aalco®

Company Profile

Stainless Steel

Aluminium

Copper, Brass & Bronze

General Data

www.aalco.co.uk

To receive a copy of any of the following literature or to download a pdf version please visit www.aalco.co.uk or contact your local Service Centre. Details on back cover.

Weights

All weights shown in this publication are for guidance only. They are calculated using nominal dimensions and scientifically recognised densities. Please note that in practice, the actual weight can vary significantly from the theoretical weight due to variations in manufacturing tolerances and compositions.

Issue No. 3 – 02/2011

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General Data

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Aalco is the UK's largest independent multi-metals stockholder. Customers from every sector of UK manufacturing and engineering industry, whether small local businesses or large multinational corporations, benefit from a cost-effective single source for all their metals requirements:

- An inventory that includes aluminium, stainless steel, copper, brass, bronze and nickel alloys in all semi-finished forms
- Comprehensive processing services providing items cut and/or finished to customer requirements
- Eighteen locations bringing local service to every corner of the UK
- Ongoing investment in technology and logistics to ensure on-time delivery

No order is too large or too small and Aalco offers a responsive and competitive service for supplying anything from single item orders to major JIT contracts, tailoring this service to the individual needs.

Whatever your requirement, in whatever quantity, your local Aalco service centre is ready and willing to satisfy your needs For a quotation, for further information, more extensive technical information, advice on product selection or to place an order, please contact your local Aalco service centre or refer to the web site

www.aalco.co.uk

Service

The most comprehensive stock range; the highest investment in processing equipment; local service centres nationwide; helpful, friendly, knowledgeable staff and the industry's biggest fleet of delivery vehicles – it all adds up to unbeatable service.

Aalco has maintained market leadership over many years through an absolute dedication to customer service – a service level that is continuously monitored and improved through key performance indicators.

That's why, for reliable, on-time delivery of exactly what you want, when and where you need it, whether it's a small one-off item or a complex JIT contract, Aalco is the essential first choice.

People

Exceptional customer service starts with people. Aalco develops and retains high quality personnel using a variety of 'in house' courses which cover both skills training, product knowledge and teamwork.

Every Aalco Service Centre has a dedicated team of people working together to provide an unbeatable service to customers in their region.

Customers can expect to receive a quick and informed response to any enquiries for material or for information.

Quality

Aalco takes great care when selecting manufacturing sources for its products and every mill we use is measured against a series of predetermined quality control requirements.

All products supplied by Aalco conform to the relevant BS or international standards certification can be supplied on request.

Aalco service centres operate a quality manual designed to ISO9000/2005 requirements. Many vendor approvals and bespoke quality control systems are operated through individual Aalco service centres, including aerospace approved materials from Southampton and Hull.

AALCO: Delivering Customer Service, Investing in Capability

Standard Stock & "Specials"

In providing customers with a cost-effective single source for all their metals requirements, over 50% of Aalco sales are made up of non standard or customer-special items. Many such items are held in stock at the Service Centres for call-off by their local customers, whilst others are processed as required.

The Aalco multi-metal stock range comprises around 10,000 items of stainless steel, aluminium, copper, brass and bronze in all semi-finished forms. Full detail of the ranges is given on page 28 for stainless steel rolled products, page 33 for stainless steel bar, page 36 for stainless steel tubular products (tube, pipe, fittings & flanges), page 59 for rolled aluminium, page 62 for Aluminium Extrusions and page 70 for Copper-Based Alloys.

This combines with a comprehensive processing services offering items cut to customer's instructions as well as finishing and coating. In addition, Aalco regularly arranges sub-contract processing using a range of approved suppliers.

Aluminium Extrusions

As well as holding the UK's widest range of standard sections, Aalco has developed a particular expertise in the sourcing, stocking and processing of bespoke extrusions, bringing customers the benefit of Aalco's unrivalled purchasing power and sourcing expertise.

The standard stock range (detailed fully on page 60) covers round, flat & square bars in a choice of machinable alloys; tube, scaffold tube & box section; angle, tee & channel; a complete package of Road Transport sections plus a selection of shapes and sizes in various aerospace alloys.

The range of Road Transport sections includes bearers, runners, side raves, side guards, corner pillars, cant rails, tops hats, drop-sides, Zeds, mouldings, cappings and kick strips as well as a range of flooring options.

Processing Services

Processed material can save customers both time and money. Understanding this, Aalco has made a major investment in a wide range of modern processing equipment, particularly for cutting and finishing, at both its local and central service centres.

In addition, Aalco regularly arranges a wide array of processing services for customers on a sub-contract basis.

Logistics & Systems

Like all world-class distribution businesses, Aalco operates a hub and satellite system.

The satellites are 18 local Service Centres providing unrivalled service to customers in their local area.

The hub is The Metal Centre – a 270,000 square foot (25,000m^2) facility located in the West Midlands, bringing together 6,000 tonnes of stock and 130 employees. This state-of-the-art facility has a capacity to handle over 150,000 tonnes per year thanks to the largest automated handling system in Europe – this comprises a 5,500 cassette Kasto system in two 14 metre high units and one 8 metre high unit.

Linking The Metal Centre to the Service Centres is a 25-vehicle carrier fleet that travels overnight to ensure that an item in stock anywhere across the country can be delivered to any Aalco customer the next day, using the local truck fleet of well over 100 vehicles.

Keeping the whole system operating at maximum efficiency are highly sophisticated Information Systems, designed in-house and undergoing constant development to support the evolution of the Aalco business and maximise customer service.

Product Information

Aalco provides a wealth of product information to ensure that its customers are fully informed, not just about the choice of materials and sizes available but also on a range of technical topics including product selection, specifications, properties, fabrication & joining, finishing, installation and maintenance.

Shown inside the front cover of this brochure is a selection of the other publications that are all available free of charge from your local Service Centre - Everything from simple data-sheets to a CD-ROM with over 400 pages of technical information on stainless steel tubular products. What's more, all of these publications are available on-line and for down-load at any time of the day or night, every day of the year at **www.aalco.co.uk**

Road Transport Products

The range includes:

- **Rolled Products** – sheet & patterned sheet, plate & treadplate, shate
- **Standard Extrusions** – angle, channel, tee, tube & box section, flat/square/round bar
- **Special Sections** – Bearers/Runners, Floor Planks, Side Raves & Guards, Corner Pillars, Cant Rails, Top Hats, Zeds, Mouldings, Kick Strips
- **Dropside Sections & Systems**
- **Slip-resistant flooring** – Phenolic mesh-faced Birch wood plywood
- **Cappings** – ABS & Aluminium/ABS
- **Patterned aluminium flooring sheet**
- **GRP Panels**

Energy, Offshore & Process Industries

Aalco has established a Contract Services Division to meet the specialist project requirements of the energy, offshore and process industries.

Based at Aalco's Service Centre in Hull, the Contract Services team includes a number of staff with extensive experience in the sector. With the backing of Aalco's huge UK stock as well as access to the Amari stock held by Aalco's associated companies in Europe, the new Division provides the process industries with an outstanding service for all project requirements. Customers range from nuclear fuel reprocessing facilities to onshore/ offshore oil, gas and petrochemical plants where Aalco has ongoing exclusive supply contracts.

Export

The wide Aalco stock range is of great interest to customers throughout the world seeking ready availability of semi-finished metal alloys.

Because export customers have specialist requirements in areas such as packaging and documentation, all exports from Aalco are handled by a dedicated team located at our Southampton service centre, which sources a full range of materials and:

- Provides the specialist knowledge and procedures required to service export markets together with the appropriate quality approvals
- Arranges special testing, inspection, documentation and releases as required
- Is ideally located to provide international deliveries to customers world-wide. Southampton is one of the UK's premier ports, with efficient and economic shipping routes for destinations across Europe and throughout the world. Equally, air-freight can be readily arranged for more urgent cargos.

AALCO: Delivering Customer Service, Investing in Capability

Aalco stocks all of the commonly required forms of copper and its alloys including sheet, plate, machining rod & hollow rod, flat bar, hexagon bar and tube. In addition to a comprehensive range of standard sizes, Aalco Service Centres stock industry specific items and customer specials.

Aalco also provides a complete range of processing services including bar, tube & pipe cutting and plate processing.

The Core Product Ranges are:

Brass
Free Machining rod and hexagon
Riveting Brass rod
Dezincification Resistant (DZR) brass rod
High Tensile Brass rod
Naval Brass rod and plate
Angle, Flat Bar & Square Bar
Tube
Half Hard, Polished and Spinning Quality sheet

Copper
Half Hard and Spinning Quality sheet
Plate
High Conductivity flat bar
Rod
Tube, including coiled tube for refrigeration and air conditioning

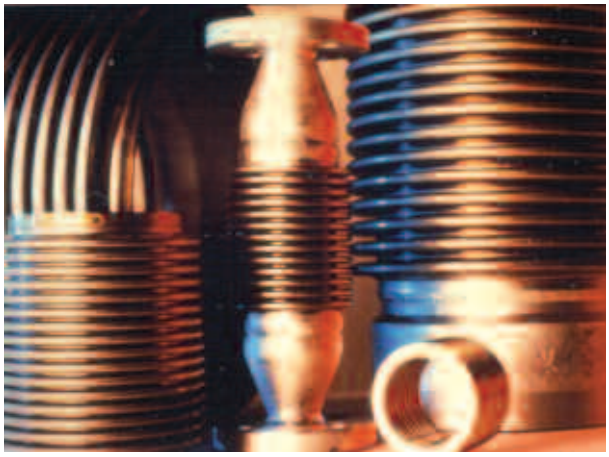
Bronze
Phosphor Bronze rod PB102
Bearing Bronze rod and hollows SAE660,
Aluminium Bronze rod CA104
Phosphor Bronze plate and sheet
Aluminium Bronze rod and hexagon DEFSTAN833

Full detail of all product ranges, alloys and sizes can be found in the Aalco Stocklist available **FREE** from your local Service Centre as well as on the website **www.aalco.co.uk**

Copper is the oldest metal used by man. It's use dates back to prehistoric times. Copper has been mined for more than 10,000 years with a Copper pendant found in current day Iraq being dated to 8700BC. By 5000BC Copper was being smelted from simple Copper Oxides.

