NONFERROUS BOLTING MATERIALS

Nonferrous materials are defined as simply those materials that do not contain any significant amounts of iron: except in trace amounts which are unintentionally present and with some grades of stainless steels. All nonferrous alloys will work harden to some degree and some can be heat treated. What they all share in common is the ability to be corrosion resistant, and acid resistant, to some extent and certainly so when compared with ferrous materials.

by Guy Avellon

Because these materials exhibit corrosion resistant properties does not mean that the surface does not form an oxide. Actually, it is this oxide layer formation that enhances the corrosion resistance properties of aluminum, stainless steel and titanium. Some of these alloys will resist heat scaling and heat oxidation, but may be prone to stress corrosion cracking, as with aluminum, or carbide precipitation, as with austenitic stainless steels.

The American Society for Testing and Materials (ASTM) has two standards for general purpose externally threaded fasteners: F468 and F468M, inch and metric, respectively. The F467 and F467M are the requirements for nonferrous nuts and the F2281 is for fasteners used in high temperature applications, in the range from 500°F (260°C) to 1,800°F (962°C).

Copper and its alloys are designated by the prefix letter C in the UNS (Unified Numbering System). There are many alloys of copper, ranging from brass, bronze, silicon bronze and cupro-nickel and these are represented as both UNS and ASTM numbers in the F468 and F468M standards.

For example: brass alloy 260 has a mechanical property marking of F 468AB and a UNS number of C26000; a common fastener material, silicon bronze, alloy 651, requires a bolt head identification marking of F 468K and has a UNS designation of C65100; and the cupro-nickel alloy 715 (C71500) has a marking of F 468R.

The UNS designation for nickel begins with the prefix letter N; such as N05500 for alloy 500, whose ASTM mechanical property marking is F 468W.

Aluminum has a UNS designation of the prefix A; such as A96061 for alloy 6061, whose ASTM head marking is F 468Y and F 468X for alloy 2024-T4 (UNS A92024).

Titanium is recognized by the UNS prefix of R; such as R56401 for alloy 23, which is Ti-6Al-4V, or F 468GT for its head marking.

The UNS designations only denote the alloy, whereas the ASTM numbering system refers to the mechanical properties and marking system for the finished product. Only the ASTM numbers will let the user know if the product he has is an inch or metric threaded part. The F 468 numbers remain the same for each alloy but are immediately followed by the letter M to denote 'metric' properties; such as F 468MGT, F 468MY and F 468MW, etc.

As always, it is best to consult the standard for complete information.

Copper is mainly alloyed with zinc. Some alloys include aluminum, manganese, silicon, nickel and lead. As usual, some element combinations will enhance ductility, tensile or yield characteristics. Some properties make it ideal for bearing use. These alloys have excellent corrosion resistance to

sea water. Silicon bronze 651 is most frequently used in general fasteners.

Aluminum has good electrical and thermal conductivity. It is resistant to oxidation, is light weight but not strong. It is used to join other aluminum parts to avoid galvanic corrosion with dissimilar metals. Aluminum and steel react violently against each other.

Titanium has the highest strength-to-weight ratio of any metal. Without any benefit of an alloy, it is as strong as most steels but 45% lighter. Alloys can achieve tensile strengths of 200ksi (1,400 MPa) but will begin to lose strength when exposed to temperatures above 800°F (430°C). Its high density ratio to strength gives titanium excellent corrosion and fatigue resistance, along with high crack resistance. It also has the ability to withstand moderate temperature increases without experiencing creep. Besides being able to withstand elevated temperatures, it also exhibits excellent cryogenic properties.

Nickel is such a versatile element, that when alloyed with other elements such as chromium, cobalt, molybdenum, titanium, copper, aluminum, etc. spawns a category called 'super alloys'. It should also be noted that these super alloys are for highly specialized applications and are very expensive.

Inconel® is a registered trademark of Special Metals Corporation. Inconel® is from a family of austenitic nickel-chromium based super alloys used for high temperatures. The nickel content may vary from 44-72%. Operating temperature range is up to 1,200°F (650°C) and is very oxidation and corrosion resistant. Strength is developed by age hardening, solid solution strengthening, or precipitation strengthening. The material is difficult to machine due to its rapid cold working, so tensile testing full sized specimens is always recommended. Besides fasteners, this alloy is used in nuclear steam generators and in exhaust systems for Formula 1 race cars.

Hastelloy® is the registered trademark of Haynes International and represents a group of super alloys with many designation numbers to identify different physical characteristics. Tensile strengths can be up to 135 ksi and are used for high stress and elevated temperature applications. It has excellent corrosion resistance, especially to acids, and is used in many chemical plants.

Monel® is also the trade mark of Special Metals Corporation. Monel is a nickel-copper alloy that is extremely resistant to corrosion, alkalis and acids, such as hydrofluoric and sulfuric acids. The K-500 alloy can reach tensile strengths of 190 ksi. This material also work hardens rapidly.

Waspalloy® is the registered trademark of United Technology Corporation. This is an age hardening, austenitic nickel-based super alloy that is used in very high temperature applications. The Waspalloy® maintains its strength properties through 1,800°F (980°C). It exhibits good corrosion resistance and is impervious to oxidation.

The ASTM F2281 is a standard for stainless steel and nickel alloy fasteners used for heat resistance and high temperature applications. This standard describes several different heat treated conditions which are explicitly outlined and given a new numeric designation for the product head marking. Therefore, a heat resisting austenitic alloy (Type 316) with a condition HWA (hot formed from annealed or solution-annealed stock and then re-annealed) will have a head marking of F1F.

This is of extreme importance when ordering for special applications: make sure the engineering staff gives the full details to Purchasing, and be sure the vendor understands those requirements when placing an order. For example: a full alloy condition description would be; condition AH3 - precipitation hardened alloy, Type III Class B, head marking F3F.

As mentioned several times, nonferrous alloys cold work, some more than others. Cold working means that the metal will become harder and lose its ductility the more its grain boundaries are moved around, by machining, bending or forming into a different shape.

When testing a full sized nonferrous fastener, it is not uncommon to have the shank begin to yield and dog-bone instead of the threads. The stresses begin in the weaker cross-section of the threads, but as that area rapidly becomes harder, the material must yield elsewhere.

Always, verify all data with the product standard.