Company Profile

Stainless Steel

Aluminium

Copper, Brass & Bronze

General Data
The information contained herein is based on our present knowledge and experience and is given in good faith. However, no liability will be accepted by the Company in respect of any action taken by any third party in reliance thereon.

As the products detailed herein may be used for a wide variety of purposes and as the Company has no control over their use, the Company specifically excludes all conditions or warranties expressed or implied by statute or otherwise as to dimensions, properties and/or their fitness for any particular purpose. Any advice given by the Company to any third party is given for that party’s assistance only and without any liability on the part of the Company.

Any contract between the Company and a customer will be subject to the Company’s Conditions of Sale. The extent of the Company’s liabilities to any customer is clearly set out in those Conditions; a copy of which is available on request.

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.

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Issue No. 3 – 02/2011

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.
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 website 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.
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.

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 19 local Service Centres providing unrivalled service to customers in their local area.

The hub is The Metal Centre – a 270,000 square foot (25,000m²) 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:

<table>
<thead>
<tr>
<th>Brass</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Free Machining rod and hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riveting Brass rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dezincification Resistant (DZR) brass rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Tensile Brass rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naval Brass rod and plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle, Flat Bar &amp; Square Bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half Hard, Polished and Spinning Quality sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Copper</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Half Hard and Spinning Quality sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Conductivity flat bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube, including coiled tube for refrigeration and air conditioning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bronze</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphor Bronze rod PB102</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing Bronze rod and hollows SAE660,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium Bronze rod CA104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphor Bronze plate and sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium Bronze rod and hexagon DEFSTAN833</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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](http://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

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

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.

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

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 toxicity 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.
<table>
<thead>
<tr>
<th>EN Number</th>
<th>Title</th>
<th>Nearest Old BS Equivalent</th>
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</thead>
<tbody>
<tr>
<td><strong>Unwrought Products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>Cast unwrought copper products</td>
<td>6017</td>
</tr>
<tr>
<td>1977</td>
<td>Copper drawing stock (wire rod)</td>
<td>6926</td>
</tr>
<tr>
<td>1978</td>
<td>Copper cathodes</td>
<td>6017</td>
</tr>
<tr>
<td>1981</td>
<td>Master alloys</td>
<td>-</td>
</tr>
<tr>
<td>1982</td>
<td>Ingots and castings</td>
<td>1400</td>
</tr>
<tr>
<td><strong>Rolled Flat Products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1172</td>
<td>Sheet and strip for building purposes</td>
<td>2870</td>
</tr>
<tr>
<td>1652</td>
<td>Plate, sheet, strip and circles for general purposes</td>
<td>2870, 2875</td>
</tr>
<tr>
<td>1653</td>
<td>Plate, sheet and circles for boilers, pressure vessels and hot water</td>
<td>2870, 2875</td>
</tr>
<tr>
<td></td>
<td>storage units</td>
<td></td>
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(These are arranged broadly in increasing order of alloying content)

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# Copper – Specifications, Grades and Properties

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<td>CuNi95n2</td>
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<td>CuNi10Fe1Mn</td>
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<tr>
<td>CN108</td>
<td>CuNi30Fe2Mn2</td>
<td>CW353H</td>
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<td>CN107</td>
<td>CuNi30Mn1Fe</td>
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### Copper-nickel-zinc (Nickel Silver)

<table>
<thead>
<tr>
<th>Nearest Old BS Equivalent</th>
<th>EN Material Designation</th>
<th>Symbol</th>
<th>Number</th>
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<tbody>
<tr>
<td>NS103</td>
<td>CuNi10Zn27</td>
<td>CW401J</td>
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<tr>
<td>NS104</td>
<td>CuNi12Zn24</td>
<td>CW403J</td>
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<td>NS111</td>
<td>CuNi12Zn25Pb1</td>
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<td>NS113</td>
<td>CuNi18Zn19Pb1</td>
<td>CW408J</td>
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<td>NS106</td>
<td>CuNi18Zn20</td>
<td>CW409J</td>
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<td>NS107</td>
<td>CuNi18Zn27</td>
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<td>NS101</td>
<td>CuNi10Zn42Pb2</td>
<td>CW402J</td>
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<td>NS102</td>
<td>CuNi12Zn38Mn3Pb2</td>
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## Listing of Old BS Standards replaced by EN Standards

