ANCHOR BRONZE & METALS, INC.

E-mail: metals@anchorbronze.com website: www.anchorbronze.com

C95410 ALUMINUM BRONZE IMPROVEMENT

The more popular aluminum bronze bar stock alloy in Europe is one with a nickel content. There is a good reason for this as well as the preference for nickel aluminum bronzes in the United States market for superior strength and corrosion resistance.

When C95400 aluminum bronze alloy (85Cu-11AL-4Fe) is cast, slow cooling of the solid metal between 1050° F and 800° F will cause a very brittle and corrosion prone structure to form. When C95400 freezes initially, the crystals formed are all the same (beta). Each crystal has the same average composition as the prior liquid metal. Upon cooling to 1050° F, the beta crystal can no longer contain the 11% aluminum and it decomposes into a mixture of two kinds of crystals. One is sift (alpha), containing less than 11% aluminum. The other is very brittle (gamma 2) and contains almost 16% aluminum. This mixture forms in alternate layers of soft and brittle material. Resulting physical properties are less than typical for a properly produced casting. A tensile test of the slowly cooled casting may show only 3% elongation and 75,000 psi tensile strength, while a properly cooled casting may show 20% elongation and 90,000 psi tensile strength.

The "bad" casting can be improved by reheating above 1050° F for two hours and quenching in water or fan cooling. The room temperature micro-structure would then be retained beta and alpha in amounts relative to the cooling rate, the cooling rate being sufficiently rapid to avoid the formation of gamma 2. More alpha will give greater ductility while more retained beta will give greater tensile strength. The ratios of alpha to retained beta can be varied by the above mentioned "solution anneal" and subsequent tempering heat treatments, all avoiding the formation of gamma 2 crystals. A further negative effect of gamma 2 crystals is the tendency for dealuminization of those crystals in seawater and other corrosive environments.

The inherent production problems and varying quality of the C95400 alloy can be overcome in a reliable and repeatable manner by altering the chemistry of the alloy to stabilize the beta crystals, thus retarding the formation of gamma 2 at any cooling rate. Additions of nickel to the alloy will retard the diffusion of aluminum from the beta crystals. An addition of 2% nickel will yield an alloy that corrodes at only 1/6th the rate of nickel free aluminum bronze. The reason for this is that 2% nickel is sufficient to eliminate the formation of gamma 2. Nickel bearing aluminum bronzes also have increased tensile properties because of the elimination of the brittle gamma 2 crystals.

C95400 aluminum bronze has been a popular bar stock alloy in the United States for many years. When properly produced or enhanced by remedial heat treatment, this metal has served well. All the quality problems and variations in micro-structure can be overcome by the addition of nickel, which will eliminate the gamma 2, seen in so much of the material sold by metal service centers today.

C95410 aluminum bronze with a nickel requirement of 1.5% to 2.5% should be substituted for the C95400 bar stock. This change will result in uniform material, stronger and more corrosion resistant than C95400 aluminum bronze.

Engineers will appreciate that the gamma 2 phase is a dangerous situation in gear teeth or other cyclically loaded parts. Gamma 2 is desired in only one application - that is the production of wear plates where the aluminum bronze is sliding on hardened steel. 82Cu-13Al-4Fe-1Mn is mainly lamellar alpha and gamma 2, and serves well as a wear plate. However, this alloy is never recommended for structural parts or corrosion resistant parts.

C95410 should be the design engineer's alloy of choice for made to order or stock requirements.