Copper is found as native metal and in minerals cuprite, malachite, azurite, chalcopyrite and bornite. It is also often a by-product of silver production. Sulphides, oxides and carbonates are the most important ores.

Copper and Copper alloys are some of the most versatile engineering materials available. The combination of physical properties such as strength, conductivity, corrosion resistance, machinability and ductility make copper suitable for a wide range of applications. These properties can be further enhanced with variations in composition and manufacturing methods.



The largest end use for Copper is in the building industry. Within the building industry the use of copper based materials is broad. Construction industry related applications for copper include:

- Roofing
- Cladding
- Rainwater systems
- Heating systems
- Water pipes and fittings
- Oil and gas lines
- Electrical wiring

The building industry is the largest single consumer of copper alloys. The following list is a breakdown of copper consumption by industry on an annual basis:

- **Building industry – 47%**
- **Electronic products – 23%**
- **Transportation – 10%**
- **Consumer products – 11%**
- **Industrial machinery – 9%**

There are around 370 commercial compositions for copper alloys. The most common grade tends to be C106/ CW024A - the standard water tube grade of copper.

World consumption of copper and copper alloys now exceeds 18 million tonnes per annum.

Applications

Copper and copper alloys can be used in an extraordinary range of applications. Some of these applications include:

- Power transmission lines
- Architectural applications
- Cooking utensils
- Spark plugs
- Electrical wiring, cables and busbars
- High conductivity wires
- Electrodes
- Heat exchangers
- Refrigeration tubing
- Plumbing
- Water-cooled copper crucibles

Structure

Copper has a face centred cubic crystal structure. It is yellowish red in physical appearance and when polished develops a bright metallic lustre.

Key Properties of Copper Alloys

Copper is a tough, ductile and malleable material. These properties make copper extremely suitable for tube forming, wire drawing, spinning and deep drawing. The other key properties exhibited by copper and its alloys include:

- Excellent heat conductivity
- Excellent electrical conductivity
- Good corrosion resistance
- Good biofouling resistance
- Good machinability
- Retention of mechanical and electrical properties at cryogenic temperatures
- Non-magnetic

Other Properties

- Copper and Copper alloys have a peculiar smell and disagreeable taste. These may be transferred by contact and therefore Copper should be kept clear of foodstuffs.
- Most commercially used metals have a metallic white colour. Copper is a yellowish red.

Melting Point

The melting point for pure copper is 1083°C.

Electrical Conductivity

The electrical conductivity of copper is second only to silver. The conductivity of copper is 97% that of silver. Due to its much lower cost and greater abundance, copper has traditionally been the standard material used for electricity transmission applications.

However, weight considerations mean that a large proportion of overhead high voltage power lines now use aluminium rather than copper. By weight, the conductivity of aluminium is around twice that of copper. The aluminium alloys used do have a low strength and need to be reinforced with a galvanised or aluminium coated high tensile steel wire in each strand.

Although additions of other elements will improve properties like strength, there will be some loss in electrical conductivity. As an example a 1% addition of cadmium can increase strength by 50%. However, this will result in a corresponding decrease in electrical conductivity of 15%.

Corrosion Resistance

All Copper alloys resist corrosion by fresh water and steam. In most rural, marine and industrial atmospheres Copper alloys also resistant to corrosion. Copper is resistant to saline solutions, soils, non-oxidising minerals, organic acids and caustic solutions. Moist ammonia, halogens, sulphides, solutions containing ammonia ions and oxidising acids, like nitric acid, will attack Copper. Copper alloys also have poor resistance to inorganic acids.

The corrosion resistance of Copper alloys comes from the formation of adherent films on the material surface. These films are relatively impervious to corrosion therefore protecting the base metal from further attack.

Copper Nickel alloys, Aluminium Brass, and Aluminium Bronzes demonstrate superior resistance to saltwater corrosion.

Surface Oxidation of Copper

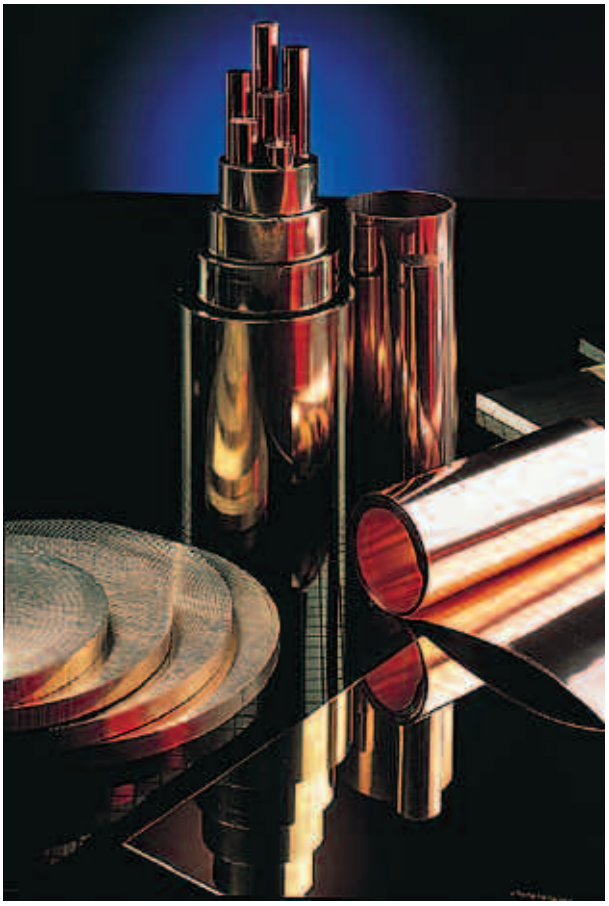
Most Copper alloys will develop a blue-green patina when exposed to the elements outdoors. Typical of this is the colour of the Copper Statue of Liberty in New York. Some Copper alloys will darken after prolonged exposure to the elements and take on a brown to black colour.

Lacquer coatings can be used to protect the surface and retain the original alloy colour. An acrylic coating with benzotriazole as an additive will last several years under most outdoor, abrasion-free conditions.

Yield Strength

The yield point for Copper alloys is not sharply defined. As a result it tends to be reported as either a 0.5% extension under load or as 0.2% offset.

Most commonly the 0.5% extension yield strength of annealed material registers as approximately one-third the tensile strength. Hardening by cold working means the material becomes less ductile, and yield strength approaches the tensile strength.



Joining

Commonly employed processes such as brazing, welding and soldering can be used to join most copper alloys. Soldering is often used for electrical connections. High Lead content alloys are unsuitable for welding.

Copper and Copper alloys can also be joined using mechanical means such as rivets and screws.

Hot and Cold Working

Although able to be work hardened, Copper and Copper alloys can be both hot and cold worked.

Ductility can be restored by annealing. This can be done either by a specific annealing process or by incidental annealing through welding or brazing procedures.

Temper

Copper alloys can be specified according to temper levels. The temper is imparted by cold working and subsequent degrees of annealing.

Typical tempers for Copper alloys are

- Soft
- Half-hard
- Hard, spring
- Extra-spring.

Yield strength of a hard-temper Copper alloy is approximately two-thirds of the materials' tensile strength.

Copper Designations

Designation systems for Copper are not specifications, but methods for identifying chemical compositions. Property requirements are covered in EN, ASTM, government and military standards for each composition.

The alloy designation system used in the UK and across Europe uses a 6 character alpha-numeric series.

The 1st letter is C for copper-based material

The second letter indicates the product form:

- B = Ingot for re-melting to produce cast products
- C = Cast products
- F = Filler materials for brazing and welding
- M = Master Alloys
- R = Refined unwrought Copper
- S = Scrap
- W = Wrought products
- X = Non-standard materials

There is then a 3 digit number between 001 and 999 with the numbers being in groups as shown in the table below

There is then a letter indicating the copper or alloy grouping, also shown in the table

Number Seres	Letters	Materials
001 - 099	A or B	Copper
100 - 199	C or D	Copper Alloys, Min. 95% Cu
200 - 299	E or F	Copper Alloys, < 95% Cu
300 - 349	G	Copper-Aluminium Alloys
350 - 399	H	Copper-Nickel Alloys
400 - 449	J	Copper-Nickel-Zinc Alloys
450 - 499	K	Copper-Tin Alloys
500 - 599	L or M	Copper-Zinc Alloys – Binary
600 - 699	N or P	Copper-Zinc-Lead Alloys
700 - 799	R or S	Copper-Zinc Alloys – Complex

UNS Designations

The method for designating Copper alloys is an expansion upon the system developed by the U.S. copper and brass industry using five digits preceded by the letter C.

