

Solutions for seawater valves: aluminium-bronze alloys

Corrosion leads to maintenance issues and downtime which in some cases considerably affects ROI and equipment availability. Selecting the proper alloy for a given application, for example seawater-contact applications, is therefore an important step. The purpose of this article is not to detail all corrosion scenarios but rather present the main properties of Nickel Aluminium Bronze (NAB) Alloys to consider them early in design stage.

This family of copper (Cu) based alloys are not always well-known but were initially developed to solve sea water corrosion issues due to their content in Nickel (Ni) and Aluminium (Al). Corrosion resistance or NAB alloys are very well documented with regards to sea water corrosion (example of corrosion rate 0.05-0.075mm/year) in particular due to their self-repairing copper/aluminium oxide film which offers better protection than any painting/coating process which can be damaged during lifecycle.

The images below show a heat exchanger channel in welded steel construction with a protective coating compared to a butterfly valve in aluminium bronze after use 30 years on the cooling system of a nuclear power plant.

What is much less known, yet also documented, is the resistance to major chemical products, all cannot be listed here but are available in *the guide to nickel aluminium bronze for engineers* published by the copper development association. The properties of those alloys are such that they are even compared to Titanium.

Mechanical characteristics

Adjusting the chemical composition of an aluminium bronze alloy enables targeting the right corrosion resistance but also improving the mechanical properties required by engineering; adding Nickel and Iron helps improve those properties compared to more standard bronze or naval brass alloys. Some example of mechanical characteristics commonly reached are:

Applications can have additional requirements with regards to:

- Cavitation for pumps,
- Low temperature for cryogenics,
- Non magnetic for mine hunter propulsions,
- Non sparking for improved safety on offshore platform,



5 year old steel coated channel (credit TOTAL).



Aluminium bronze valve body during maintenance after 30 years (credit EDF).

More unusual but nonetheless interesting, the presence of copper and aluminium gives excellent electrical and thermic conductivity capabilities as those required for electrical motor cooling applications in sea water environment.

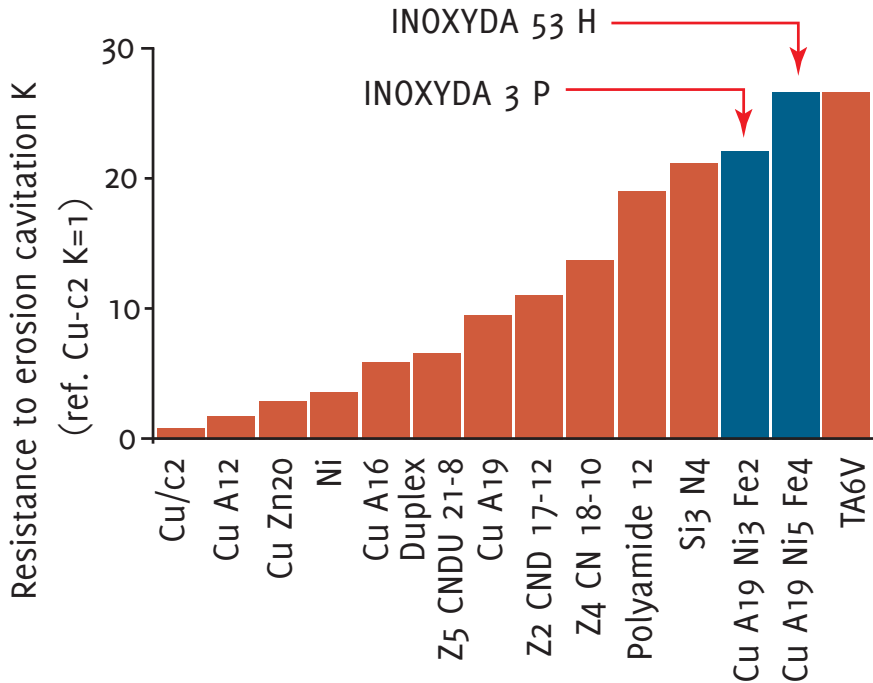
Casting technology

Manufacturing technology is also a factor to take into consideration to address corrosion. Welded construction is very often used and may lead to corrosion issues starting at the welded joints. Using casting technology, not only is repeatability improved but increased thickness and weldless

Specification	Grade	Rm Tensile Strength Mpa	Rp Proof Stress 0.2% MPa	A Elongation %	Hardness HB
	TITANIUM (TA6V)	895	825	10	340
ASTM/ASME	B148 C95800	585	240	15	(150)
EN 1982	CuAl10Fe5Ni5 (CC 333 G)	600	250	13	140
Steel	Super Duplex	800	550	15	
INOXYDA	I 154	750	450	8	200
INOXYDA	I 154 forged	800	500	10	240
INOXYDA	I 72	700	350	8	190
EN 1982	CuSn10 (CB480K)	250	130	18	70

COMPARISON OF AVERAGE CAVITATION RESISTANCE

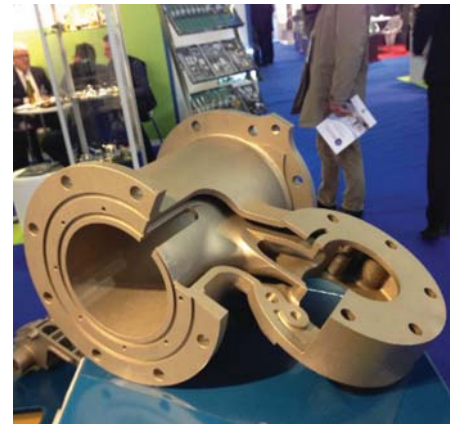
Source STCAN/MSN - Mr. Heuze



Resistance to cavitation (credit Inoxyda).



