Section 3 – CHOOSING THE RIGHT BRASS

There are over sixty brasses specified in EN Standards. The alloys cover a wide range of properties and attributes, so it is essential to select the appropriate alloy for the application and fabrication route required.

For convenience this section will also include some discussion of the nickel silvers which are a group of copper-zinc alloys containing significant amounts of nickel. They are noted for their corrosion resistance, white colour and excellent elastic properties.

The compositions and properties of all the standard brasses and nickel silvers are listed in ***Tables 19 and 20***.

Further information on the Standards documents is given in ***Section 4*** under 'Ordering Information'.

BRASSES FOR SPECIFIC MANUFACTURING PROCESSES

High-speed machining brasses

Lead is added to brass to improve its machinability. It also has the effect of reducing the cold ductility of the metal so the amount of lead used depends on the exact combination of properties required. The lead exists as discrete particles in the matrix and causes the swarf from the machining operation to be broken into fine chips rather than long curls, allowing it to clear from the work piece. The lead also has some lubricant action. Further information on these materials is given in ***Section 6***.

The most commonly available alloys are summarised in ***Table 6.***

The casting and extrusion of these brasses must be carefully controlled to ensure that the lead particles are finely dispersed and that any iron or silicon impurities are retained in solution. Lack of care in manufacture can result in these impurities precipitating out as hard particles which accentuate tool wear. For highest machining rates and minimum tool wear it is therefore desirable to purchase stock from reputable suppliers.

For applications where some cold forming operations are required after machining, a brass with a higher copper content and less lead must be used. For example the alloy CW601N (CZ131) is widely used where cold heading is to be carried out.

Brasses for hot working

In order to select an appropriate brass, a little knowledge of the basic metallurgy of the brasses is useful. This is discussed in more detail in ***Section 6***, but can briefly be summarised here.

When the alloy contains less than about 35% Zn, the zinc stays in solid solution in the copper. Such brasses are known as single phase, or alpha brasses. They have good ductility at ambient temperatures and are ideal for cold working. When more zinc is added, a second phase, beta, is formed, and at room temperature the alloy is a mixture of the two phases. These brasses are known as two-phase, alpha/beta, or duplex brasses.

Because the beta phase has very good hot ductility, the most appropriate alloys for hot working are the duplex brasses. The choice of alloy will then depend on other factors.

Hot stamping brasses

The most popular alloys for hot stamping are summarised in ***Table 7***, with a complete list being given in ***Table 13***. They combine maximum ductility at the stamping temperature (650° – 750°C) to allow complex shapes to be formed, with strength and reasonable ductility at room temperature. The optimum compositions are in the region of 60% Cu and 40% Zn. These are predominantly in the plastic, beta phase at the stamping temperature and have a mixture of alpha and beta phases at room temperature. The precise choice of alloy will depend on the service requirements and other fabrication processes. Other alloys which can be hot stamped are listed in ***Section 4***.

TABLE 6 – Free-machining brasses

Compositional Designation EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties
CuZn39Pb3 CW614N	CZ121 Pb3	The most commonly used alloy for high-speed machining. Has limited cold ductility but can be knurled.
CuZn36Pb3 CW603N	CZ124	Has better cold ductility coupled with excellent machinability.
CuZn36Pb2As CW602N	CZ132	Dezincification-resistant brass.
CuZn37Pb2 CW606N	CZ131	Good machinability with improved cold ductility. Suitable for cold heading and riveting.
CuZn39Pb2 CW612N	CZ128	Good machinability and sufficient ductility for some cold work.
CuZn40Pb2 CW617N	CZ122	Good machinability but limited cold ductility. Generally used for hot stamping.

TABLE 7 – The most popular brasses for hot stamping

Compositional Designation EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties
CuZn40Pb2 CW617N	CZ122	This is the alloy most frequently used for hot stamping. Complex shapes can be formed and it has good machinability.
CuZn40 CW509L	CZ109	This lead-free alloy has superior cold ductility as well as excellent hot working properties. It is not so easily machined.
CuZn39Pb3 CW614N	CZ121 Pb3	Has excellent machinability.
CuZn39Pb2 CW612N	CZ128	This alloy has better cold ductility than CuZn40Pb2.
CuZn36Pb2As CW602N	CZ132	Dezincification-resistant brass. Used for plumbing fittings.

Brasses for cold working (*Table 8*)

The alloys with maximum cold ductility are single phase alpha alloys. The most ductile, with the highest copper content is CW505L (CZ106, 70/30), also called Cartridge Brass, is widely used for deep drawing. For less demanding applications requiring simple forming, the lower copper, cheaper alloys CW507L (CZ107, 64/36) or CW508L (CZ108, 63/37) may be used.

