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PRODUCT DATA SHEET

Copper and Copper Alloys

Copper Alloys

Copper and copper alloys are one of the major groups of commercial metals. They offer a wide range of properties, including excellent electrical and thermal conductivity, outstanding corrosion resistance, good strength and fatigue resistance, and appearance. They can be readily worked, brazed and welded.

Primary selection criteria include:

- **Electrical conductivity:** copper has the highest conductivity of the engineering metals. Silver or other elements may be added to increase strength, softening resistance or other properties without major loss of conductivity.
- **Thermal conductivity:** this property is similar to electrical conductivity. Alloys of copper may be used for this property, where good corrosion resistance compensates for loss of conductivity with increased alloying.
- **Colour and appearance:** many of the copper alloys have a distinctive colour, which may change as the object weathers. For most of alloys it is easy to prepare and maintain the surface to a high standard, even in adverse corrosion conditions. Many of the alloys are used in decorative applications, either in their native form or after metal plating. The alloys have specific colours, ranging from the salmon pink of copper through yellow, gold and green to dark bronze in the weathered condition. Atmospheric exposure can produce a green or bronze surface, and prepatinated alloys are available in some product forms.
- **Ease of fabrication:** most of the alloys can be easily cast, hot or cold formed, machined, joined etc. These alloys are often the standard against which other metals are compared.

Many of the alloys are solid solution strengthened, but are based on the copper crystal structure and have good ductility. Most alloys can be further strengthened by cold work, which improves tensile and fatigue strength while retaining useful ductility. Some alloys can be dispersion strengthened, and a few can be age hardened to very high strength levels.

The metals are commonly divided into six families: coppers, high copper alloys, brasses, bronzes copper nickels, and nickel silvers. Most alloys are available in the wrought or the cast condition, with different UNS numbers.

- 1. Coppers** are essentially commercially pure copper, which ordinarily is very soft and ductile, containing up to about 0.7% total impurities. These materials are used for their electrical and thermal conductivity, corrosion resistance, appearance and colour, and ease of working. They have the highest conductivity of the engineering metals and are very ductile and easy to braze, and generally to weld. Typical applications include electrical wiring and fittings, busbars, heat exchangers, roofs, wall cladding, tubes for water, air and process equipment.
- 2. High copper alloys** contain small amounts of various alloying elements such as beryllium, chromium, zirconium, tin, silver, sulphur or iron. These elements modify one or more of the basic properties of copper, such as strength, creep resistance, machinability or weldability. Most of the uses are similar to those given above for coppers, but the conditions of application are more extreme.

3. Brasses are copper zinc alloys containing up to about 45% zinc, with possibly small additions of lead for machinability, and tin for strength. Copper zinc alloys are single phase up to about 37% zinc in the wrought condition. The single phase alloys have excellent ductility, and are often used in the cold worked condition for better strength. Alloys with more than about 37% zinc are dual phase, and have even higher strength, but limited ductility at room temperature compared to the single phase alloys. The dual phase brasses are usually cast or hot worked. Typical uses for brasses are architecture, drawn & spun containers and components, radiator cores and tanks, electrical terminals, plugs and lamp fittings, locks, door handles, name plates, plumbers hardware, fasteners, cartridge cases, cylinder liners for pumps.

4. Bronzes are alloys of copper with tin, plus at least one of phosphorus, aluminium, silicon, manganese and nickel. These alloys can achieve high strengths, combined with good corrosion resistance. They are used for springs and fixtures, metal forming dies, bearings, bushes, terminals, contacts and connectors, architectural fittings and features. The use of cast bronze for statuary is well known.

5. Copper nickels are alloys of copper with nickel, with a small amount of iron and sometimes other minor alloying additions such as chromium or tin. The alloys have outstanding corrosion resistance in waters, and are used extensively in sea water applications such as heat exchangers, condensers, pumps and piping systems, sheathing for boat hulls.

6. Nickel silvers contain 55 – 65% copper alloyed with nickel and zinc, and sometimes an addition of lead to promote machinability. These alloys get their misleading name from their appearance, which is similar to pure silver, although they contain no addition of silver. They are used for jewellery and name plates and as a base for silver plate (EPNS), as springs, fasteners, coins, keys and camera parts.

Classification of wrought copper alloys

Class Name	UNS numbers	Composition	Typical Uses
1. Coppers	C10100 - C15760	>99% Copper	Electrical conductors & connectors, water supply, heat exchangers, tanks, chemical equipment.
2. High-copper alloys	C16200 - C19600	>96% Copper	Electrical conductors & connectors, springs, fasteners.
3. Brasses	C20500 - C28580	Cu - Zn	Deep drawn containers, tanks, heat exchangers, architectural panels, coins.
Leaded brasses	C31200 - C38590	Cu - Zn - Pb	Cylinders, builders hardware, wear plates, fasteners.
Tin brasses	C40400 - C49080	Cu - Zn - Sn - (Pb)	Electrical switches, springs, terminals, bearings.
Other copper - zinc alloys	C66400 - C69900		Valve stems.
4. Phosphor bronzes	C50100 - C52400	Cu - Sn - P	Fasteners, springs, chemical hardware, wear plates.
Leaded phosphor bronzes	C53200 - C54800	Cu - Sn - Pb - P	Bearings, bushings, gears, valves.
Aluminum bronzes	C60600 - C64400	Cu - Al - Ni - Fe - Si - Sn	Heat exchangers, pump parts, machine parts, structural members.
Silicon bronzes	C64700 - C66100	Cu - Si - Sn	Fasteners, springs, electrical connectors.
5. Copper - nickels	C70000 - C79900	Cu - Ni - Fe	Condensers, heat exchangers, brake lines, salt water pipes.
6. Nickel silvers	C73200 - C79900	Cu - Ni - Zn	Sliver plate (EPNS), nameplates, hollow ware

Classification of cast copper alloys

Class Name	UNS numbers	Composition	Typical Uses
1. Coppers	C80100 - C81100	>99% Copper	Electrical & thermal conductors
2. High - copper alloys	C81300 - C82800	>94% Copper	High strength electrical conductors, including spot welding electrodes
3. Red brasses	C83300 - C85800	Cu - Zn - Sn - (Pb) (75 - 89% Cu)	Valves, pump parts, plumbing hardware
Yellow brasses	C85200 - C85800	Cu - Zn - Sn - (Pb) (57 - 74% Cu)	Fittings, trim, builders hardware
4. Manganese bronzes	C86100 - C86800	Cu - Zn - Mn - Fe - (Pb)	Gears, bearings, bushings, marine fittings
Silicon bronzes, silicon bronzes	C87300 - C87900	Cu - Zn - Si	Gears, bearings, bushings, marine fittings
Tin bronzes	C90200 - C94500	Cu - Sn - Zn - (Pb)	Gears, bearings, bushings, pump parts
Nickel - tin bronzes	C94700 - C94900	Cu - Ni - Sn - Zn - (Pb)	Wear parts, low speed bearings
Aluminum bronzes	C95200 - C95810	Cu - Al - Fe - Ni	Gears, bearings, bushings, pump parts, pickling equipment, non sparking tools
5. Copper - nickels	C96200 - C96800	Cu - Ni - Fe	Valves, pumps etc resistant to seawater
6. Nickel silvers	C97300 - C97800	Cu - Ni - Zn - (Pb) - Sn	Builders hardware, valves, pumps
Miscellaneous alloys	C99300 - C99750	-	Various

Alloy designations: Alloys are available according to several numbering systems, including AS, UNS, BS, JIS and others as required. Individual alloy data sheets give alloy equivalents.