UNS Numbers	Types	Alloy Names
C10000-C19999	Wrought	Coppers, High-Copper Alloys
C20000-C49999	Wrought	Brasses
C50000-C59999	Wrought	Phosphor Bronzes
C60600-C64200	Wrought	Aluminium Bronzes
C64700-C66100	Wrought	Silicon Bronzes
C66400-C69800	Wrought	Brasses
C70000-C79999	Wrought	Copper nickels, nickel silvers
C80000-C82800	Cast	Coppers, High-Copper Alloys
C83300-C85800	Cast	Brasses
C86100-C86800	Cast	Manganese Bronzes
C87200-C87900	Cast	Silicon Bronzes and Brasses
C90200-C94800	Cast	Tin Bronzes
C95200-C95800	Cast	Aluminium Bronzes
C96200-C97800	Cast	Copper Nickels, Nickel Silvers
C98200-C98800	Cast	Leaded Copper
C99300-C99750	Cast	Special Alloys

Cast Copper Alloys

The nature of the casting process means that most cast Copper alloys have a greater range of alloying elements than wrought alloys.

Wrought Copper Alloys

Wrought copper alloys are produced using a variety of different production methods. These methods including processes such as annealing, cold working, hardening by heat treatments or stress relieving.

Copper Alloy Families

Within the wrought and cast categories for Copper alloys, the compositions can be divided into the following main families:

- Pure Coppers
- High Copper Alloys
- Brasses
- Bronzes

Coppers

The Pure Coppers have a Copper content of 99.3% or higher.

High Copper Alloys

Wrought high Copper alloys have Copper contents of less than 99.3% but more than 95% but don't fall into another Copper alloy group. Cast high Copper alloys have Copper contents in excess of 94%. Silver may be added to impart special properties.

Brasses

Brasses contain Zinc as the principal alloying element. Other alloying elements may also be present to impart advantageous properties. These elements include Iron, Aluminium, Nickel and Silicon.

Brasses are most commonly characterised by their free machining grades by which machining standards are set for all other metals.

Brasses can also have high corrosion resistance and high tensile strength. Some brasses are also suited to hot forging.

Brass Additives

Adding Lead to a brass composition can result in a brass with the ability to be rapidly machined. It will also produce less tool wear. Adding Aluminium, Iron and Manganese to brass improves strength. Silicon additions improve wear resistance.

Brasses are divided into two classes and three families.

Brass Classes

Brasses are divided into two classes. These are:

- The alpha alloys, with less than 37% Zinc. These alloys are ductile and can be cold worked.
- The alpha/beta or duplex alloys with 37-45% Zinc. These alloys have limited cold ductility and are typically harder and stronger.

Brass Families

There are three main families of wrought alloy brasses:

- Copper-Zinc alloys
- Copper-Zinc-Lead alloys (Leaded brasses)
- Copper-Zinc-Tin alloys (Tin brasses)

Cast brass alloys can be broken into four main families:

- Copper-Tin-Zinc alloys
- Manganese Bronze (high strength brasses) and Leaded Manganese Bronze (high tensile brasses)
- Copper-Zinc-Silicon alloys (Silicon brasses and bronzes)
- Cast Copper-Bismuth and Copper-Bismuth-Selenium alloys.

Bronzes

The term bronze originally described alloys with Tin as the only or principal alloying element.

Modern day bronzes tend to be Copper alloys in which the major alloying element is not Nickel or Zinc.

Bronzes can be further broken down into four families for both wrought and cast alloys.

Bronze Families

The wrought bronze alloy families are:

- Copper-Tin-Phosphorus alloys (Phosphor Bronzes)
- Copper-Tin-Lead-Phosphorus alloys (Leaded Phosphor Bronzes)
- Copper-Aluminium alloys (Aluminium Bronzes)
- Copper-Silicon alloys (Silicon Bronzes)

The cast bronze alloy families are:

- Copper-Tin alloys (Tin Bronzes)
- Copper-Tin-Lead alloys (Leaded and high leaded Tin Bronzes)
- Copper-Tin-Nickel alloys (nickel-tin bronzes)
- Copper-Aluminium alloys (Aluminium Bronzes)

Other Alloy Groups

Copper-Nickel Alloys

As the name suggests, the principal alloying element is Nickel. They can contain other alloying elements or simply have Nickel alone.

Copper-Nickel-Zinc Alloys

These alloys are commonly known as "Nickel Silvers" due to the colour of the alloy. They contain Zinc and Nickel as the principal alloying elements and may also contain other alloying elements.

Leaded Coppers

Leaded Coppers are cast Copper alloys with 20% or more Lead added. They may also contain a small amount of Silver but have no Tin or Zinc. Due to the toxity of Lead these are no longer in widespread use.

Special Alloys

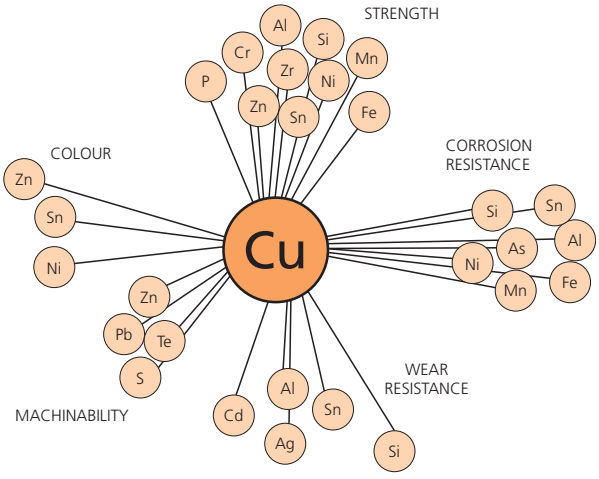
When alloys have chemical compositions that do not fall into any of the other categories mentioned, they are grouped together as "special alloys".

Free Machining Coppers

Free machining properties are imparted upon Copper alloys by the addition of Sulphur and Tellurium.

Recycling

Copper alloys are highly suited to recycling. Around 40% of the annual consumption of Copper alloys is derived from recycled Copper materials.



EN Standards for Copper and Copper Alloys		
EN Number	**Title**	**Nearest Old BS Equivalent**
Unwrought Products		
1976	Cast unwrought copper products	6017
1977	Copper drawing stock (wire rod)	6926
1978	Copper cathodes	6017
1981	Master alloys	-
1982	Ingots and castings	1400
Rolled Flat Products		
1172	Sheet and strip for building purposes	2870
1652	Plate, sheet, strip and circles for general purposes	2870, 2875
1653	Plate, sheet and circles for boilers, pressure vessels and hot water storage units	2870, 2875
1654	Strip for springs and connectors	2870
1758	Strip for lead frames	-
13148	Hot dip tinned strip	-
14436	Electrolytically tinned strip	-
Tubes		
1057	Seamless, round tubes for water and gas in sanitary and heating applications	2871 Pt1
12449	Seamless, round tubes for general purposes	2871 Pt 2
12450	Seamless, round capillary tubes	-
12451	Seamless, round tubes for heat exchangers	2871 Pt 3
12452	Rolled, finned, seamless tubes for heat exchangers	-
12735	Seamless round tubes for air conditioning and refrigeration Part 1: Tubes for piping systems Part 2: Tubes for equipment	- - -
13348	Seamless, round copper tubes for medical gases	-
13349	Pre-insulated copper tubes with solid covering	-
Rod/Bar, Wire, Profiles		
12163	Rod for general purposes	2874
12164	rod for free machining purposes	2874
12165	Wrought and unwrought forging stock	2872
12166	Wire for general purposes	2873
12167	Profiles and rectangular bar for general purposes	2874
12168	Hollow rod for free machining purposes	-
13347	Rod and wire for welding and braze welding	1453, 1845, 2901
Electrical Purposes		
13599	Copper plate, sheet and strip for electrical purposes	4608
13600	Seamless copper tubes for electrical purposes	1977
13601	Copper rod, bar and wire for general electrical purposes	1433, 1432, 4109
13602	Drawn round copper wire for the manufacture of electrical conductors	4109
13604	Products of high conductivity copper for electronic tubes, semiconductor devices and vacuum applications	3839
13605	Copper profiles for electrical purposes	-
60317-0-1	Enamelled copper wire	6811

Wrought Copper Alloys – Conversion of old BS into EN Material Designations

(These are arranged broadly in increasing order of alloying content)

Nearest Old BS Equivalent	EN Material Designation Symbol	Number
Heat-treatable Alloys		
CB101	CuBe1.7	CW100C
-	CuBe2	CW101C
-	CuBe2Pb	CW102C
-	CuCo1Ni1Be	CW103C
C112	CuCo2Be	CW104C
-	Cu/Ni2Be	CW110C
CC101	CuCr1	CW105C
CC102	CuCr1Zr	CW106C
C113	CuNi1P	CW108C
-	CuNi1Si	CW109C
-	CuNi2Si	CW111C
-	CuNi3Si1	CW112C
-	CuZr	CW120C
Non Heat-treatable Alloys – Free Machining		
-	CuPb1P	CW113C
C109	CuTeP	CW118C
C111	CuSP	CW114C
Non Heat-treatable Alloys – Other		
-	CuFe2P	CW107C
-	CuSi1	CW115C
CS101	CuSi3Mn	CW116C
-	CuSn0.15	CW117C
-	CuZn0.5	CW119C
C108	CuCd	-
-	CuCd0.7	CW130C
-	CuCd1.0	CW131C
Copper-tin (Phosphor Bronze)		
PB101	CuSn4	CW450K
PB102	CuSn5	CW451K
PB103	CuSn6	CW452K
PB104	CuSn8	CW453K
-	CuSn8P	CW459K
-	CuSn4Pb2P	CW455K
-	CuSn4Te1P	CW457K
-	CuSn5Pb1	CW458K
-	CuSn8PbP	CW460K
-	CuSn3Zn9	CW454K
-	CuSn4Pb4Zn4	CW456K
Copper-zinc (Brass)		
CZ125	CuZn5	CW500L
CZ101	CuZn10	CW501L
CZ102	CuZn15	CW502L
CZ103	CuZn20	CW503L
-	CuZn28	CW504L
CZ106	CuZn30	CW505L
-	CuZn33	CW506L

