Technical Data

Finishes and Protective Coatings

Aluminum threaded fasteners can be supplied with a variety of finishes, colors and protective coatings.

In standard practice, small bolts, screws and nuts have bright finishes, produced by burnishing in a tumbling barrel or other special mechanical finishing device. The same parts can be supplied with machine or etched finishes by specification. A wide variety of special finishes can be applied for aesthetic reasons, functional characteristics or both. Chemical, electrochemical and applied coatings have been developed to meet a variety of needs.

Where special service requirements, appearance, or color cannot be satisfied by the standard finish described below, special finishes are available and inquiries are invited.

Anodizing of fasteners is used frequently to improve resistance to corrosioin and abrasion. For maximum resistance to saline environments, a dichromate seal should be specified. The dichromate sealed Alumilite* 205 finish will have a characteristic yellow color that may be objectionable for certain applications. Alumilite 204 finishes have a characteristic aluminum color and are applied when the typical yellow color from the dichromate seal is not suitable. When clear finish is desirable along with higher resistance to corrosion, the Alumilite 204 finish is usually specified.

Small items are anodized by bulk techniques, being solidly packed in perforated baskets. While these techniques are the only ones practical for small items, they provide a lower degree of coating control than individual rack techniques, and some rejects must be expected with each load. Large fasteners are ocasionally racked separately for more uniform finishes.

Anodic coatings are available in a wide variety of colors. The final choice of color match or contract usually requires meeting specific service needs, and can best be ascertained by special inquiry and the submission of samples.

Prepainting is becoming increasingly popular. High gloss or flat enamal finishes can be applied to the entire surface of any fastener that forms its own thread and the coating on the head will suffer little, if any, damage in driving. Fasteners engaging pretapped holes requre a more expensive painting of the heads only.

Chemical conversion coatings may be applied as paint bases or used without further treatment in order to improve corrosion resistance. Those which contain chromates are especially resistant to saline environments. Chemical conversion coatings are extremely thin. They are softer, less corrosion resistant than anodic coatings and offer little improvement in abrasion resistance.

Metallurgical Aspects

In high-purity form aluminum is soft and ductile. Most commercial uses however, require greater strength than pure aluminum affords. This is achieved in aluminum first by the addition of other elements to produce various alloys, which singly or in combination impart strength to the metal. Further strengthening is possible by means which classify the alloys roughly into two categories, non-heat-treatable and heat-treatable.

Non-heat treatable alloys

The initial strength of alloys in this group depends upon the hardening effect of elements such as manganese, silicon, iron and magnesium, singly or in various combinations. The non-heat-treatable alloys are usually designated, therefore, in the 1000, 3000, 4000 or 5000 series. Since these alloys are work-hardenable, further strengthening is made possible by various degrees of cold working, denoted by the “H” series of tempers. Alloys containing appreciable amounts of magnesium when supplied in strain-hardened tempers are usually given a final elevated-temperature treatment called stabilizing to insure stability of properties.

Heat-treatable alloys

The initial strength of alloys in this group is enhanced by the addition of alloying elements such as cooper, magnesium, zinc and silicon. Since these elements singly or in various combinations show increasing solid solubility in aluminum with increasing temperature, it is possible to subject them to thermal treatments which will impart pronounced strengthening.

The first step, called heat treatment or solution heat treatment, is an elevated-temperature process designed to put the soluble element or elements in solid solution. This is followed by rapid quenching, usually in water, which momentarily “freezes” the structure and for a short time renders the alloy very workable. It is at this stage that some fabricators retain this more workable structure by storing the alloys at below freezing temperatures until they are ready to form them. At room or elevated temperatures the alloys are not stable after quenching, however, and precipitation of the consituents from the super-satureated solution begins. After a period of several precipitation, the alloy is considerably stronger. Many alloys approach a stable condition at room temperature, but some alloys, particularly those containing majnesium and silicon or majnesium and zinc, continue to age-harden for long periods of time at room temperature.

By heating for a controlled time at slightly elevated temperatures, even further strengthening is possible and properties are stabilized. This process is called artificial aging or preceipitation hardening. By the proper combination of solution heat treatment, quenching, cold working and artificial aging, the highest strengths are obtained.