<table>
<thead>
<tr>
<th>Old BS Standard</th>
<th>Title (abbreviated)</th>
<th>EN Standards</th>
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</thead>
<tbody>
<tr>
<td>1400</td>
<td>Copper and copper alloy ingots and castings</td>
<td>1982</td>
</tr>
<tr>
<td>1432</td>
<td>Drawn copper strip for electrical purposes</td>
<td>13601</td>
</tr>
<tr>
<td>1433</td>
<td>Copper rod and bar for electrical purposes</td>
<td>13601</td>
</tr>
<tr>
<td>1434</td>
<td>Copper sections in bars, blanks and segments for commutators (electrical purposes)</td>
<td>n/a</td>
</tr>
<tr>
<td>1453</td>
<td>Filler metals for gas welding</td>
<td>13347</td>
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<td>1845</td>
<td>Filler metals for brazing</td>
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<tr>
<td>1977</td>
<td>Copper tubes for electrical purposes</td>
<td>13600</td>
</tr>
<tr>
<td>2870</td>
<td>Sheet, strip and foil</td>
<td>1172,1652,1653,1654</td>
</tr>
<tr>
<td>2871 Pt 1</td>
<td>Tubes for water, gas and sanitation</td>
<td>1057</td>
</tr>
<tr>
<td>2871 Pt 2</td>
<td>Tubes for general purposes</td>
<td>12449</td>
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<td>2871 Pt 3</td>
<td>Tubes for heat exchangers</td>
<td>12451</td>
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<tr>
<td>2872</td>
<td>Forgings and forging stock</td>
<td>12165, 12420</td>
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<tr>
<td>2873</td>
<td>Wire</td>
<td>12166</td>
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<td>2874</td>
<td>Rods and sections</td>
<td>12163, 12164, 12167</td>
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<tr>
<td>2875 Pt 3</td>
<td>Plate</td>
<td>1652, 1653</td>
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</tbody>
</table>
# Wrought Low-Alloyed Copper Alloys- Compositions, Uses, Typical Mechanical Properties, Relevant Standards and Approximate Electrical Conductivity