Cold working brasses are typically used to make semi-finished products such as sheet, strip, foil, wire and tube.

The gilding metals, CW501L (CZ101), CW502L (CZ102) and CW503L (CZ103) have excellent ductility, strength and corrosion resistance and are frequently chosen for colour and durability for decorative architectural applications and costume jewellery. For special purposes, where even better corrosion resistance is required, aluminium or arsenical brasses are available. A typical application would be for condenser tubes for use with brackish or seawater.

Brasses for casting (*Table 9*)

Specific alloys have been developed for each of the different casting processes. The most commonly used are listed in ***Table 9***. Some of the alloys have an addition of lead for machinability, others have tin to improve corrosion resistance and strength. All have a good combination of fluidity while pouring, and hot strength to avoid hot tearing while solidifying. Manganese is a useful deoxidant, as little as 0.02% present giving stronger, sound castings. For diecasting the 60/40 type alloys are normally used. The higher zinc content lowers the casting temperature and gives essential hot ductility. Small additions of silicon or tin improve fluidity; tin also improves corrosion resistance. Aluminium is added to form a protective oxide film to keep the molten metal clean and reduce the attack on the die materials. This type of alloy with a suitably controlled composition may also be used for castings required to be resistant to dezincification.

For applications requiring higher strength, high tensile brasses can be used. These can be sand cast and CC7655 (HTB1) is also used for gravity diecasting.

The casting process is ideal for the production of complex shapes. End uses range from pipeline valves and electrical switchgear components which require high soundness and strength, a long operating life and, in the case of components for mines and the petrochemical industry, spark-resistant characteristics, to non critical ornamental applications where the requirement is for a good surface finish as well as a long service life.

BRASSES FOR SPECIAL APPLICATIONS

High tensile brasses

The high tensile brasses are copper-zinc alloys with additions to increase the tensile strength over that of the simple binary copper-zinc brasses. They have been in use for many years and were commonly but incorrectly called 'Manganese Bronzes'. Development work over many years has provided for industry a family of alloys with tensile strengths in excess of 700N/mm^2 and also with enhanced properties of wear resistance and corrosion resistance.

They are suitable for a wide range of applications and service conditions, ranging from decorative architectural use to wear-resistant automobile transmission components and the high strength, high integrity equipment used in mines. The alloys containing aluminium have an attractive, naturally lustrous surface; the self-healing film confers extra corrosion resistance. The silicon-containing alloy has excellent wear resistance.

The readily available high tensile brasses included in EN Standards are shown in ***Table 10***. Further details of these materials can be found in ***Section 6***.

TABLE 8 – Brasses for Cold Working

Compositional Designation and EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties
CuZn30 CW505L	CZ106	Excellent cold ductility. In sheet form can be used for deep drawing. As wire, suitable for the most severe cold deformation.
CuZn37 CW508L	CZ108	Known as 'Common Brass', this is a good general purpose alloy suitable for simple forming.
CuZn10 CW501L	CZ101	Gilding metal with highest copper content. Very good corrosion resistance. Can be brazed and enamelled.
CuZn15 CW502L	CZ102	Similar to CW501L with slightly superior mechanical properties.
CuZn20 CW503L	CZ103	Further improvement in mechanical properties. Corrosion resistance not quite so good as CW501L. Good for deep drawing.
CuZn20Al2As CW703R	CZ110	Aluminium brass, common in tube form. Has excellent corrosion resistance. Used particularly for applications in clean seawater.

TABLE 9 – Brasses for Casting

Compositional Designation and EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties
CuZn33Pb2-C CC750S	SCB3	General purpose sand castings. Moderate strength and good corrosion resistance.
CuZn39Pb1Al-C CC754S	DCB3	This is the most commonly supplied die casting brass. A fine grained version is available.
CuZn35Pb2Al-C CC752S	DZR1	This and CC751S (DZR2) have properties similar to CC754S (DCB3) but can be heat-treated to give resistance to dezincification.
CuZn33Pb2Si-C CC751S	DZR2	See remarks for CC752S (DZR1).
CuZn35Mn2Al1Fe1-C CC765S	HTB1	Alloy has good strength and toughness and good corrosion resistance. Sand casting is employed for most purposes, but die castings can also be produced and these will have superior mechanical properties.
CuZn25Al5Mn4Fe3-C CC762S	HTB3	This alloy is the nearest equivalent to the British Standard CC762S (HTB3) but there are many differences. Neither alloy should be used for marine conditions. They have higher strength than CC765S (HTB1).

