Guide to:
Nickel Aluminum Bronze

Nickel Aluminum Bronze alloys are one of the toughest corrosion resistant of all of the bronze alloys. This guide will introduce you to the alloys, their specifications, and detail how to make them work for your components.
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Aluminum Bronze Alloys are important materials due to their excellent physical, mechanical, anti-corrosive, and wearing properties. Add Nickel to the alloy and you can achieve an increase in strength without diminishing it’s excellent ductility, toughness, and corrosion resistance.

Nickel Aluminum Bronze Alloys are used in a wide array of components in many different industries. Normally specified for their high strength, good wear resistance, abrasion resistance, and excellent resistance to corrosion in sea water and many other aggressive environments.

Advantages of Nickel Aluminum Bronze

- **High Strength** - Good wear and abrasion resistance. With the addition of Nickel can be achieved without diminishing ductility
- **Corrosion resistant** - Especially in sea water and in various chemical environments
- **Excellent physical and mechanical properties** that can be improved via various thermal treatments
Nickel Aluminum Bronze Alloys are known for their superior corrosion resistance in seawater and many other chemical environments. The corrosion resistant property relies on the formation of a copper/aluminum oxide film. This film is self-repairing in media containing even low levels of oxygen.

This oxide film provides the following benefits:
- It adheres firmly to the surface of the substrate
- It has a resistance to liquid penetration
- The hardness of the alumina content creates higher resistance to erosion and abrasion

Nickel Aluminum Bronze alloys can be considered for service in the following chemicals. Selection must take into account the operational temperature, concentrations, service conditions, and impurities.

**Chemicals in which Nickel Aluminum Bronze can be considered for service:**

- Acetic Acid
- Carbon Dioxide
- Glycerine
- Sewage
- Acetic Anhydride
- Carbonic Acid
- Glycerol
- Soaps
- Acetate Solvents
- Caustic Potash
- Hydrochloric Acid
- Sodium Bisulfate
- Alcohols
- Caustic Soda
- Hydrofluoric Acid
- Sodium Bisulfite
- Aldehydes
- Chlorine (dry)
- Hydrogen
- Sodium Chloride
- Aluminum Chloride
- Chloroform
- Inert Gases
- Sodium Hypochlorite
- Aluminum Fluoride
- Citric Acid
- Lactic Acid
- Sodium Nitrate
- Aluminum Hydroxide
- Coal Tar
- Linseed Oil
- Sodium Silicate
- Aluminum Sulfate
- Coal Tar Solvents
- Magnesium Chloride
- Sodium Sulfate
- Ammonia (Dry)
- Copper Sulfate
- Mineral Oils
- Sodium Bisulfite
- Amyl Chloride
- Dyestuffs, Acid Dyes
- Naphthenic Acids
- Sulphur
- Asphalt
- Esters
- Nickel Sulfate
- Sulfuric Acid
- Barium Chloride
- Ethers
- Nitrogen
- Sulfurous Acid
- Benzole
- Fats
- Oxalic Acid
- Sulfur Dioxide
- Borax
- Fatty Acids
- Oxygen
- Tannic Acid
- Boric Acid
- Fluosilicic Acid
- Oleic Palmytic
- Stearic Acid
- Tartaric Acid
- Brine
- Formaldehyde
- Paints
- Trichlorethylene
- Bromine (Dry)
- Formic Acid
- Petroleum Products
- Tri-Sodium Phosphate
- Calcium Chloride
- Furfural
- Phosphoric Acid
- Zinc Chloride
- Calcium Hypochlorite
- Fuel Gases
- Pickling Solutions
- Zinc Sulfate
- Cane Sugar Liquors
- Gelatine
- Refrigeration Gases
- Carbolic Acid
- Glucose
- Seawater
Many of the standard Nickel Aluminum Bronze Alloys are heat treated per their alloy standard. The heat treated alloys are as follows:

- C63000 ASTM B150 HR50 AMS 4640
- C95510 ASTM B505 AMS 4880
- C63020 ASTM B150 AMS 4590
- C95520 ASTM B505 AMS 4890

The reason for this, is that heat treating these alloys can have many beneficial effects to the metal. They are as follows:

- Relieve internal stress
- Increase ductility
- Adjusts tensile and hardness
- Improve wear resistance
- Reduces magnetic permeability

There are different methods of heat treating. Each with their own unique benefits and purposes.

**Stress Relieving**

This type of heat treatment is used to relieve internal stress caused by cold working, rapid cooling, and/or machining. Stress relieving of Nickel Aluminum Bronze is done at lower temperatures than annealing. This is useful when the Nickel Aluminum Bronze is being machined into thin walled bushings, like those used in aircraft landing gears. As some Nickel Aluminum Bronze bar stock can have a tendency to spring after larger amounts of metal is removed. By having the bar stock stress relieved, it is less likely to spring out of tolerance after machining.