Nearest Old BS Equivalent	EN Material Designation Symbol	Number
Copper-zinc (Brass) – continued		
CZ107	CuZn36	CW507L
CZ108	CuZn37	CW508L
CZ109	CuZn40	CW509L
Copper-zinc-lead Alloys (Leaded Brasses)		
CZ104	-	-
CZ124	CuZn36Pb3	CW603N
CZ121Pb4	CuZn38Pb4	CW609N
CZ121Pb3	CuZn39Pb3	CW614N
CZ122	CuZn40Pb2	CW617N
CZ119	CuZn37Pb2	CW606N
CZ131	CuZn37Pb2	CW606N
CZ120	CuZn38Pb2	CW608N
CZ128	CuZn38Pb2	CW608N
CZ120	CuZn39Pb2	CW612N
CZ128	CuZn39Pb2	CW612N
CZ118	CuZn35Pb1	CW600N
CZ119	CuZn35Pb2	CW601N
CZ131	CuZn35Pb2	CW601N
-	CuZn38Pb1	CW607N
CZ123	CuZn39Pb0.5	CW610N
CZ137	CuZn39Pb0.5	CW610N
CZ129	CuZn39Pb1	CW611N
CZ132	CuZn36Pb2As	CW602N
-	CuZn39Pb2Sn	CW613N
-	CuZn40Pb2Sn	CW619N
-	CuZn39Pb3Sn	CW615N
-	CuZn40Pb1Al	CW616N
-	CuZn40Pb2Al	CW618N
-	CuZn41Pb1Al	CW620N
-	CuZn42PbAl	CW621N
-	CuZn43Pb1Al	CW622N
CZ130	CuZn43Pb2Al	CW624N
CZ130	CuZn43Pb2	CW623N
-	CuZn37Pb0.5	CW604N
-	CuZn37Pb1	CW605N
Copper-zinc Alloys (Corrosion Resistant Alloys)		
CZ127	CuZn13Al1Ni1Si1	CW700R
CZ110	CuZn20Al2As	CW702R
CZ111	CuZn28Sn1As	CW706R
CZ126	CuZn30As	CW707R
CZ105	CuZn30As	CW707R
-	CuZn38AlFeNiPbSn	CW715R
-	CuZn38Sn1As	CW717R
-	CuZn32Pb2AsFeSi	CW709R
CZ134	CuZn36Pb2Sn1	CW711R
CZ112	CuZn36Sn1Pb	CW712R
CZ113	-	-
-	CuZn37Pb1Sn1	CW714R
CZ133	CuZn39Sn1	CW719R

cont. – Wrought Copper Alloys – Conversion of old BS into EN Material Designations
(These are arranged broadly in increasing order of alloying content)

Nearest Old BS Equivalent	EN Material Designation Symbol	Number
High Tensile Brasses		
-	CuZn23Al6Mn4Fe3Pb	CW704R
CZ116	CuZn25Al5Fe2Mn2Pb	CW705R
-	CuZn35Ni3Mn2AlPb	CW710R
CZ114	CuZn40Mn1Pb1AlFeSn	CW721R
CZ115	CuZn40Mn1Pb1FeSn	CW722R
-	CuZn31Si1	CW708R
CZ135	CuZn37Mn3Al2PbSi	CW713R
-	CuZn39Mn1AlPbSi	CW718R
Other Brasses		
-	CuZn19Sn	CW701R
-	CuZn23Al3Co	CW703R
-	CuZn38Mn1Al	CW716R
CZ136	CuZn40Mn1Pb1	CW720R
-	CuZn40Mn2Fe1	CW723R
Copper-aluminium (Aluminium Bronze)		
-	CuAl5As	CW300G
CA101	-	-
CA107	CuAl6Si2Fe	CW301G
-	CuAl7Si2	CW302G
CA106	CuAl8Fe3	CW303G
CA102	-	-
CA105	CuAl9Ni3Fe2	CW304G
CA103	-	-
-	CuAl10Fe1	CW305G
-	CuAl10Fe3Mn2	CW306G
CA104	CuAl10Ni5Fe4	CW307G
-	CuAl11Fe6Ni6	CW308G

Nearest Old BS Equivalent	EN Material Designation Symbol	Number
Copper-nickel		
CN105	CuNi25	CW350H
CN101	-	-
-	CuNi9Sn2	CW351H
CN102	CuNi10Fe1Mn	CW352H
CN103	-	-
CN104	-	-
CN106	-	-
CN108	CuNi30Fe2Mn2	CW353H
CN107	CuNi30Mn1Fe	CW354H
Copper-nickel-zinc (Nickel Silver)		
NS103	CuNi10Zn27	CW401J
NS104	CuNi12Zn24	CW403J
NS111	CuNi12Zn25Pb1	CW404J
-	CuNi12Zn29	CW405J
-	CuNi12Zn30Pb1	CW406J
NS105	-	-
NS112	-	-
NS113	CuNi18Zn19Pb1	CW408J
NS106	CuNi18Zn20	CW409J
NS107	CuNi18Zn27	CW410J
NS108	-	-
NS109	-	-
-	CuNi7Zn39Pb3Mn2	CW400J
NS101	CuNi10Zn42Pb2	CW402J
-	CuNi12Zn38Mn5Pb2	CW407J

Listing of Old BS Standards replaced by EN Standards

Old BS Standard	Title (abbreviated	EN Standards
1400	Copper and copper alloy ingots and castings	1982
1432	Drawn copper strip for electrical purposes	13601
1433	Copper rod and bar for electrical purposes	13601
1434	Copper sections in bars, blanks and segments for commutators (electrical purposes)	n/a
1453	Filler metals for gas welding	13347
1845	Filler metals for brazing	13347
1977	Copper tubes for electrical purposes	13600
2870	Sheet, strip and foil	1172,1652,1653,1654
2871 Pt 1	Tubes for water, gas and sanitation	1057
2871 Pt 2	Tubes for general purposes	12449
2871 Pt 3	Tubes for heat exchangers	12451
2872	Forgings and forging stock	12165, 12420
2873	Wire	12166
2874	Rods and sections	12163, 12164, 12167
2875 Pt 3	Plate	1652, 1653

Wrought Low-Alloyed Copper Alloys- Compositions, Uses, Typical Mechanical Properties, Relevant Standards and Approximate Electrical Conductivity

Material Designation		Composition, %, Range or Max							Nearest Old BS Equivalent	Characteristics and Uses	Typical Mechanical Properties				Approx. Conductivity % IACS
Symbol	Number	Cu	Be	Cr	Ni	P	Si	Others & Total Impurities			0.2% Proof Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%)	Hardness (HV)	
Heat Treatable Alloys															
CuBe1.7	CW100C	Rem.	1.6-1.8					0.5	CB101	High Strength beryllium coppers for springs and pressure sensitive devices. CW102C is the free machining version.	200-1100	410-1300	35-3	100-400	30
CuBe2	CW101C	Rem.	1.8-2.1					0.5	-		200-1300	410-1400	20-2	100-420	30
CuBe2Pb	CW102C	Rem.	1.8-2.0					0.2-0.6 Pb 0.5	-		200-1300	410-1400	20-4	100-210	45
CuCo1Ni1Be	CW103C	Rem.	0.4-0.7		0.8-1.3			0.8-1.3 Co 0.5	-	Beryllium containing alloys with lower strength and better conductivity and ductility than beryllium copper, also suitable for higher temperature service.	135-760	250-800	25-3	100-230	
CuCo2Be	CW104C	Rem.	0.4-0.7					2.0-2.8 Co 0.5	C112		135-900	240-800	25-3	90-230	45
CuNi2Be	CW110C	Rem.	0.2-0.6		1.4-2.4			0.5	-		135-900	240-800	25-3	90-230	
CuCr1	CW105C	Rem.		0.5-1.2				0.2	CC101	Resistance Welding electrode materials. Good conductivity and strength at elevated temperatures. Zr in CW106C raises softening temperature.	100-440	220-500	30-8	70-185	80
CuCr1Zr	CW106C	Rem.		0.5-1.2				0.03-0.3 Zr 0.2	CC102		100-440	220-540	35-5	55-175	75
CuNiP	CW108C	Rem.			0.8-1.2	0.15-0.25		0.1	C113	As silicon is added and increased, strength and wear resistance increase and conductivity decreases. Electrode holders, seam welding wheel shafts, welding dies and bearing cages.	140-730	250-800	30-5	80-240	50
CuNi1Si	CW109C	Rem.			1.0-1.6		0.4-0.7	0.3			100-570	300-590	30-5	80-220	
CuNi2Si	CW111C	Rem.			1.6-2.5		0.4-0.8	0.3			100-620	300-700	35-5	80-220	40
CuNi3Si1	CW112C	Rem.			2.6-4.5		0.8-1.3	0.5			120-780	320-800	30-5	80-230	
CuZr	CW120C	Rem.						0.1-0.2 Zr 0.1		Special applications at elevated temperatures.	40-350	180-350	30-14	40-135	85-90
Non Heat-treatable Alloys – Free Machining															
CuPb1P	CW113C	Rem.				0.003-0.012		0.7-1.5 Pb 0.1		Free machining high conductivity coppers with machinability index of about 80%	200-320	250-360	7-2	90-110	75
CuSP	CW114C	Rem.				0.003-0.012		0.2-0.7 S 0.1	C111		200-320	250-360	7-2	90-110	93
CuTeP	CW118C	Rem.				0.003-0.012		0.4-0.7 Te 0.1	C109		200-320	250-360	7-2	90-110	90