Weldless Inoxyda 3P Aluminium bronze casting.



Valve casting using 3D printed cores (Credit LBI Foundries).

process reduce all the risks of corrosion-induced leakage which is a source of down time in continuous chemical processes.

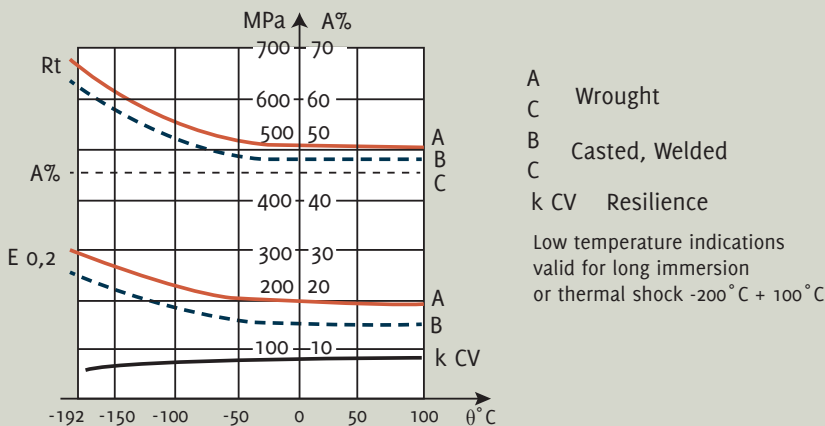
A perfect example is the use of casted lids on Esterfier lines. Not only Inoxyda 3P was found to be the best alloy to face the corrosion issue in that specific process and where casted constructions removed the risks linked to welding seams.

Different casting technologies are available to cover the scope of mechanical designers, among which: sand casting for complex and large size parts (pump casings, impellers, valve bodies, centrifugal casting (bushings, rings, pressure screw etc.), continuous castings (billets ready for machining small components or forgings). Today, 3D sand printing process can remove the hassle of recreating old or lost patterns, thus highlighting another benefit of casting technology.

Biocide/biofouling: a property often ignored

Copper is already known for its biocide properties which, in association with nickel,

AVERAGE MECHANICAL PROPERTIES REACHED



Effect of temperature on mechanical properties (credit Inoxyda).

	CASTING	MACHINING	MATERIAL COST	CORROSION	HEAT TREATMENT	IMPREGNATION
TITANIUM	-	+++	++++	+++	Necessary	No
NAB Alloys	+++	+++	++	++	Possible	No
DUPLEX Steel	++	++	+	++	Necessary	No
Bronze Alloys	++	+++	++	++	No	Often needed

Quality control of casted components

In addition to commonly required dimensional controls, the quality of casted parts are controlled with or without 3rd party inspections, thru several NDT tests such as:

- Chemical analysis : spectrometer
- Mechanical properties : tensile test, Charpy test, hardness
- Corrosion resistance : salt spray test,
- Surface defect : Dye penetrant test,
- Internal defects : X rays,
- Water tightness : pressure test.



Dye penetrant test of pre-machined valve body (Credit Inoxyda).



Pressure Testing (Credit Inoxyda).



Test bar ready for tensile test.

properties and associated advantages. These properties also minimize the occurrence of corrosion and mitigate possible negatives such as unplanned downtime due to equipment failure and/or leakages. Reduced down time due to less leakage issues.

Engineers looking for additional support on their projects can usefully turn to Inoxyda (www.inoxyda.fr) for design advices, prototypes, testing or casting simulation work.

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Olivier Gouriou – LBI Foundries

(www.lbi-foundries.com)

References:

- Guide to Nickel Aluminium Bronze for Engineers - I. Richardson (Copper Development Association),
- Interest in the Use of Cupro Aluminium in Chemical and Allied Industry – (Sulzer Brothers Ltd, Winterthur)
- Aluminium Bronze and their uses – P. Weill Couly – Chief Engineer FFAHR
- Propriétés Générales du Cuivre – Centre d'Information Cuivre-Laitons-Alliages
- NAB vs Titanium – Karan Sotoodeh in Valve World Nov .- 2019

offer excellent anti-biofouling performances. These are relevant in all systems that are subject to marine organisms by avoiding the application of an additional chemical biofilm.

In terms of recyclability, NAB alloys offer benefits as these are 100 per cent re-usable. Therefore, scrapped parts still have an interesting value and can be remelted thus

increasing ROI even after full equipment has been amortized, also reducing the pressure on scarce resources.

To conclude, faced with corrosive environments, engineers rarely consider Nickel Aluminium Bronze (NAB) alloys as being an interesting solution. However, the alloys offer a wide range of capabilities to meet stringent design requirements, given their