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Clad alloys
The heat-treatable in which copper or zinc are major alloying consituents, are less resistant to corrosive attack than the majority of non-heat-treatable alloys. To increase the corrosion resistance of these alloys in sheet and plate form they are often clad with high-purity aluminum, a low magnesium-silicon alloy, or an alloy containing 1 percent zinc. The cladding, usually from 2 1/2 to 5 percent of the total thickness on each side, not only protects the composite due to its own inherently excellent corrosion resistance, but also exerts a galvanic effect which further protects the core materials.

Special composites may be obtained such as clad non-heat-treatable alloys for extra corrosion protection, for brazing purposes, or for specials surface finishes. Some alloys in wire and tubular form are clad for similar reasons and on an experimental basis extrusions also have been clad.

Annealing characteristics
All wrought aluminum alloys are available in annealed form. In addition, it may be desirable to anneal an alloy from any other initial temper, after working, or between successive stages of working such as in deep drawing.

Effect of Alloying Elements

1000 series
Aluminum of 99 percent or higher purity has many applications, especially in the electrical and chemical fields. These alloys are characterized by excellent corosion resistance, high thermal and electrical conductivity, low mechanical properties and excellent workability. Moderate increases in strength may be obtained by strain-hardening. Iron and silicon are the major impuritites.

2000 series
Cooper is the prinicpal alloying element in this group. These alloys require solution heat-treatment to obtain optimum properties; in the heat treated condition mechanical properties are similar to, and sometimes exceed, those of mild steel. In some instances artificial aging is employed to further increase the mechanical properties. This treatment materially increases yield strength, with attendant loss in elongation; its effect on tnsile (ultimate) strength is not as great. The alloys in the 2000 series do not have as good corrosion resistance as most other aluminum alloys and under certain conditions they may be subject to intergranular corrosion. Therefore, these alloys in the form of sheet are usually clad with a high-purity alloy or a magnesium-silicon alloy of the 6000 series which provides galvanic protection to the core material and thus greatly increases resistance to corrosion. Alloy 2024 is perhaps the best known and most widely used aircraft alloy.

3000 series
Manganese is the major alloying element of alloys in this group, which are generally non-heat-treatable. Because only a limited percentage of manganese, up to about 1.5 percent, can be effectively added to aluminum, it is used as a major element in only a few instances. One of these, however, is the popular 3003, which is widely used as a general purpose alloy for moderate-strength applications requiring good workability.

4000 series
Major alloying element of this group is silicon, which can be added in sufficient quantities to cause substantial lowering of the melting point without producing brittleness in the resulting alloys. For these reason aluminum-silicon alloys are used in welding wire and as brazing alloys where a lower melting point than that of the parent metal is required. Most alloys in this series are non-heat-treatable, but when used in welding heat-treatable alloys they will pick up some of the alloying constituents of the latter and so respond to heat treatment to a limited extent. The alloys containing appreciable amounts of silicon become dark gray when anodic oxide finishes are applied, and hence are in demand for architectural applications.

5000 series
Magnesium is one of the most effective and widely used alloying elements for aluminum. When it is used as the major alloying element or with manganese, the result is a moderate to high strength non-heat-treatable alloy. Magnesium is considerably more effective than manganese as a hardener, about 0.8 percent magnesium being equal to 1.25 percent manganese, and it can be added in considerably higher quantities. Alloys in this series possess good welding characteristics and good resistance to corrosion in marine atmosphere. However, certain limitations should be placed on the amount of cold work and the safe operating temperatures permissible for the higher magnesium content alloys (over about 3 1/2 percent for operating temperatures above about 150^{o} F) to avoid susceptibility to stress corrosion.

6000 series
Alloys in this group contain silicon and magnesium in approximate proportions to form magnesium silicide, thus making them heat-treatable. Major alloy in this series is 6061, one of the most versatile of the heat-treatable alloys. Though less strong than most of the 2000 or 7000 alloys, the magnesium-silicon (or magnesium-silicide) alloys posses good formability and corrosion resistance, with medium strength. Alloys in this heat-treatable group may be formed in the T4 temper (solution heat-treated but not artificially aged) and then reach full T6 properties by artificial aging.

7000 series

Zinc is the major alloying element in this group, and when coupled with a smaller percentage of magnesium results in heat-treatable alloys of very high strength. Usually other elements such as copper and chromium are also added in small quantities. Outstanding member of this group is 7075, which is among the highest strength alloys available and is used in air-frame structures and for highly stressed parts.