Brasses for electrical applications

Brass is widely used for contacts and terminals in electrical applications. Its electrical conductivity is good and it has the great advantage that the thin oxide film which forms on exposure to the air is electrically conductive so that contact resistance does not increase. The precise choice of alloy will depend on the service conditions. The electrical properties of some readily available alloys are listed in *Table 11*.

Brasses for architectural applications

Brasses containing aluminium or manganese are frequently used for architectural applications because of the self-healing, attractive surface films which they exhibit. Manganese brass CW720R (CZ136) has a chocolate coloured film when oxidised and the aluminium-containing brasses which are included in EN 12167 as CW623N (CZ130) have a bright yellow colour with a silvery sheen. Both types of alloy have excellent hot workability which allows the complex section shapes required in many architectural applications to be produced. Other attractive colours are available with the use of the gilding metals, CW501L (CZ101), CW502L (CZ102) and CW503L (CZ103) available as extruded sections, rolled sheet and strip and as tube.

For information on surface finishes, see *Section 5.*

Brasses for decorative applications

For costume jewellery, decorative trims and other similar applications the low-zinc brasses or gilding metals mentioned above are recommended. They have an attractive golden colour which varies with copper content, and good tarnish resistance. For applications where lustre must be retained indefinitely they should be lacquered (*see Section 5*).

Nickel silvers are also widely used for decorative purposes. They require no protection or special attention when used indoors, although it should be noted that there will be a slight yellowing of the original silvery-white colour on the lower-nickel alloys. Outdoors, treatment with very light oil, wax polish or lacquer is required to prevent eventual development of a light powdery green patina.

Dezincification-resistant brass

In certain circumstances where water supplies are unusually aggressive, conventional duplex brass water fittings can suffer a form of corrosion known as dezincification. This involves selective leaching of the zinc which can cause fracture of the fitting. Dezincification-resistant brass, CW602N (CZ132), should then be specified. This is made as fittings, stopcocks and valves with a carefully controlled composition by extrusion or hot stamping, followed by heat treatment to ensure that the material will satisfy the requirements of the standard dezincification-resistance test. Versions of the alloy suitable for diecasting are also available. Further details of the alloy are given in *Section 7*.

TABLE 10 – High tensile brasses included in EN Standards

Compositional Designation and EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties	
		Typical Applications	Tensile Strength N/mm²
CuZn40Mn1Pb1AlFeSn CW721R	CZ114	Gas valves, lift track sections, switchgear. Door lock parts for railway carriages. Spinners for classic cars. Yacht fittings - rope guides.	450-580
CuZn40Mn1Pb1FeSn CW722R	CZ115	Low aluminium content makes this suitable for use when components are to be assembled by soldering or brazing. Very suitable for finish plating.	450-580
CuZn25Al5Fe2Mn2Pb CW705R	CZ116	High strength and corrosion resistance. Suitable for valve spindles, etc.	600-750
CuZn37Mn3Al2PbSi CW713R	CZ135	Silicon addition gives extra wear and galling resistance to suit applications such as gearbox components.	540-700
CuZn40Mn1Pb1 CW720R	CZ136	Manganese brass for architectural sections.	350-600
CuZn35Mn2Al1Fe1-C CC765S	HTB1	Casting brass of good strength and corrosion resistance.	450 (sand cast)
CuZn25Al5Mn4Fe3-C CC762S	HTB3	Casting brass with higher strength but reduced corrosion resistance.	750 (sand cast)

TABLE 11 – Electrical conductivity and elastic modulus of some brasses

Compositional Designation and EN number	Nearest Equivalent Old British Standard Alloy	Relevant Properties		
		Typical Applications	Modulus of elasticity N/mm²x10³	Electrical Conductivity %IACS
CuZn10 CW501L	CZ101	Springs	124	44
CuZn30 CW505L	CZ106	Lamp caps. In strip and wire form for springs and contacts	117	28
CuZn37 CW508L	CZ108	Lamp caps and switch components. In strip and wire form for springs and contacts	111	26
CuNi12Zn24 CW403J	NS104	Used in strip form for relay and contact springs. Resistance wire and strip for moderately elevated temperatures, contacts, connectors, connector pins and terminals.	130	8
CuNi18Zn20 CW409J	NS106	As above	135	6
CuNi18Zn27 CW410J	NS107	As above	140	5.5
CuZn40Pb2 CW617N	CZ122	Hot stamped components such as terminals	96	27
CuZn39Pb3 CW614N	CZ121 Pb3	Machined components such as plug pins, switch terminals	96	28
CuZn33Pb2-C CC750S	SCB3	Cast components	-	20
CuZn39Pb1Al-C CC754S	DCB3	Cast components	-	18
CuZn35Mn2Al1Fe1-C CC765S	HTB1	Heavy duty components requiring strength and moderate electrical conductivity	-	22