Wrought Copper-aluminium, Copper-nickel and Copper-nickel-zinc Alloys – Compositions, Uses, Typical Properties, Relevant Standards and Machinability

Material Designation		Composition, %, Range or Max								Nearest Old BS Equivalent	Characteristics and Uses	Typical Mechanical Properties				Approx. Conductivity % IACS
Symbol	Number	Cu	Al	Fe	Mn	Ni	Pb	Si	Others & Total Impurities			0.2% Proof Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%)	Hardness (HV)	
Copper-aluminium (Aluminium Bronze)																
CuAl5As	CW300G	Rem.	4.0-6.5						0.1-0.4 AS 0.3		An alpha phase alloy for tube manufacture. May be heavily cold worked.	130	380	55	85	20
CuAl6Si2FE	CW301G	Rem.	6.0-6.4	0.5-0.7				2.0-2.4	0.2	CA107	Medium strength alloys, readily hot worked and moderately cold workable. With machinability of 40-50%, the alloys are suitable for manufacture of items of chemical plant, machine parts, tools and instruments when good corrosion resistance is required.	250-350	500-650	25-10	125-160	50
CuAl7Si2	CW302G	Rem.	7.3-7.6					1.5-2.2	0.2			250.350	500-650	25-10	125-160	50
CuAl8Fe3	CW303G	Rem.	6.5-8.5	1.5-3.5					0.2	CA106		180-210	460-500	30	125-135	20
CuAl9Ni3Fe2	CW304G	Rem.	8.0-9.5	1.0-3.0		2.0-4.0			0.2	CA105		180	500	30	125	20
CuAl10Fe1	CW305G	Rem.	9.0-10.0	0.5-1.5					0.3	-		210-480	420-670	22-5	110-205	20
CuAl10Fe3Mn2	CW306G	Rem.	9.0-11.0	2.0-4.0	1.5-3.5				0.2	-	High strength alloys for use in aggressive media when wear resistance and good impact strength are required.	330-510	600-720	15-5	130-210	30
CUAl10Ni5Fe4	CW307G	Rem.	8.5-11.0	3.0-5,0		4.0-6.0			0.2	CA104		400-530	600-760	15-5	170-220	30
CUAl11FE6Ni6	CW308G	Rem.	10.5-12.5	5.0-7.0		5.0-7.0			0.2	-		500-680	750-850	10-5	200-260	30
Copper-nickel																
CuNi25	CW350H	Rem.				24.0-26.0			0.1	CN105	UK "silver" coinage alloy.	120	300	-	85	20
CuNI9Sn2	CW351H	Rem.				8.5-10.5			1.8-2.8 Sn 0.1	-	Good elastic properties for electrical contacts.	200-550	350-620	45-2	80-220	20
CuNi10Fe1Mn	CW325H	Rem.		1.0-2.0	0.5-1.0	9.0-11.0			0.2	CN102	Excellent sea-water corrosion resistance. The aloys with 30% nickel have good resistance to erosion.	100-420	290-520	35-8	80-160	20
CuNi30Fe2Mn2	CW353H	Rem.		1.5-2.5	1.5-2.5	29.0-32.0			0.2	CN108		175	450	35	110	20
CuNi30Mn1FE	CW354H	Rem.		0.4-1.0	0.5-1.5	30.0-32.0			0.2	CN107		130-330	350-520	35-12	90-130	20
Copper-nickel-zinc (Nickel-Silver)																
CuNi10Zn27	CW401J	Rem.	61.0-64.0			9.0-11.0			Zn. Rem. 0.2	NS103	Alpha phase alloys with good corrosion resistance. Colour becomes whiter as nickel content increases. Lead, when present, improves machinability. Applications include tableware, telecommunication components, decorative building features and general mechanical and food manufacturing equipment.	180-880	360-880	50-2	80-210	30

Wrought Copper-zinc-lead Alloys (Leaded Brasses) – Compositions, Uses, Typical Properties, Relevant Standards and Machinability

Material Designation		Composition, %, Range or Max							Nearest Old BS Equivalent	Characteristics and Uses	Typical Mechanical Properties				Machinability Index (%)
Symbol	Number	Cu	Al	As	Pb	Sn	Zn	Others & Total Impurities			0.2% Proof Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%)	Hardness (HV)	
CuZn36Pb3	CW603N	60-62.0			2.5-3.5		Rem.	0.2	CZ124	These alloys have excellent machinability but very limited cold workability. Alloy CW614N is rated as a standard against which other materials are compared. Alloy CW617N is the standard hot forging brass.	160.450	340-580	35-5	90-150	95
CuZn39Pb3	CW614N	57.0-59.0			2.5-3.5		Rem.	0.2	CZ121Pb3		150-420	360-580	25-5	100-160	100
CuZn40Pb2	CW617N	57.0-59.0			1.6-2.5		Rem.	0.2	CZ122		150-420	360-580	25-5	100-160	90
CuZn37Pb2	CW606N	61.0-62.0			1.6-2.5		Rem.	0.2	CZ119, CZ131	These alloys have good machinability and some cold workability for limited bending and riveting.	160.450	300.580	45-5	90-150	70
CuZn38Pb2	CW608N	60.0-61.0			1.6-2.5		Rem.	0.2	CZ120, CZ128		150-450	360-580	40-5	90-150	75
CuZn39Pb2	CW612N	59.0-60.0			1.6-2.5		Rem.	0.2	CZ120 CZ128		150-450	360-580	40-5	90-160	80
CuZn35Pb1	CW600N	62.5-64.0			0.8-1.6		Rem.	0.1	CZ118	These alloys are machinable and have a good to very good cold workability. This group contains the standard alloys for bending, CW610N, and extreme riveting, CW601N.	150-450	300-580	45-10	90-150	50
CuZn35Pb2	CW601N	62.0-63.5			1.6-2.5		Rem.	0.1	CZ119, CZ131		150-350	330-470	30-10	90-130	65
CuZn38Pb1	CW607N	60.0-61.0			0.8-1.6		Rem.	0.2	-		150-420	360-580	30-5	90-150	55
CuZn39Pb0.5	CW610N	59.0-60.5			0.2-0.8		Rem.	0.2	CZ123, CZ137		150-450	360-580	40-5	90-150	50
CuZn39Pb1	CW611N	59.0-60.0			0.8-1.6		Rem.	0.2	CZ129		150-420	360-580	30-5	90-150	60
CuZn36Pb2As	CW602N	61.0-63.0		0.02-0.15	1.7-2.8		Rem.	0.2	CZ132	Dezincification resistant brass with good machinability and moderate hot and cold workability.	120-200	280-450	40-20	80-140	70
CuZn39Pb2Sn	CW613N	59.0-60.0			1.6-2.5	0.2-0.5	Rem.	0.2	-	These alloys have good machinability and limited cold workability.	150-420	360-580	30-5	90-150	75
CuZn40Pb2Sn	CW619N	57.0-59.0			1.6-2.5	0.2-0.5	Rem.	0.2	-		150-420	360-580	25-5	100-160	85
CuZn39Pb3Sn	CW615N	57.0-59.0			2.5-3.5	0.2-0.5	Rem.	0.2	-	These alloys are designed for hot forging.	130-160	340-380	20-12	85-95	95
CuZn40Pb1Al	CW616N	57.0-59.0	0.05-0.30		1.0-2.0		Rem.	0.2	-		130-160	340-380	20-12	85-95	60
CuZn40Pb2Al	CW618N	57.0-59.0	0.05-0.5		1.6-3.0		Rem.	0.2	-	This group of alloys is used for production of profiles by hot extrusion. Aluminium imparts a golden lustre, avoiding need for further polishing. The alloys with more than 1.6% Pb have very good machinability.	-	-	-	-	90
CuZn41Pb1Al	CW620N	57.0-59.0	0.05-0.5		0.8-1.6		Rem.	0.2	-		-	-	-	-	85
CuZn42PbAl	CW612N	57.0-59.0	0.05-0.5		0.2-0.8		Rem.	0.2	-		-	-	-	-	55
CuZn43Pb1A1	CW622N	55.0-57.0	0.05-0.5		0.8-1.6		Rem.	0.2	-		-	-	-	-	60
CuZn43Pb2Al	CW624N	55.0-57.0	0.05-0.5		1.6-3.0		Rem.	0.2	CZ130		-	-	-	-	95
CuZn43Pb2	CW623N	55.0-57.0			1.6-3.0		Rem.	0.2	CZ130		150-220	350-420	30-20	100-130	95
CuZn37Pb0.5	CW604N	62.0-64.0			0.1-0.8		Rem.	0.2	-	For manufacture of plate and tube.	160-450	300-580	45-10	80-150	45
CuZn37Pb1	CW605N	61.0-62.0			0.8-1.6		Rem.	0.2	-	For manufacture of tube and hollow rod.	160-340	340-440	35-10	80-130	50

