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Bi-Metallic Drill Screws

by Laurence Claus

In construction applications where predrilled and tapped joint members are impractical, Drill Screws are an exceptionally versatile and helpful fastener product. Drill Screws can be easily assembled into and through a wide assortment of building materials without the need for any access to the back side of the joint. The application opportunities are abundant both for interior and exterior purposes. Drill screws are excellent resources on the interior, where they are commonly utilized to attach gypsum board, wood members, and other metal components to metal structural members and studs. Generally, the interior environment is controlled and these screws are not subject to challenging or abusive environmental conditions. Drill Screws are also highly favored by installers of metal roofs and cladding. Drill Screws provide an easy way to pierce the metal roof or cladding sheets and the underlying steel structural components without the need for any predrilling of pilot or clearance holes. Unlike interior environments, however, the exterior of the building will be subject to whatever variable environmental conditions the climate zone is known for.

For Drill Screws, therefore, in exterior applications these often challenging and potentially harsh conditions present a real problem with corrosion. The most common corrosion site is the exposed head. Corrosion in this area can result in unsightly staining of the roofing or cladding materials, open up potential leak paths into the structure, trigger expensive maintenance campaigns, and generally detract from the building's curb appeal. The head, however, is not the only place where these fasteners can corrode. They are also subject to shank corrosion in sections that may be exposed or are in contact with moist surrounding building materials and crevice corrosion. Like corrosion in the head, corrosion in the lower part of the fastener can result in staining of surroundings surfaces, reducing the mechanical strength of the fastener or joint, and increase the potential for environmentally induced stress corrosion cracking.

For these reasons, exterior Drill Screws must be manufactured with protective coatings or from corrosion resistant materials. Although protective coatings would provide a simple and, most likely, cost effective means of protection, the reality is that they will only prolong the time until failure. In other words, failure is eventually a reality; it may just take a little longer to get there. As a result, using corrosion resistant Stainless Steel is a much better option. The problem with this "solution", however, is that although the stainless steel is usually able to be work hardened enough in the threaded section to allow the threads to withstand forces exerted during thread forming, it cannot be sufficiently strengthened on the drill tip to hold up to the drilling application. The solution to this problem is about forty years old, the Bi-Metallic Drill Screw.

The Bi-metallic Drill Screw is a combination of a Stainless Steel body and a hardened Carbon Steel drill point. The remainder of this article will introduce the fundamentals of this very valuable and specialty Drill Screw.

Corrosion Types:

Drill Screws used in roofing and cladding applications could be exposed to several different types of corrosion. The most noticeable form of corrosion is likely the rusting of steel components which is a form of corrosion known as Uniform Attack or General Overall Corrosion. It is an electrochemical mechanism that is triggered when unprotected steel or iron components are exposed to a wet environment in such a way that mini electrical currents are generated. For the most part, Carbon Steel fasteners are protected against such attack with surface coatings. These coatings, however, only prolong the inevitable and eventually weak areas of the coating will expose the base steel and trigger the beginning of rust. Since the fasteners are expected to last the life of the roof, such coated Carbon Steel variations may not suffice. Bi-metallic versions, however, should perform quite well against General Corrosion.

Drill Screws on roof and cladding are commonly exposed to another type of corrosion, Galvanic Corrosion. This is a corrosion mechanism triggered by contact with dissimilar materials. When certain dissimilar materials are in contact with one another and an electrolyte (an electrically conducting substance) is present, a galvanic cell is created and the less chemically "noble" of the materials will begin to corrode. This is a common problem experienced by Drill Screws used for metal roofing and cladding because these components are often made of aluminum. Carbon Steel versions are not as well protected as Bi-metallic versions will be.

Drill Screws may also be subject to Crevice Corrosion. This occurs when localized areas remain in contact with stagnant liquids, moist substrates. Drill Screws in roof and cladding applications often use washers or gaskets to prevent water infiltration. Should this seal fail in any way, these types of joints become vulnerable to crevice corrosion underneath the head or along the shank where water has infiltrated and moistened contacting materials.

Finally Carbon Steel Drill Screws may be surface hardened to very high hardness levels. This could make them vulnerable to Hydrogen Induced Stress Corrosion Cracking (Environmental Hydrogen Embrittlement) if the right conditions exist.

Stainless Steel:

Clearly the solution to these corrosion issues is to utilize a material that is free from such corrosion mechanisms. Our immediate inclination is probably Stainless Steel. Stainless Steels are alloys that contain at least a minimum of 11% Chromium. The Chromium results in the formation of a Chromium Oxide, Cr^2O^3, when exposed to atmospheric oxygen. Unfortunately the ability to actually generate this oxide is not the same with all types of Stainless Steel.

