MULTIAlloys

*A division of **EMV**Africa*

OUR COPPER ALLOYS: PROPERTIES AND APPLICATIONS

Copper has been a most useful metal for more than 5000 years and thus in some respects it is a “mature” product, a commodity. However, there are many copper alloys that have a useful combination of properties that make them an essential material in the modern world and some of these are reviewed in this e-Book.

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INTRODUCTION

Apart from gold, copper is the only non-white metallic element and its colour is a primary feature and a reason for the use of the metal in many an architectural application. Copper's electrical and thermal conductivities are surpassed only by silver and so these too are fundamental properties of the metal and many of its alloys. Copper is placed in the periodic table near the "noble" metals which implies yet another important property of copper – its corrosion resistance.

Whilst copper is a soft ductile metal, alloying results in increased strength and it is on these alloys which offer higher mechanical properties that we focus and which can be conveniently grouped according to their applications as shown in the table.

Alloy	Nominal Composition	0.2% proof strength (Minm)	Applications			
		MPa	Bearing	Tooling	Electronics	Corrosion Resisting
Copper		140[1]				
90/10 Cu/Ni	Cu-10Ni-1.4Fe-0.5Mn	140[1]				√
70/30 Cu/Ni	Cu-31Ni-1Mn-0.7Fe	170[1]				√
Alloy 25	Cu-1.9Be	1000[2]	√	√(P,R)	√	
Alloy 3	Cu-1.8Ni-0.4Be	660[2]	√	√(R)	√	
MoldMAX HH	Cu-1.9Be	1000		√(P)		
PROtherm	Cu-1.8Ni-0.4Be	620		√(P)		
Cu-Cr-Zr	Cu-1Cr-0.1Zr	260[3]		√(R)		
ToughMet® 2	Cu-9Ni-6Sn	620[4]	√		√	
ToughMet® 3	Cu-15Ni-8Sn	760[5]	√		√	

P=Plastics Tooling R=Resistance Welding Tooling
1: Annealed 2: Bar, HT Temper 3: Aged 4: CX 90 Temper 5: CX 105 Temper

Brass and bronze are two terms used to describe some copper alloys. Brasses are alloys of copper with zinc whilst bronzes are alloys primarily with tin but several other elements may also be added.

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COPPER ALLOYS FOR CORROSION RESISTING APPLICATIONS

Copper and many copper alloys have inherently good resistance to corrosion in the atmosphere and in fresh water. But the presence of oxygen or oxidizing agents in a solution generally accelerates the corrosion rates of copper and copper alloys. In sea water it is the copper nickel alloys which have superior resistance to corrosion and which offer anti fouling properties and strength.

The addition of nickel to copper enhances its resistance to corrosion, erosion and cavitation in seawater and other natural waters and it also has a solid solution strengthening effect. The other alloying elements added to enhance properties are iron and manganese. Copper – nickel alloys have the added advantage of resistance to biofouling which makes them ideal for desalination plants, marine fire water systems, oil rig equipment, seawater intake screens and heat exchangers. The alloys are also quite suitable for hot and cold working making them fabrication “friendly”.

The 2 common alloys are:

90 Cu /10 Ni (UNS C 70600) *which is preferred for reasonably clean, flowing seawater.*

and

70 Cu / 30 Ni (UNS C71500) *better suited for faster flowing polluted seawater and resistant to impingement.*

STRENGTHENING OF COPPER ALLOYS

The common strengthening mechanisms in copper alloys are solid solution alloying, precipitation hardening and cold working. Spinodal decomposition is possible in some alloy systems. The phenomena, which involves a solid-state phase change requires a very homogeneous structure and controlled processing and in the case of the alloys under consideration a three-fold increase in yield strength results. In contrast, the mechanism by which Cu-Be alloys are strengthened involves the formation of precipitates and in its hardened condition Brush Alloy 25 attains the highest strength of commercial based copper alloys.

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COPPER ALLOYS FOR BEARING APPLICATIONS

Bearing bronzes may be grouped into a number of well-defined categories. These are: **Tin bronzes, leaded – tin bronzes, high leaded tin bronzes, aluminium bronze and manganese bronze. Phosphor bronze is also widely used for bushes.**

Whilst these alloys have met the requirements for many bearing applications, they have fallen short in the most demanding of them. Such duties may exist in equipment used for earth moving and mining, offshore gas and oil recovery. These are industries in which asset productivity and reliability are essential. In such applications the combination of properties required are:

- High compressive and impact strengths to resist high static and shock loads.
- High fatigue and creep strengths.
- Low co-efficient of friction and good thermal conductivity.

Copper alloy bearing technology was advanced by the development of yet another group of bearing alloys - spinodal bronzes. Using a proprietary casting process combined with a controlled heat treatment step to produce the spinodal decomposition, which enables a fine homogeneous microstructure and ultra – microscopic strengthening. Metals strengthened in this way develop a characteristic modulated microstructure which has been found to be ideal for bearing applications. This has resulted in a range of alloys that can outperform in conditions where lubrication may be a problem and sealing to prevent the ingress of moisture and dirt may be difficult.

There are 2 basic compositions and 3 tempers in which the alloys may be supplied but the higher nickel variant is the more common.

ToughMet®3: Cu-15Ni-8Sn &
ToughMet®2: Cu-9Ni-6Sn
Tempers:
CX= Cast and spinodal hardened
AT= Wrought and spinodal hardened
TS= Cold drawn and spinodal hardened

The number after the temper = minimum yield strength in 1000's psi
eg: ToughMet 3 CX105

The production of spinodal alloys in strip form has given rise to a range of thin-walled wrapped bearings which obviates waste and the cost associated with the machining of components from solid or thick-walled tube.