Wrought Copper-zinc and Copper-tin Binary Alloys – Compositions, Uses and Typical Properties

Material Designation		Composition, %, Range or Max						Nearest Old BS Equivalent	Characteristics and Uses	Typical Mechanical Properties			
Symbol	Number	Cu	P	Pb	Sn	Zn	Others			0.2% Proof Strength (N/mm²)	Tensile Strength (N/mm²)	Elong-gation (%)	Hardness (HV)
Copper-zinc (Brass)													
CuZn5	CW500L	94.0-96.0				Rem.	0.1	CZ125	Very good cold working properties for electrical engineering components. Flexible tubes and sleeves. Attractive range of colours for costume jewellery. Can easily be enamelled.	60-240-420	240-420	45-4	50-25
CuZn10	CW501L	89.0-91.0				Rem.	0.1	CZ101		120.560	240-600	45-2	60-165
CuZn15	CW502L	84.0-86.0				Rem.	0.1	CZ102		120-590	260-630	50-2	65-170
CuZn20	CW503L	79-0-81.0				Rem.	0.1	CZ103		120-590	260-630	50-2	65-170
CuZn28	CW504L	71.0-73.0				Rem.	0.1	-	Very good cold working properties for extreme deep drawing and cold forging applications.	120-420	310-500	30-2	90-160
CuZn30	CW505L	69.0-71.0				Rem.	0.1	CZ106		130-810	300-830	55-1	65-200
CuZn33	CW506L	66-0-68.0				Rem.	0.1	-		120-420	300-500	30-2	65-160
CuZn36	CW507L	63.5-65.5				Rem.	0.1	CZ107	The standard alloys for deep drawing, spinning, upsetting, thread rolling and bending. Good soldering properties.	130-800	280-820	50-1	65-190
CuZn37	CW508L	62.0-64.0				Rem.	0.1	CZ108		130-800	280-820	50-1	65-190
CuZn40	CW509L	59.5-61.5				Rem.	0.2	CZ109		200-420	340-500	45-2	90-150
Copper-tin (Phosphor Bronze)													
CuSn4	CW450K	Rem.	0.01-0.4		3.5-4.5		0.2	PB101	Strength increases as tin content increases. Good corrosion and corrosion fatigue properties lead to uses such as springs, instrument components, wire cloth, condenser tube-plates and vessels, and electronic components. Controlled resistivity wire for power applications.	140-850	320-950	60-1	75-230
CuSn5	CW451K	Rem.	0.01-0.4		4.5-5.5		0.2	PB102		140-850	320-950	60-1	75-230
CuSn6	CW452K	Rem.	0.01-0.4		5.5-7.0		0.2	PB103		140-950	340-1000	60-1	80-250
CuSn8	CW453K	Rem.	0.01-0.4		7.5-8.5		0.2	PB104		170-1000	390-1100	60-1	85-270

Wrought Complex, Copper-zinc Alloys (Special Brasses) – Compositions, Uses and Typical Properties

Material Designation		Composition, %, Range or Max									Nearest Old BS Equivalent	Characteristics and Uses	Typical Mechanical Properties			
Symbol	Number	Cu	Al	Fe	Mn	Pb	Si	Sn	Others	Zn			0.2% Proof Strength (N/mm²)	Tensile Strength (N/mm²)	Elong-gation (%)	Hardness (HV)
Corrosion Resistant Alloys																
CuZn36Sn1Pb	CW712R	61.0-63.0				0.2-0.6		1.0-1.5		Rem.	CZ112	Naval Brasses for sea-water environments; 60-70% machinability when lead is included.	160-360	340-480	30-10	90-150
High Tensile Brasses																
CuZn23Al6Mn4Fe3Pb	CW704R	63.0-65.0	5.0-6.0	2.0-3.5	3.5-5.0	0.2-0.8				Rem.	-	High Strength structural materials. CW722R is aluminium-free and suitable for brazing and soldering. Machinability 50-80%.	500-540	700-800	10	190-210
CuZn25Al5Fe2Mn2Pb	CW705R	65.0-68.0	4.0-5.0	0.5-3.0	0.5-3.0	0.2-0.8				Rem.	CZ116		300-400	550-650	12	150-200
CuZn35Ni3Mn2AlPb	CW710R	58.0-60.0	0.3-1.3		1.5-2.5	0.2-0.8			2.0-3.0Ni	Rem.	-		250-350	450	15	120-150
CuZn40Mn1Pb1AlFeSn	CW721R	57.0-59.0	0.3-1.3	0.2-1.2	0.8-1.8	0.8-1.6		0.2-1.0		Rem.	CZ114		200-380	450-580	30-15	130-170
CuZn40Mn1Pb1FeSn	CW722R	56.5-58.5		0.2-1.2	0.8-1.8	0.8-1.6		0.2-1.0		Rem.	CZ115		200-380	450-580	30-15	130-170
CuZn31Si1	CW708R	66.0-70.0					0.7-1.3			Rem.	-		200-380	450-580	30-15	130-170
CuZn37Mn3Al2PbSi	CW713R	57.0-59.0	1.3-2.3		1.5-3.0	0.2-0.8	0.3-1.3			Rem.	CZ135	Bearings and sliding stress requirements, synchro rings. Machinability 40-50%.	300-450	550-650	25-8	170-210
CuZn39Mn1AlPbSi	CW718R	57.0-59.0	0.3-1.3		0.8-1.8	0.2-0.8	0.2-0.8			Rem.	-		N0-350	440-540	20-10	120-170

Copper and Copper alloys are amongst the most versatile materials available and are used for applications in every type of industry. World consumption of Copper now exceeds 18 million tonnes per annum.

Copper is well known for it's conductivity but it has other properties that have been exploited in a wide range of copper alloys. These alloys have been developed for a wide variety of applications and numerous fabrication processes employed to produce finished goods.

Fabrication techniques that copper alloys are largely suited to include machining, forming, stamping, joining, polishing and plating.

The exceptional machinability of some Copper alloys means that free machining brass sets the standard of machinability by which all other metals are judged.

Handling and Storage

The procedures for the handling and storage of Copper and Copper alloys are very similar to those used for Aluminium and stainless steel.

The most important factor is cleanliness. Contaminated Copper can be the cause of cracking or porosity during heat treatment or welding. Corrosion resistance can also be adversely affected. Tooling and work surfaces should be dedicated to use with Copper materials or thoroughly cleaned before use. If this is rule is not adhered to, cross contamination can occur.

Copper sheets should remain in their packaging until required and should be kept separated by protective material to avoid abrasion between the sheets.

Plates and sheets should be stored vertically in covered racks. All Copper materials should never be walked upon.

Ductility and Malleability

The ductility and malleability of Copper and Copper alloys makes them ideally suited to fabrication methods that involve severe deformation such as:

- Tube forming
- Wire drawing
- Spinning
- Roll forming
- Deep drawing

These fabrication methods require specialised, heavy equipment and skilled operators. If fabrication by one of these methods is required, more information should be sought independently.

Cutting

Most Copper alloys are relatively soft and can be readily cut using common hand tools and standard cutting methods.

While the relative softness of Copper makes it easy to cut, it is important to protect the component from unwanted damage during cutting. This damage may include, but not be limited to, bending, denting or scratching.

Pipe and Tube Cutting

When cutting Copper pipe, a fine toothed hacksaw may be used quite successfully. To ensure the cut is square to the pipe, a tube cutter should be used.

When a pipe cutter is used, it is recommended to grip the Copper tubing with a pipe vice or a similar holding device.

To hold material for cutting with a hacksaw use a mitre box or a jig consisting of a piece of wood containing a notch to hold the tube or pipe in place.

After cutting any burrs need to be removed from the inside and outside of the tube. For this, use a half round file. Pipe cutters tend to cause more burrs than do hacksaws.

Cutting Copper Sheet and Plate

The method employed for cutting Copper sheet or plate largely depends on two factors; the thickness of the material and the amount of cutting required.

For thin gauge material where only a minimal amount of cutting is to be done, tin snips or hand shears may be adequate. Thicker material can be cut using a bandsaw or other mechanical saw fitted with a bimetallic blade suited to the cutting of Copper alloys. For large cutting runs or for thick material it may be necessary to utilise one of the common industrial cutting methods like:

- Shearing
- Electrical discharge machining (EDM)
- Laser cutting
- Water jet cutting
- Plasma cutting
- Slitting
- Guillotining
- Abrasive disc cutting

Tube and Pipe Bending

Most Copper pipe/ tube can be readily bent and two main methods are employed. The first uses bending springs and the second, a pipe bending machine.

The simplest tool for bending pipe is the bending spring. Bending springs are normally used for thinner walls where the pipe can be bent by hand. Two types of spring are used: internal and external. Both types of spring serve the same function; to prevent the wall of the pipe from collapsing during bending.

External springs are used for smaller diameter copper piping (6 to 10mm external diameter). As the name suggests, the spring is fitted over the tube during the bending operation. Internal springs are placed inside the pipe during bending.