<table>
<thead>
<tr>
<th>Material Designation</th>
<th>Composition, %, Range or Max</th>
<th>Nearest Old BS Equivalent</th>
<th>Characteristics and Uses</th>
<th>Typical Mechanical Properties</th>
<th>Approx. Conductivity % IACS</th>
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<tbody>
<tr>
<td></td>
<td>symbol</td>
<td>number</td>
<td>Cu</td>
<td>Be</td>
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<td>Heat Treatable Alloys</td>
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<td>CuBe1.7</td>
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<td>1.6-1.8</td>
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<tr>
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<td>1.8-2.1</td>
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<tr>
<td>CuBe2Pb</td>
<td>CW102C</td>
<td>Rem.</td>
<td>1.8-2.0</td>
<td>0.2-0.6 Pb 0.5</td>
<td>-</td>
</tr>
<tr>
<td>CuCoNi1Be</td>
<td>CW103C</td>
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<td>0.4-0.7</td>
<td>0.8-1.3</td>
<td>0.8-1.3 Cu 0.5</td>
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<td>CuCo2Be</td>
<td>CW104C</td>
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<td>0.4-0.7</td>
<td>2.0-2.8 Cu 0.5</td>
<td>C112</td>
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<td>CuNi2Be</td>
<td>CW110C</td>
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<td>0.2-0.6</td>
<td>1.4-2.4</td>
<td>0.5</td>
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<tr>
<td>CuCr1</td>
<td>CW105C</td>
<td>Rem.</td>
<td>0.5-1.2</td>
<td>0.2</td>
<td>CC111</td>
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<tr>
<td>CuCr1Zr</td>
<td>CW106C</td>
<td>Rem.</td>
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<td>0.03-0.3 0.2</td>
<td>CC112</td>
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<tr>
<td>CuNiP</td>
<td>CW108C</td>
<td>Rem.</td>
<td>0.8-1.2</td>
<td>0.15-0.25</td>
<td>0.1</td>
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<tr>
<td>CuNi1Si</td>
<td>CW109C</td>
<td>Rem.</td>
<td>1.6-1.6</td>
<td>0.4-0.7</td>
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<tr>
<td>CuNi2Si</td>
<td>CW111C</td>
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<td>0.4-0.8</td>
<td>0.3</td>
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<tr>
<td>CuNi3Si1</td>
<td>CW112C</td>
<td>Rem.</td>
<td>2.6-4.5</td>
<td>0.8-1.3</td>
<td>0.5</td>
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<tr>
<td>CuZr</td>
<td>CW120C</td>
<td>Rem.</td>
<td>0.1-0.2</td>
<td>0.1</td>
<td>Zr 0.1</td>
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<tr>
<td>Non Heat-treatable Alloys – Free Machining</td>
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<tr>
<td>CuPbP</td>
<td>CW113C</td>
<td>Rem.</td>
<td>0.003-0.012</td>
<td>0.7-1.5 Pb 0.1</td>
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<tr>
<td>CuSP</td>
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<td>0.2-0.7 5 0.1</td>
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<tr>
<td>CuTeP</td>
<td>CW118C</td>
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<td>0.003-0.012</td>
<td>0.4-0.7 Te 0.1</td>
<td>C109</td>
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## 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. Conduc- 
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>0.2% Proof Strength (N/mm²)</td>
<td>Elongation (%)</td>
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<td>Tensile Strength (N/mm²)</td>
<td>Hardness (HV)</td>
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<td>(%)</td>
<td>% IACS</td>
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<tr>
<td><strong>Copper-aluminium (Aluminium Bronze)</strong></td>
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<tr>
<td>CuAI5As</td>
<td>CW300G Rem. 4.0-6.5</td>
<td>0.1-0.4 As 0.3</td>
<td>An alpha phase alloy for tube manufacture. May be heavily cold worked.</td>
<td>130</td>
<td>380</td>
</tr>
<tr>
<td>CuAI6Si2Fe</td>
<td>CW301G Rem. 6.0-6.4 0.5-0.7</td>
