Aluminium–bronze: **a solution for tube and shell heat exchangers** using brackish and/or sea water

Aluminium–bronze and nickel–aluminium–bronze (NAB) are not necessarily widely known but have been developed as solutions for seawater corrosion issues. At the same time, they also offer other interesting properties, such as resistance to biofouling.

By Olivier Gouriou, Sales Manager at the LBI Foundries Group, France

Interesting properties of aluminium–bronze

Aluminium–bronze is a family of alloys, which includes copper, aluminium, nickel, iron, and manganese. Each individual component is adjusted in the mix to improve either strength, corrosion resistance and/or machinability properties, such as:

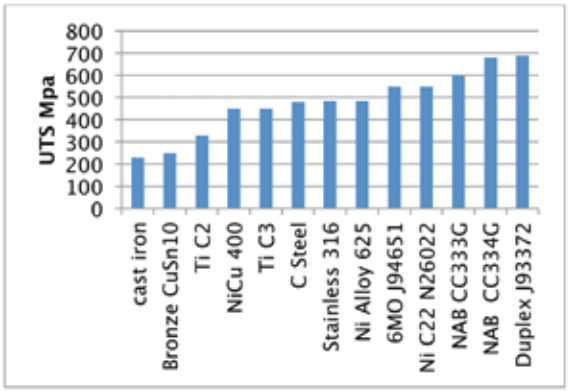
- High strength.
- Density (5 % lighter than steel).
- Non sparking.
- Low magnetic permeability (of <1.03µ in selected grades).
- High corrosion resistance (especially sea water related).
- Good cryogenic properties.
- High resistance to biofouling.

One of the main advantages being the protective oxide surface film, which has the ability to self-repair so that it outperforms steel-coated applications in the long run.

The family of nickel–aluminium–bronze (NAB) is available according to various international standards, in addition to the most used ASME code (EN 1982, ASTM B148, BS …). Each has very specific properties, some examples of which are listed below in Table 1:

Mechanical strength

Some design engineers, because of a lack of data, consider copper-based alloys as being low strength. As a result they tend to choose more easily steel-coated solutions. As is shown below, however, copper-based alloys are high up in the mechanical strength ratings of cast alloys that have a good degree of corrosion resistance.



» *Fig. 2. Tensile strengths of cast material.*

» *Table 1*

ASTM/ASME main grades	Tensile strength Mpa min	Yield strength MPa min	A Elongation % min	Hardness HBW min	Similar approved grades
B 148 C95 800	585	240	15		Similar INOXYDA 53
B 148 C95 400	515	205	12	150	
B 171 C63 000	620	250	10		Similar INOXYDA 90
B 171 C46 400	345	140	35		

» *Fig. 1. Some examples of corrosion issues on coated steel channels and floating heads. (Photo courtesy of TOTAL Antwerp.)*

Biofouling: a property often ignored

Biofouling can be a problem in systems handling sea water. Crustaceans that adhere to stainless steels have a direct impact on the material's corrosion resistance through causing crevice corrosion.

High-copper alloys have a natural resistance to the growth of crustaceans and seaweed. This means that less maintenance is required for process equipment either through mechanical removal or chlorination.

Fig. 4 shows a corrosion rack, which has been immersed in sea water for twenty-two months. The rack contains titanium, nickel alloys and stainless steels, all of which are heavily infested with marine growths. The copper alloys which include the sample (1) CuAl9Ni5Fe5, (25) CuAl9Ni5Fe4Mn and (26) CuAl10Ni5Fe4 are all free from marine organisms.

Military applications

Heat exchangers are not only found in the process industries, they are also found on most ships including very critical ones like submarines. In these underwater applications, two properties are looked at: corrosion resistance under high pressure because of the diving depth and low magnetic permeability. For these situations aluminium bronze alloys like Inoxyda 53 AMA have been specifically developed and sometimes used in conjunction with a forging process to increase strength.

Quality controls

Due to the environments where the heat exchangers are used, strict quality controls need to be put in place based on international standards:

- *Initial foundry certification:*
  - ISO 9001
  - PED (Pressure Equipment Directive 2014/68/EU)
  - End user qualification
- *Manufacturing process:*
  - Inspection and test plans
  - Dye penetrant test
  - Pressure test
  - UL thickness measurement
  - X-rays (in particular for high pressure applications)
- *3rd party inspection.*

Casting and repairability

NAB alloys have the following advantages :

- *Machining* of nickel aluminium bronze is easy and cost effective.
- Nickel aluminium bronze can easily be *repaired* by qualified welding technicians using corresponding feeder material.

In combination with sand casting process which easily covers parts up to 8 To, the numbers of weld seam is greatly reduced to improve long term reliability and availability of the equipment, thus improving the TCO (total cost of ownership).

« *Fig. 6. (Courtesy Copper Alloys Ltd .UK & Copper Alliance UK (CDA).)*

Summary

Due to its properties, nickel aluminium bronze is an option that should be considered when compared to other coated or stainless steels alloys, which are confronted with sea water corrosion, biofouling or non-sparking issues. If the cost of these latter alloys are significant, it is worthwhile remember that it is possible to get back 60% of the raw material costs when you scrap it, thus further improving your TCO.

More detailed technical data can be found in: A Guide to Nickel–Aluminium–Bronze for Engineers, by Ivan Richardson, a Metallurgical Consultant. It has been and published by the Copper Development Association and is available for download (http://www.inoxyda.co.uk/telechargement.php) «

ABOUT THE AUTHOR

Olivier Gouriou is a Sales Manager at the LBI Foundries Group , which has been specialized in the production of large size aluminium–bronze centrifugal and sand castings for pumps, valves, heat exchangers, and propulsion systems since 1919. See also www.lbi-foundries.com

« *Fig. 3. Examples of tube and shell heat exchanger parts, which can easily be cast in various aluminium bronze alloy grades . (a) ASTM B171 C63000 tube sheets. (b) ASTM B148 C95400 channels. (c) ASTM B148 C95800 float head. (d) Inoxyda 3P covers for chemical processes. (All photos courtesy of Inoxyda SA.)*