Each pipe size requires its own specific size of spring.

All bending machines are different but the principal is the same.

The bending machine is fitted with a bending roller and former matched to the size of the pipe. The pipe is secured at one end and the lever handle of the machine moved to bend the pipe around the former.

Bar and Flat Bending

Copper and Copper alloy bar can be bent using standard bending methods.

As a general rule, the minimum bending radius for copper bar is equal to the thickness of the bar.

Joining of Copper Components

Copper and Copper alloys are more readily joined than most other materials used in engineering.

Although 90% of Copper based components are assembled using conventional welding and brazing techniques, they can be successfully joined using every known joining process.

When welding, soldering or brazing Copper the joint must be clean and free of dirt, grease or paint.

Soldering

Soldering can be divided into two methods:

- Soft soldering using alloys that melt below 350°C
- Hard soldering using stronger, high melting point alloys

In regard to soldering Copper alloys, hard soldering is often referred to as Silver soldering.

Soft soldering normally uses Tin based solders for joining Copper and brass when high mechanical strength is not required. The method is commonly used for joining Copper in domestic electrical and plumbing applications.

Brazing

With the exception of alloys containing more than around 10 per cent Aluminium or 3 per cent Lead, brazing can be used to join all Copper alloys.

Brazing is particularly popular for joining Copper components used in building, heating, ventilation, air-conditioning and the manufacturing of electronic products.

Welding

Copper alloys are readily welded using all common welding techniques including:

- Arc welding
- Gas-shielded arc welding
- Tungsten inert gas (TIG) welding
- Metal inert gas (MIG) welding
- Plasma arc welding
- Pulsed-current MIG welding
- Electron Beam welding
- Laser welding
- Friction welding
- Ultrasonic welding

Bolting and Riveting

Copper and all Copper alloys can be successfully bolted or riveted. However consideration must be given to the material used in the bolts or rivets. As Copper is often chosen for its corrosion resistance, the material used in the bolts and rivets should be made from the same or similar material to that being joined.

For roofing applications, Copper nails are preferred but brass or stainless steel can be substituted.

Mechanical joining like bolting and riveting may induce localised areas of high stress, which could induce failure in the component. Replacing the mechanical joint with adhesive bonding can eliminate this. Adhesive bonding can also be used in conjunction with mechanical bonding.

Adhesive Bonding

With consideration given to joint design so there is an adequate overlap on the joint area, Copper and Copper alloys can be successfully joined using adhesive bonding.

As Copper and Copper alloys form a protective surface oxide layer, the surfaces must be cleaned before the adhesive is applied.

Casting

Copper and many Copper alloys are ideally suited to fabrication of components by casting.

The most flexible casting technique utilises sand moulds. Sand moulds can be used for production runs from simple one-off items to long casting runs. These items can also range in size from a few grams to many tonnes.

The other popular casting technique uses iron moulds and is called die casting. Die casting is suited to long casting runs.

Both die casting and sand casting can be used for the low cost production complex near net-shape components. This minimises expensive post casting machining.

Bars, sections and hollows that require tight dimensional control are often produced by continuous casting.

Rings, discs and other symmetrical shapes tend to be produced using centrifugal casting.

Machining

All Coppers and Copper alloys can be machined accurately, cheaply, with a good tolerance standard and good surface finish. Some Copper alloys are specifically formulated to have excellent machinability.

If machinability is the paramount consideration for the material, the material of choice is high speed machining brass.

The relative machinability of metals is demonstrated by a percentage rating. This rating system is based on the original free machining brass (CZ121 / CW614N) which has a rating of 100.

Descaling

The surface oxide films that form on Copper alloys can prove to be quite tenacious. Often these films need to be removed before some fabrication processes can be performed.

Very fine abrasive belts or discs can be used to remove oxides and discolouration adjacent to welds.

Pickling might be necessary by using a hot 5-10% sulphuric acid solution containing 0.35g/l potassium dichromate. Before commencing pickling, oxides can be broken up by a grit blast. Components that have been pickled should be rinsed thoroughly in hot, fresh water and finally dried in hot air.

Finishing

Copper components can be finished in a vast variety of ways. The finish used for any given Copper component is dependent upon function and/or aesthetics. Copper naturally forms a protective oxide layer on exposure to the elements. This layer is normally blue – green and may or may not be desirable.

The blue – green patina develops over time but its development can be enhanced and accelerated by the use of commercially available oxidising agents.

If the tarnished patina of Copper is not desirable, the material can be protected using a lacquer coating. An acrylic coating with benzotriazole as an additive will last several years under most outdoor, abrasion-free conditions.

Painting

In most instances Copper and Copper alloys do not require painting. The inherent properties of Copper resist corrosion and biofouling. Painting of Copper is occasionally done for aesthetic reasons. It is also done to reduce the incidence of metal to metal contact of bimetallic couples where galvanic corrosion might be a problem.

Before painting Copper, the surface of the material should be roughened by grit or sand blasting. Other specific procedures will depend upon the type of paint being used. Please consult the paint manufacturer for details.

Cleaning and Polishing Copper

The best way to keep Copper clean is to not allow it to get dirty in the first place.

Where possible, decorative items should be kept clean and free of dust. Many decorative copper items are coated with lacquer to protect the finish. Other than dusting, for these items occasional washing with luke warm, soapy water may be required. They should never be polished as this may remove the protective lacquer.

To remove tarnish from Copper cookware, simply rub with lemon halves dipped in salt.

Tarnish can be removed from Copper in industrial applications using commercial copper polishes. These polishes should be applied following the manufacturers instructions.

If a brushed finish is required on Copper or copper alloys, stainless steel brushes must be used to eliminate cross contamination.

Recycling

Copper alloys are highly suited to recycling. Around 40% of the annual consumption of Copper alloys comes from recycled copper materials. Both process scrap and the component, at the end of its working life, can be readily recycled.

Corrosion Susceptibility of Metals

Most susceptible to corrosive attack (less noble)

Magnesium and its alloys
Zinc and its alloys
Aluminium and its alloys
Cadmium
Mild steel
Cast iron
Stainless steel, 13% Cr, type 410 (active)
Lead-tin solder, 50/50
Stainless steel, 18/18 type 304 (active)
Stainless steel, 18/18/3% Mo, type 316 (active)
Lead
Tin
BRASSES
Gunmetals
Aluminium Bronzes
Copper
Copper-nickel alloys
Monel
Titanium and its alloys
Stainless steel, 18/8, type 304 (passive)
Stainless steel, 18/8/3 Mo, type 316 (passive)
Silver
Gold
Platinium

Least susceptible to corrosive attack (more noble)

Imperial Wire and Sheet Metal Gauge

No.	Imperial Standard (swg)	
	ins	mm
0	0.324	8.23
1	0.300	7.62
2	0.276	7.01
3	0.252	6.40
4	0.232	5.89
5	0.212	5.38
6	0.192	4.48
7	0.176	4.47
8	0.160	4.06
9	0.144	3.66

No.	Imperial Standard (swg)	
	ins	mm
10	0.128	3.25
11	0.116	2.95
12	0.104	2.64
13	0.092	2.34
14	0.080	2.03
15	0.072	1.83
16	0.064	1.63
17	0.056	1.42
18	0.048	1.22
19	0.040	1.02

No.	Imperial Standard (swg)	
	ins	mm
20	0.036	0.914
21	0.032	0.813
22	0.028	0.711
23	0.024	0.610
24	0.0220	0.559
25	0.0200	0.508
26	0.0180	0.457
27	0.0164	0.417
28	0.0148	0.376

Conversion Factors

Description	From Unit	To Units	Multiply by
Angstrom units to microns			0.001
Atmospheres (standard) to pounds per square inch	A	lbfin² (psi)	14.70
Atmospheres (standard) to Pascal	A	Pa	101325
Bar to kilograms force per square centimetre	bar	kgf/cm²	1.0197
Bar to pounds force per square inch	bar	lbf/in² (psi)	14.5038
Centigrade to Fahrenheit	°C	°F	multply by 1.8 and add 32
Centimetres to feet	cm	ft	0.03280840
Centimetres to inches	cm	in	0.393701
Centimetres³ to feet³	cm³	ft³	0.0000353147
Centimetres³ to inches³	cm³	in³	0.06102376
Fahrenheit to Centigrade	°F	°C	substract 32 and multiply 0.5555
Feet per second to miles per hour	ft/s	mph	0.681818
Feet to centimetres	ft	cm	30.48
Feet to metres	ft	m	0.3048
Feet to millimetres	ft	mm	304.8
Feet³ to metres³	ft³	m³	0.02831685
Feet³ to gallons	ft³	gal	6.2288
Foot pounds to kilogram metres	ftlb	kgm	0.1382
Gallons (UK) to litres	gal	l	4.546092
Gallons (US) to litres	gal	l	3.785412
Grams per centimetres³ to pounds per inch³ (density)	gm/cm³	lb/in³	0.0361275
Grams to ounces	gm	oz	0.035274
Grams to pounds	gm	lb	0.00220462
Inches to centimetres	in	cm	2.540
Inches to metres	in	m	0.0254
Inches to millimetres	in	mm	25.4
Inches³ to centimetres³	in³	cm³	16.38706
Inches³ to litres	in³	l	0.01639
Kilogram metres to foot pounds	kgm	ftlb	7.233
Kilograms force to bar	kgf	B	0.9807
Kilograms force to Newtons	kgf	N	9.806650
Kilograms per metre to pounds per foot (assuming constant cross sectional area)	kg/m	lb/ft	0.671970
Kilograms per square centimetre to pounds per square inch	kg/cm²	lb/in² (psi)	14.223
Kilograms per square metre to pounds per square foot	kg/cm²	lb/ft²	0.2048
Kilograms per square metre to Newtons per square metre	kg/m²	N/m²	9.806650
Kilograms per square millimetre to pounds per square inch	kg/mm²	lb/in² (psi)	1422.34
Kilograms per square millimetre to tons per square inch	kg/mm²	ton/in²	0.63497
Kilograms to pounds	kg	lb	2.205
Kilograms to tons (long)	kg	ton	0.0009842
Kilometres to miles	km	mile	0.62137
Litres of water at 62°F to pounds	l	lb	2.205
Litres to inches³	l	in³	61.03
Litres to gallons (UK)	l	gal	0.2199692
Litres to gallons (US)	l	gal	0.2641720
Metres to inches	m	in	39.37008
Metres to microns			1 million
Metres to miles	m	miles	0.000621371
Metres to feet	m	ft	3.28084
Metres to yards	m	yd	1.093613
Metre³ to inch³	m³	in³	61023.76
Metre³ to feet³	m³	ft³	35.31466