<td>2.0-2.4 0.2</td>
<td>CA107</td>
<td>Medium strength alloys, readily hot worked and moderately cold workable. With correct machinability of 40-50%, the alloys are suitable for manufacture of items of chemical plant, machine parts, tools and instruments where good corrosion resistance is required.</td>
<td>250-350</td>
</tr>
<tr>
<td>CuAI7Si2</td>
<td>CW302G Rem. 7.3-7.6</td>
<td>1.5-2.2 0.2</td>
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<td>250-350</td>
<td>500-650</td>
</tr>
<tr>
<td>CuAI8Fe3</td>
<td>CW303G Rem. 6.5-8.5 1.5-3.5</td>
<td>0.2</td>
<td>CA106</td>
<td>High strength alloys for use in aggressive media when wear resistance and good impact strength are required.</td>
<td>180-210</td>
</tr>
<tr>
<td>CuAI9Ni3Fe2</td>
<td>CW304G Rem. 8.0-9.5 1.0-3.0</td>
<td>2.0-4.0 0.2</td>
<td>CA105</td>
<td>High strength alloys for use in aggressive media when wear resistance and good impact strength are required.</td>
<td>180</td>
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<tr>
<td>CuAI10Fe1</td>
<td>CW305G Rem. 9.0-10.0 0.5-1.5</td>
<td>0.3</td>
<td>-</td>
<td>Good elastic properties for electrical contacts.</td>
<td>210-480</td>
</tr>
<tr>
<td>CuAI10Fe3Mn2</td>
<td>CW306G Rem. 9.0-11.0 2.0-4.0 1.5-3.5</td>
<td>0.2</td>
<td>-</td>
<td>Good elastic properties for electrical contacts.</td>
<td>330-510</td>
</tr>
<tr>
<td>CuAli0Ni5Fe4</td>
<td>CW307G Rem. 8.5-11.0 3.0-5.0</td>
<td>4.0-6.0 0.2</td>
<td>CA104</td>
<td>Excellent sea-water corrosion resistance. The alloys with 30% nickel have good resistance to erosion.</td>
<td>400-530</td>
</tr>
<tr>
<td>CuAI11Fe6Ni6</td>
<td>CW308G Rem. 10.5-12.5 5.0-7.0</td>
<td>5.0-7.0 0.2</td>
<td>-</td>
<td>Good elastic properties for electrical contacts.</td>
<td>500-680</td>
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<tr>
<td><strong>Copper-nickel</strong></td>
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<tr>
<td>CuNi25</td>
<td>CW350H Rem. 24.0-26.0</td>
<td>0.1</td>
<td>CN105</td>
<td>Good elastic properties for electrical contacts.</td>
<td>120</td>
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<tr>
<td>CuNi9Sn2</td>
<td>CW351H Rem. 8.5-10.5</td>
<td>1.8-2.8 Sn 0.1</td>
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<td>Good elastic properties for electrical contacts.</td>
<td>200-550</td>
</tr>
<tr>
<td>CuNi10Fe1Mn</td>
<td>CW325H Rem. 1.0-2.0 0.5-1.0 9.0-11.0</td>
<td>0.2</td>
<td>CN102</td>
<td>Excellent sea-water corrosion resistance. The alloys with 30% nickel have good resistance to erosion.</td>
<td>100-420</td>
</tr>
<tr>
<td>CuNi30Fe2Mn2</td>
<td>CW353H Rem. 1.5-2.5 1.5-2.5 29.0-32.0</td>
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<td>CN108</td>
<td>Good elastic properties for electrical contacts.</td>
<td>175</td>
</tr>
<tr>
<td>CuNi30Mn1Fe</td>
<td>CW354H Rem. 0.4-1.0 0.5-1.5 30.0-32.0</td>
<td>0.2</td>
<td>CN107</td>
<td>Good elastic properties for electrical contacts.</td>
<td>130-330</td>
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<td><strong>Copper-nickel-zinc (Nickel-Silver)</strong></td>
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<tr>
<td>CuNi10Zn27</td>
<td>CW401U Rem. 61.0-64.0</td>
<td>9.0-11.0</td>
<td>Zn. Rem. 0.2</td>
<td>NS103</td>
<td>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.</td>
</tr>
<tr>
<td>Material Designation</td>
<td>Composition, %, Range or Max</td>
<td>Nearest Old BS Equivalent</td>
<td>Characteristics and Uses</td>
<td>Typical Mechanical Properties</td>
<td>Machinability Index (%)</td>
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<td>Al</td>
<td>As</td>
<td>Pb</td>
<td>Sn</td>
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<tr>
<td>CuZn36Pb3 CW603N</td>
<td>60-62.0</td>
<td>2.5-3.5</td>
<td>Rem.</td>
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<td>CZ124</td>
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<tr>
<td>CuZn39Pb3 CW614N</td>
<td>57.0-59.0</td>
<td>2.5-3.5</td>
<td>Rem.</td>