Although there are over two hundred different Stainless Steel alloys we generally form our limited "knowledge" of Stainless Steel based on personal experience. What I mean is that we formulate our understanding on what we know from everyday experiences and interactions. For most of us, when it comes to Stainless Steel, that means the flatware we use to eat with, the cookware we use, our kitchen appliances, and working surfaces in many restaurants and hospitals. Our experience in this regard is universal; these items don't rust and are inert to harsh environments. In reality, however, this understanding is incomplete, because some of the different Stainless Steel alloys do not exhibit these properties and are subject to rusting and oxidation.

Although there are five families of Stainless Steel, let us look at the primary three; Ferritic, Martensitic, and Austenitic. After exploring these three families we will find that only one of them provides the corrosion resistant properties that we normally attribute to Stainless Steel.

- **Ferritic Stainless Steel**: Ferritic Stainless Steels contain less than 12% Chromium. As a result they have low to moderate corrosion resistance. They can be susceptible to brittleness. They are not recommended for roof and cladding applications.
- **Martensitic Stainless Steel**: Martensitic Stainless Steels have a minimum of 11% Chromium. They can be heat treated to make them very hard and strong. However, of all the Stainless Steel varieties, they have the poorest corrosion resistance. Although one might be able to make a case that they could be used for Drill Screws because of their ability to be hardened, their lack of corrosion protection negates them as a real viable option for roofing or cladding Drill Screws.
- **Austenitic Stainless Steel**: Austenitic Stainless Steels are the materials we normally associate Stainless Steel with. This variety contains about 18% Chromium and 8% Nickel. Although they work harden they cannot be heat treated to further augment their strength. They have the best corrosion resistance of the different Stainless Steel types. Unfortunately, as previously mentioned, they are not really strong enough to generate a drill point that will hold up under the extreme pressures of drilling, especially through thicker cross sections. Therefore, although this type of Stainless Steel is the only one recommended for Drill Screws for roofing or cladding, they only become feasible when married to a high strength Carbon Steel tip.

What is a Bi-Metallic Drill Screw?

We have now identified two important points…

1. **For Drill Screws to withstand the rigors of exterior application, they must be made of Austenitic Stainless Steel.** In North America this would usually mean 304 or 316 Stainless Steels. In the rest of the world, the equivalent designations are A2 and A4. In general these materials perform well against General and Crevice Corrosion in almost all environments, as well as providing a better galvanic coupling with Aluminum (the Stainless Steel is more noble and thus won't rust and streak Aluminum panels. Although the fastener is better protected, designers still need to consider the Aluminum panels and take measures to limit the galvanic interaction of this pairing.)
2. **Austenitic Stainless Steel materials do not possess the requisite strength to suitably perform the drilling**. Therefore, for Austenitic Stainless Steels to be successful in this application a short Carbon Steel section, which will become the drill point, must be married to the Austenitic Stainless Steel body .

How does one marry two entirely different materials together to form one integrated bi-metallic part? Globally, there are several different manufacturers producing these parts. Likely they all employ their own proprietary methods and knowledge. Notwithstanding the small differences in methods, essentially the process looks like this:

1. **A body blank is cold headed from Austenitic Stainless Steel**
2. **A medium or high Carbon Steel tip blank is either cut off a wire coil or produced from some type of forming method**
3. **The Stainless Steel body blank is welded to the Carbon Steel tip blank**
4. **The Carbon Steel tip is pinch pointed to produce the drill point**
5. **The threads are thread rolled**
6. **The tip is induction hardened to strengthen the drill point and, most likely, the first one or two lead threads.**
7. **Cleaning and finishing** (some manufacturers leave the parts natural so that the Stainless Steel and Carbon Steel zones are easily distinguishable, while other manufacturers have a process step that includes zinc electroplating to camouflage the two distinct regions.)

Up until now, I have stressed the self-drilling capability of these screws. It is important not to forget, however, that these screws are also expected to form their own threads. Although the Austenitic Stainless Steel undergoes some work hardening when forming the threads, if the part is expected to fasten into a thick cross section, the lead threads may not hold up well. Therefore, it is common that the Carbon Steel tip is long enough to incorporate not only the entire length of the drill point but also the first couple of lead threads. In this way, the induction hardening can capture those lead threads and provide very hard and strong leading threads, where the thread forming is occurring.

Summary:

Bi-metallic Drill Screws are a unique and elegant solution to a vexing fastening problem. By marrying the Carbon Steel tip to facilitate easy self-drilling and thread forming, the customer is able to install an Austenitic Stainless Steel body that will hold up to even the harshest environments for the entire life of the product (roof or cladding) and likely many years beyond that.