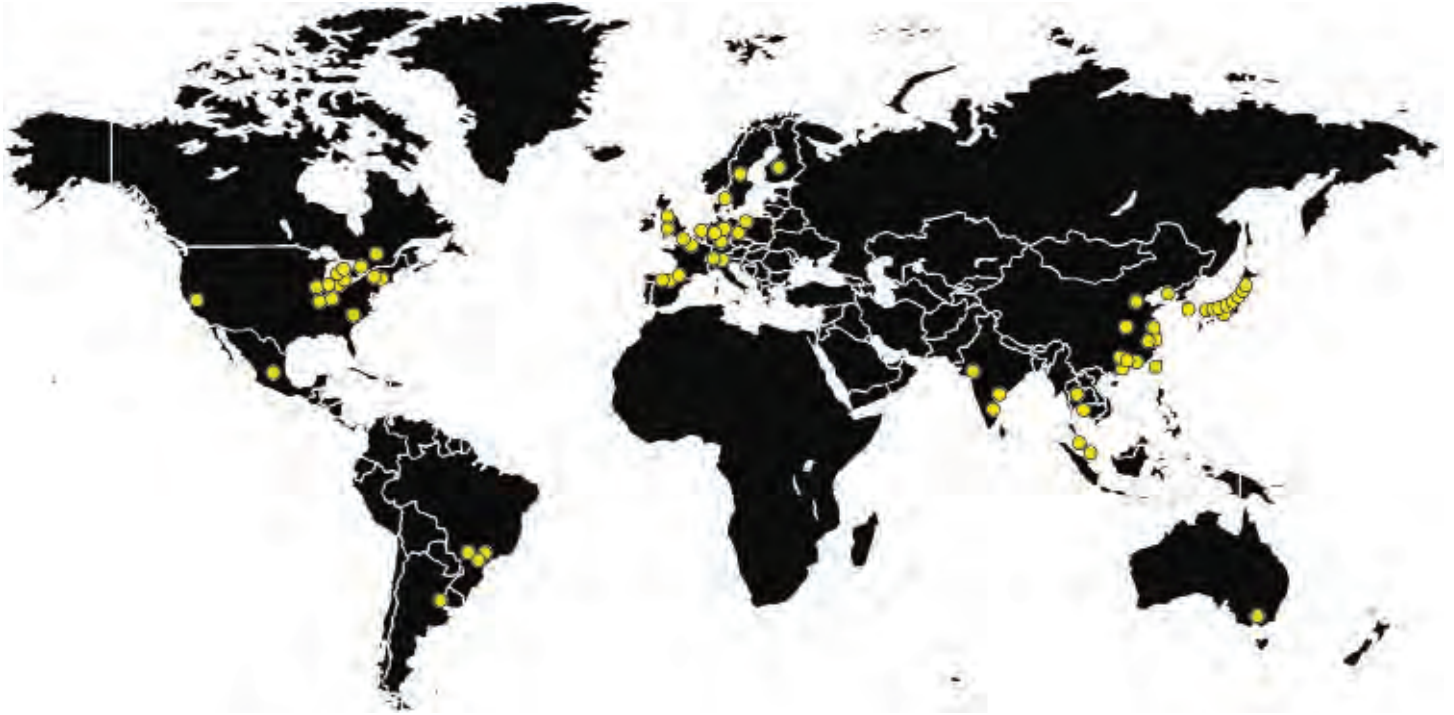
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