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<td>CZ121Pb3</td>
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<tr>
<td>CuZn40Pb2 CW617N</td>
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<td>Rem.</td>
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<td>CZ122</td>
</tr>
<tr>
<td>CuZn37Pb2 CW606N</td>
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<td>1.6-2.5</td>
<td>Rem.</td>
<td>0.2</td>
<td>CZ119, CZ131</td>
</tr>
<tr>
<td>CuZn38Pb2 CW608N</td>
<td>60.0-61.0</td>
<td>1.6-2.5</td>
<td>Rem.</td>
<td>0.2</td>
<td>CZ120, CZ128</td>
</tr>
<tr>
<td>CuZn39Pb2 CW612N</td>
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<td>1.6-2.5</td>
<td>Rem.</td>
<td>0.2</td>
<td>CZ120, CZ128</td>
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<td>0.8-1.6</td>
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<td>CZ118</td>
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<tr>
<td>CuZn35Pb2 CW601N</td>
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<td>1.6-2.5</td>
<td>Rem.</td>
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<td>CZ119, CZ131</td>
</tr>
<tr>
<td>CuZn38Pb1 CW607N</td>
<td>60.0-61.0</td>
<td>0.8-1.6</td>
<td>Rem.</td>
<td>0.2</td>
<td>-</td>
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<tr>
<td>CuZn39Pb0.5 CW610N</td>
<td>59.0-60.5</td>
<td>0.2-0.8</td>
<td>Rem.</td>
<td>0.2</td>
<td>CZ123, CZ137</td>
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<td>CuZn39Pb1 CW611N</td>
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<td>Rem.</td>
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<td>CZ129</td>
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<tr>
<td>CuZn36Pb2Al CW602N</td>
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<td>0.02-0.15</td>
<td>1.7-2.8</td>
<td>Rem.</td>
<td>0.2</td>
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<tr>
<td>CuZn39Pb2Sn CW613N</td>
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<td>1.6-2.5</td>
<td>0.2-0.5</td>
<td>Rem.</td>
<td>0.2</td>
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<td>CuZn40Pb2Sn CW616N</td>
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<td>1.6-2.5</td>
<td>0.2-0.5</td>
<td>Rem.</td>
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</tr>
<tr>
<td>CuZn39Pb3Sn CW615N</td>
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<td>2.5-3.5</td>
<td>0.2-0.5</td>
<td>Rem.</td>
<td>0.2</td>
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<tr>
<td>CuZn40Pb1Al CW614N</td>
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<td>0.05-0.30</td>
<td>1.0-2.0</td>
<td>Rem.</td>
<td>0.2</td>
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<tr>
<td>CuZn40Pb2Al CW618N</td>
<td>57.0-59.0</td>
<td>0.05-0.5</td>
<td>1.6-3.0</td>
<td>Rem.</td>
<td>0.2</td>
</tr>
<tr>
<td>CuZn41Pb1Al CW620N</td>
<td>57.0-59.0</td>
<td>0.05-0.5</td>
<td>0.8-1.6</td>
<td>Rem.</td>
<td>0.2</td>
</tr>
<tr>
<td>CuZn42Pb4Al CW612N</td>
<td>57.0-59.0</td>
<td>0.05-0.5</td>
<td>0.2-0.8</td>
<td>Rem.</td>
<td>0.2</td>
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<tr>
<td>CuZn43Pb1Al CW622N</td>
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<td>0.05-0.5</td>
<td>0.8-1.6</td>
<td>Rem.</td>
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<tr>
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<td>0.05-0.5</td>
<td>1.6-3.0</td>
<td>Rem.</td>
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<td>CuZn43Pb3 CW623N</td>
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<td>1.6-3.0</td>
<td>Rem.</td>
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</tr>
<tr>
<td>CuZn37Pb0.5 CW604N</td>
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<td>Rem.</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td>CuZn37Pb1 CW605N</td>
<td>61.0-62.0</td>
<td>0.8-1.6</td>
<td>Rem.</td>
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</table>
## Wrought Copper-zinc and Copper-tin Binary Alloys – Compositions, Uses and Typical Properties