Description	From Unit	To Units	Multiply by
Metre³ to gallon (UK)	m^3	gallon	219.9692
Metre³ to gallon (US)	m^3	gallon	264.1720
Metre³ to litre	m^3	l	1000.0
Metre³ to yard³	m^3	yd^3	1.307951
Metric tons (or tonnes, 1000kg) to long tons	tonne	ton	0.9842
Microns to Angstrom units			1000
Microns to metres			0.000001
Microns to millimetres			0.001
Microns to thousands of an inch			0.03937008
Miles per hour to feet per second	mph	ft/s	1.46666
Miles to kilometres	m	km	1.60934
Millimetres to feet	mm	ft	0.003280840
Millimetres to inches	mm	in	0.03937008
Millimetres to microns			1000
Millimetres to thousands of an inch			39.37008
Newtons per square metre (Pascal) to kilograms per square metre	N/m^2 (Pa)	kg/m^2	0.1019716
Newtons per square millimetre to pounds per square inch	N/mm^2	lb/in^2 (psi)	145.0377
Newtons per square millimetre to to tons per square inch	N/mm^2	$tons/in^2$	0.06475
Newtons to kilograms force	N	kgf	0.1019716
Newtons to pound force	N	lbf	0.2248089
Ounces to grams	oz	gm	28.3495
Pints imperial litres	pt	l	0.5679
Pounds force to Newtons	lbf	N	4.448222
Pounds per inch³ to grams per centimetre³ density	$lb.in^3$	gm/cm^3	27.67990
Pounds per foot to kilograms per metre (assuming constant cross sectional area)	lb/ft	kg/m	1.4882
Pounds per squarefoot to kilograms per square metre	lb/ft^2	kg/m^2	4.882429
Pounds per square inch to atmospheres	lb/in^2 (psi)	A	0.06803
Pounds per square inch to bars	lb/in^2 (psi)	bar	0.06894757
Pounds per square inch to kilograms per square centimetre	lb/in^2 (psi)	kg/cm^2	0.07030697
Pounds per square inch to kilograms per square millimetre	lb/in^2 (psi)	kg/cm^2	0.0007030697
Pounds per square inch to Newtons per square millimetre	lb/in^2 (psi)	N/mm^2	0.006894757
Pounds to grams	lb	gm	453.60
Pounds to kilograms	lb	kg	0.453593
Square centimetres to square inches	cm^2	in^2	0.1550003
Square feet to square metres	ft^2	m^2	0.09290304
Square inches to square centimetres	in^2	cm^2	6.4516
Square inches to square millimetres	in^2	mm^2	645.16
Square kilometres to square miles	km^2	$miles^2$	0.386103
Square metres to square feet	m^2	ft^2	10.763910
Square metres to square yards	m^2	yd^2	1.195990
Square miles to square kilometres	$miles^2$	km^2	2.590
Square millimetres to square inches	mm^2	in^2	0.001550003
Square yards to square metres	yd^2	m^2	0.8361274
Tons per square inch to kilograms per square millimetre	ton/in^2	kg/mm^2	1.575
Tons per square inch to Newtons per square millimetre	ton/in^2	N/mm^2	15.4443
Tons (long) to kiilograms	ton	kg	1016.047
Tons (long) to metric tons (or tonne, 1000kg)	ton	tonne	1.016047
Yards to metres	yd	m	0.9144
Yards³ to metres³	yd^3	m^3	0.7645549

Formulae for Calculation

All weights shown in this publication are theoretical weights for guidance only. They are calculated using nominal dimensions and scientifically recognised densities. The formulae used are shown below together with the densities of the alloys. Please note that in practice, the actual weight can vary significantly from the theoretical weight due to variations in manufacturing tolerances and compositions.

Form	Dimensions in mm	Weight for Alloys of Density p Kg/dm³	
Round	Diameter = d	0.00078540 d^2p	Kg/m
Hexagon	Width across flats = f	0.00086603 f^2p	Kg/m
Square	Side = a	0.00100 a^2p	Kg/m
Flat	Width = w Thickness = t	0.00100 wtp	Kg/m
Angle/Tee	Leg lengths = L_1, l_2 Thickness = t	0.00100 (L_1 + L_2-t)tp	Kg/m
Channel	Leg lengths = L_1, l_2 Base = B Thickness = t	0.00100 (B + L_1 + L_2-2t)tp	Kg/m
Plate/ Sheet	Thickness = t Length = L Width = w	tp 0.000001 Lwtp	Kg/m Kg/Sheet
Strip	Width = w Thickness = t	0.100 wtp	Kg/100m
Pipe/Tube (Round)	Outside diameter = D Inside diameter = d Wall thickness = t	0.0031416 (D-t)tp, or 0.0031416 (d+t)tp	Kg/m
Square/ Rectangular Tube	Sides = a_1, a_2, Wall thickness = t	0.001 ($2a_1$ + $2a_2$-4t)tp	Kg/m
Wire	Diameter = d	0.78540 d^2p	Kg/Km

Comparative Properties

Metal	Density	Melting Temp °C	Thermal Conductivity	Electrical Resistivity	UTS	Proof Stress	Elongation %	Typical Young's Modulus GPa
Aluminium pure	2.7	660	201	2.65	105	85	4	68
Aluminium alloy	2.7	660	184	3.7	310	260	7	68 to 89
Brass CZ121	8.5	954	110	6.33	400	190	20	103 to 120
Copper C101	8.9	1083	385	1.67	360	280	15	128 to 131
Iron	7.8	1537	80	9.71	210	120	40	152 to 183
Lead	11.3	327	35	20.65	20	0	60	16 to 18
Nickel alloy (Nimonic 105)	7.9	1327	12	132.0	990	800	5	180 to 234
Stainless Steel (18CR/8Ni)	7.9	1527	150	70	570	215	30	205 to 215
Mild Steel	7.8	1427	63	12	690	350	20	196 to 211
Tin	7.3	232	65	12.8	25	20	60	44 to 53

Chemical Elements

Aluminium – **Al**
Arsenic – **As**
Boron – **B**
Cadmium – **Cd**
Carbon – **C**
Chromium – **Cr**
Cobalt – **Co**
Columbium – **Cb***
Copper – **Cu**
Hydrogen – **H**
Iron – **Fe**
Lead – **Pb**
Lithium – **Li**
Manganese – **Mn**
Molybdenum – **Mo**
Nickel – **Ni**
Niobium – **Nb**
Nitrogen – **N**
Oxygen – **O**
Phosphorus – **P**
Selenium – **Se**
Silicon – **Si**
Sulphur – **S**
Tellurium – **Te**
Tin – **Sn**
Titanium – **Ti**
Zinc – **Zn**
Zirconium – **Zr**

* The American designation for Niobium

Densities

Material	Density Kg/dm³
Aluminium	2.70
Stainless Steel	
– Ferritic/Martensitic	7.75
– Austenitic	7.92
Copper	8.90
Brass	8.47
Bronze	8.89
INCOLOY® Alloy 800	7.95
INCOLOY® Alloy 800H	7.95
INCOLOY® Alloy 825	8.14
INCOLOY® Alloy 903	8.14
INCOLOY® Alloy DS	7.92
INCONEL® Alloy 600	8.42

Material	Density Kg/dm³
INCONEL® Alloy 601	8.06
INCONEL® Alloy 617	8.36
INCONEL® Alloy 625	8.44
INCONEL® Alloy 690	8.19
INCONEL® Alloy 718	8.19
INCONEL® Alloy X-750	8.25
MONEL® Alloy 400	8.83
MONEL® Alloy K-500	8.46
Nickel 200	8.89
Nickel 201	8.89
UNS 31803	7.80
17-4 PH	7.75

Comparative Densities

Material	Density Kg/dm³
Stainless Steel	1.000
Stainless Steel – Ferritic and Martensitic	0.977
Mild and Carbon Steel	0.994
Low Alloy Steel	0.987
Aluminium	0.341
Copper	1.134
Brass	1.066
Aluminium Bronze	0.970
Titanium	0.571
Lead	1.440

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