C63000 ASMT B150 AMS 4640 is stress relieved and cold drawn in sizes up to 3” diameter. Being that this alloy is used extensively in bushing applications, the stress relieving helps keep the close tolerance needed when machining bushings.
Nickel Aluminum Bronze
Heat Treatment Continued...

Annealing

Generally this is done at a higher temperature than stress relieving. Annealing can cause a greater degree of microstructural change to the metal. Recrystallization will normally occur at temperatures above 1247° F.

Quenching and Tempering

Nickel Aluminum Bronze reacts similarly to alloyed tool steels in respect to heat treatment procedures. A martensitic phase is formed in the alloy when Nickel Aluminum Bronze is water quenched from elevated temperatures. Once quenched Nickel Aluminum Bronze Bars can be tempered to improve ductility while still retaining a high tensile and hardness.

C95510 is a cast alternative to C63000. In this alloy heat treatment is used to give this cast alloy similar mechanical properties to the extruded version. This alloy is also quench hardened and temper annealed.

Heat treatment can be a useful technique used to both relieve stress and improve mechanical properties in Nickel Aluminum Bronze Alloys.
Applications for Nickel Aluminum Bronze Components

**Paper Making**
Nickel Aluminum Bronze is used in the paper making industry, where it comes into contact with low concentrations of hypochlorites and bisulfites found in the pulp. It has excellent corrosion resistance under these conditions and is used for beater bars, valves and suction rolls.

**Glass Industry**
Nickel Aluminum Bronze is used in the glass industry in the frosting of glass, utilizing its corrosion resistance in hydrofluoric acid. In this industry hydrofluoric acid is sprayed through nickel aluminum bronze nozzles onto light bulbs.

**Aerospace**
Nickel Aluminum Bronze alloys C63000 AMS 4640, C95510 AMS 4880, C63020 AMS 4590, and C95520 AMS 4881 are used in landing gear bushings. The excellent bearing properties combined with the corrosion resistance in salt conditions during deicing of run ways in the winter make these alloys ideal for this application.

**Oil & Gas**
Alloys C63000, C95510, & C95500 are used extensively in oil and gas applications. Examples include:

- Valve Seats
- Valve Guides
- Pump Shafts
- Pump Gears
- Bearings
- Bushings
- Nuts
- BOP Parts
Specifications

**C63000 Nickel Aluminum Bronze**
AMS 4640
ASTM B150
QQ-C-465
ASNA 3315
ASNA 3406
NFL 14-705
AKER SOLUTIONS 10000317419
AKER SOLUTIONS MS-480
BAKER BMS K099
EXPRO MS-1142 / MS1195
FMC M40300
GE MS004
HALLIBURTON D00001024
PATHFINDER 070.84727
SLB 101015538 / 100891990
SLB SH217036 / SH217037
NCT 10-641
UA10N
CuAl10Ni5Fe4
CW307G

**C63020 Nickel Aluminum Bronze**
AMS 4590B
ASTM B150
AKER Solutions MS 617
SLB S406500 / SP170125
SLB SP170208
GE MS038
CuAl11Ni5Fe5
CA104
UA11N
BS2B23 / BSB23
DTD 197A
LAT 1-9063 / 3-0189
SKF 40224 / 40228
NFL 14-706
DELTA CA34
NCV
SP170125
S406500
CW308G

**C95510 Nickel Aluminum Bronze**
AMS 4880
CuAl10Ni5Fe3
SKF 40226 / FTI 8701
Nickel Aluminum Bronze Machining Guidelines

On modern CNC equipment, Nickel Aluminum Bronze is relatively easy to machine. Depending on the alloy, machinability ratings vary between 20 to 50 (with free cutting brass being 100). It's still difficult to give exact machining guidelines, as the feeds and speeds rates vary depending and the size and age of CNC lathes used. This article with try to give some general guidelines to give you an idea where to start.

Lubrication

Lubrication is recommended when machining Nickel Aluminum Bronze, particularly where close tolerances are required. Like other copper based alloys, heat generation caused by the machining of the metal can cause expansion and when the part cools can result in contraction which will take the part out of tolerance.

Tooling-

Nickel Aluminum Bronze alloys can produce a curled swarf chip which can jam tooling and cause surface imperfections. Particularly when machining bores. It’s advisable to have a chip breaking profile and have sufficient lubrication, sometimes under high pressure, so that the swarf is removed from the cutting face.

Another option is to retract the tooling on a regular basis to prevent excessive metal build up. A coated carbide titanium indexable tip is recommended for roughing and removal of the bulk of the stock. For heavy metal removal, the size of the tip needs to increase.

Alloy Machinability-
C95500 Nickel Aluminum Bronze – 50
C63000 AMS 4640 Nickel Aluminum Bronze – 30
C95510 AMS 4880 Nickel Aluminum Bronze – 50
C63020 AMS 4590 Nickel Aluminum Bronze – Not listed