Brasses for service in seawater

The small additions of tin in Naval brass and Admiralty brass improve the corrosion resistance in seawater. Naval brass, old BS specification CZ112, contains 60% Cu, 39% Zn and 1% Sn. It is a duplex brass and is therefore harder and stronger, but less ductile than Admiralty brass, CW706R (CZ111), which contains 71% Cu, 28% Zn with 1% Sn and is an alpha brass. The nearest equivalent to Naval brass is a leaded alloy, CW712R. Nowadays Aluminium brass CW702R (CZ110) has replaced Admiralty brass for tubes for marine service, but Admiralty brass continues to be used for fresh water. It should be noted that the alumina film which forms on Aluminium brass will prevent wetting by solder so aluminium-free alloys must be chosen if soldering is required.

Dezincification-resistant brass and some high tensile brasses can also be used for marine applications.

Brass tubes for fluid handling

If brass tubes are used in the hard drawn condition, or if they have been severely cold worked by bending or swaging in assembly, they should generally be stress relief heat treated to ensure freedom from stress corrosion cracking, unless the conditions of service are such that exposure to ammonia in any form is unlikely. Fuel lines, oil pipes etc, made up using annealed tube and with reasonably gentle bends, do not require treatment unless their service environment is unusual.

Arsenical 70/30 brass tube for heat exchangers CW707R (CZ126) is widely used in fresh water service and is the preferred brass for applications such as automotive radiators and oil coolers. Its arsenic content (0.02 - 0.06%) helps to combat dezincification and improves corrosion resistance. Admiralty brass CW706R (CZ111), containing 1% tin, offers slightly increased general resistance to erosion corrosion and substantially increased resistance to both pitting and erosion corrosion in the presence of sulphide pollution. It is the preferred brass for condenser and heat exchanger tubes handling fresh waters with less than 2,000ppm dissolved solids, but is not recommended for seawater service at water speeds in excess of 2.5-3.0 m/s. At the low water speeds commonly associated with oil coolers, for example, Admiralty brass should not suffer erosion corrosion and, if the cooling water is polluted with sulphide, or long periods of stagnation leading to decay of marine organisms and activity of sulphate-reducing bacteria within the tubes are experienced, the sulphide-resistance imparted by its tin content makes it preferable to Aluminium brass.

Aluminium brass CW702R (CZ110) is easily best for seawater service - both as condenser and heat exchanger tubing and as seawater piping. It has been very widely used for the condensers of fossil-fuelled and nuclear power stations throughout the world and also for the heat-recovery sections of desalination plants. For optimum performance the cooling water is treated with **ferrous sulphate**, which ensures the formation of a surface film which is highly protective and does not interfere seriously with heat transfer.

Tungum Tube

The aluminium-nickel-silicon brass CW700R (CZ127) Tungum was originally developed for the hydraulic lines in the control systems of aircraft. It combines excellent fatigue properties with high strength to weight ratio and good corrosion resistance particularly in seawater (***see case study on page 27***).

Like all brasses, Tungum maintains good mechanical properties at cryogenic temperatures with values for strength and ductility at –196°C being slightly higher than at room temperature.

It has very good resistance to stress corrosion cracking but is not immune, so care should be taken not to leave highly stressed pipes in ammonical or mercurous environments.

Tungum Tube is used in:

- *Hydraulic systems in aviation, offshore and marine applications*
- *High pressure gas transportation, e.g. by BOC and Air Products for carrying high pressure oxygen where non-sparking requirements are mandatory.*

Cleanliness of tube - carbon films

Tube specified for use in fresh water or marine conditions should be purchased in accordance with EN 12449 (General) or EN 12451 (Heat exchangers). These standards specifically refer to Surface Quality (Clause 6.4) and particular consideration may need to be given to the actual or potential contamination of the surface with carbon films, even though carbon is not specifically mentioned in the standards.

Such films occur during the thermal decomposition of drawing lubricants during final annealing or they may occur during fitting if lubricant residue is left in the bores. (Most modern lubricants and manufacturing techniques are designed to avoid this problem and evidence of carbon may be a sign of questionable manufacturing practice).

Carbon films have been shown to increase the risk of pitting corrosion in copper water tube and pitting and erosion in brass condenser and heat exchanger tube. For this reason the purchaser may wish to consider invoking additional testing (***see EN 1057 annex B***).