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COPPER ALLOYS FOR TOOLING APPLICATIONS

The 2 primary tooling applications for copper alloys are resistance welding and plastic moulding

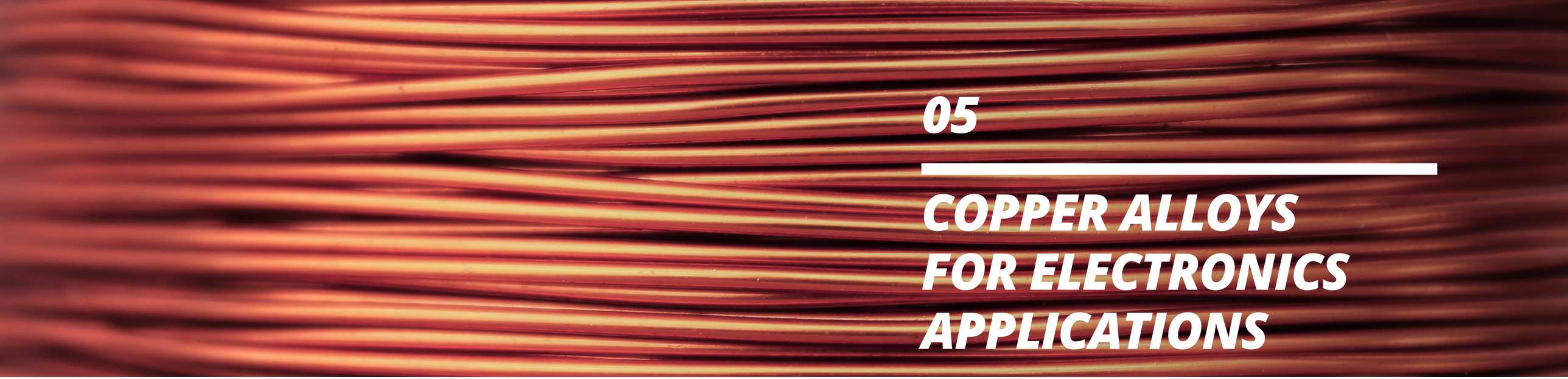
Resistance welding is a most useful process for manufacturing industries. It relies on a combination of two things, heat being generated in the work piece as a result of its resistance to the passage of an electrical current together with the application of a localized force to coincide with the points of high temperature. This gives rise to fusion of these points.

The electrode material used must have excellent electrical conductivity (at least better than that of the joined metal); thermal conductivity to dissipate heat between cycles; and mechanical strength and hot hardness to resist deformation in the application of force to the work piece. A classification system for metals used for electrodes exists having been drawn up by the *Resistance Welder Manufacturers Association* and the following are some of the more common copper based / containing metals.

- Copper chromium zirconium (RWMA class 2 – min 75% IACS and 75HRB) a heat treatable alloy used for clean mild steel, low alloy steels and coated steels.
- Copper beryllium – *Brush Alloy 3 (RWMA class 3 – min 45% IACS and 90HRB) a “low” beryllium alloy used for steels having high electrical resistance such as stainless steels.
- Copper beryllium - *Brush Alloy 25 (RWMA class 4 – min 20% IACS and 33HRC) a “high” beryllium alloy used where pressures required are high, wear may be severe but heating is not excessive.

There are several copper-based alloys which offer a combination of properties making them ideal for **tooling in the plastics industry**.
In this application the combination of thermal conductivity and strength enable shorter cycle times, improved part dimension and detail accuracy as well as better parting line maintenance. They are easily machined and polished. Brush Alloy 25 and MoldMAX HH are 2 high strength copper beryllium alloys which are well established in this application. They may be used for injection and blow moulding components – inserts, nozzles and manifolds.

PROtherm is a lower beryllium alloy and this reflects as a lower strength but higher thermal conductivity than MoldMAX HH.



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COPPER ALLOYS FOR ELECTRONICS APPLICATIONS

Given copper's electrical conductivity, it is to be expected that the metal retains a significant role in the rapidly developing electronics industry. However, consumer appliances, electronics and automotive electronics (including electric vehicles) have a need for connectors, contacts and electro-mechanical elements with more than conductivity. The properties needed for durable components offering reliable, safe performance are listed and these need to be optimized to suite the specific applications.

Since strength is an important parameter, copper beryllium alloys have facilitated miniaturization and whilst Alloy 25 is often the general-purpose grade of choice there are several others that offer better conductivity whilst still retaining a high strength. Beryllium-free, heat treatable alloys include spinodal hardened copper-nickel-tin and copper-nickel-silicon grades. The production of strip and wire allows for work hardening to be combined with heat treatment and this results in materials selection options that cover the wide range of properties indicated.

Contacts and Connectors
5 Key Material Property Considerations

- Electrical conductivity.
- Thermal conductivity to dissipate any heat generated.
- Strength to ensure a good contact force.
- A high stress relaxation resistance enables the contact force to be maintained over time and with increase in temperature.
- Good formability in both the longitudinal and transverse directions.

CONCLUSION

The unique combination of properties displayed by the copper alloys reviewed in this e-Book make them tried and tested solutions for many applications that may confront South African users and manufacturers as they strive to compete. They complement our offering of stainless steels and nickel alloys.

Application support and more comprehensive information regarding the alloys is available by contacting sales@multialloys.co.za

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