<table>
<thead>
<tr>
<th>Material Designation</th>
<th>Composition, %, Range or Max</th>
<th>Nearest Old BS Equivalent</th>
<th>Characteristics and Uses</th>
<th>Typical Mechanical Properties</th>
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## Wrought Complex, Copper-zinc Alloys (Special Brasses) – Compositions, Uses and Typical Properties

**Corrosion Resistant Alloys**

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<th>Nearest Old BS Equivalent</th>
<th>Characteristics and Uses</th>
<th>Typical Mechanical Properties</th>
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**High Tensile Brasses**

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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 its 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 methods 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.

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.

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.

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.

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 discoloration 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

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## Conversion Factors

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<td>in³</td>
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<td>Kilograms per metre to pounds per foot (assuming constant cross sectional area)</td>
<td>kg/m</td>
<td>lb/ft</td>
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<td>lb</td>
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<td>in</td>
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<td>in³</td>
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<td>ft³</td>
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<td>From Unit</td>
<td>To Units</td>
<td>Multiply by</td>
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<td>in</td>
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<td>lb/in(^2) (psi)</td>
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<td>gm</td>
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<td>l</td>
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<td>lbf</td>
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<td>Pounds per inch(^3) to grams per centimetre(^3) density</td>
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<td>gm/cm(^3)</td>
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<td>lb/ft</td>
<td>kg/m</td>
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<td>Pounds per squarefoot to kilograms per square metre</td>
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<td>kg/m(^2)</td>
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<td>lb/in(^2) (psi)</td>
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<td>kg/cm(^2)</td>
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<td>kg/cm(^2)</td>
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<td>kg</td>
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<td>in(^2)</td>
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<td>Square feet to square metres</td>
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<td>m(^2)</td>
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<td>cm(^2)</td>
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<td>mm(^2)</td>
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<td>miles(^2)</td>
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<td>ft(^2)</td>
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<td>Square metres to square yards</td>
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<td>yd(^2)</td>
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<td>Square miles to square kilometres</td>
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<td>km(^2)</td>
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<td>in(^2)</td>
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<td>m(^2)</td>
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<td>Tons per square inch to kilograms per square millimetre</td>
<td>ton/in(^2)</td>
<td>kg/mm(^2)</td>
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<td>N/mm(^2)</td>
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<td>Tons (long) to kilograms</td>
<td>ton</td>
<td>kg</td>
<td>1016.047</td>
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<td>Tons (long) to metric tons (or tonne, 1000kg)</td>
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<td>tonne</td>
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<tr>
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<td>Yards(^2) to metres(^2)</td>
<td>yd(^2)</td>
<td>m(^2)</td>
<td>0.7645549</td>
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### 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.

<table>
<thead>
<tr>
<th>Form</th>
<th>Dimensions in mm</th>
<th>Weight for Alloys of Density $p$ Kg/dm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>Diameter = d</td>
<td>$0.00078540 \cdot d \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Hexagon</td>
<td>Width across flats = f</td>
<td>$0.00086603 \cdot f \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Square</td>
<td>Side = a</td>
<td>$0.00100 \cdot a \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Flat</td>
<td>Width = w</td>
<td>$0.00100 \cdot w \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Angle/Tee</td>
<td>Leg lengths = $L_i$, $I_i$</td>
<td>$0.00100 \cdot (L_i + I_i - t) \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Channel</td>
<td>Leg lengths = $L_i$, $I_i$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Base = B</td>
<td>$0.00100 \cdot (B + L_i + I_i - 2t) \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Plate/Sheet</td>
<td>Thickness = t</td>
<td>$0.000001 \cdot L \cdot w \cdot p$ Kg/m</td>
</tr>
<tr>
<td></td>
<td>Length = L</td>
<td>$0.000001 \cdot L \cdot w \cdot p$ Kg/m</td>
</tr>
<tr>
<td></td>
<td>Width = w</td>
<td>$0.100 \cdot w \cdot p$ Kg/100m</td>
</tr>
<tr>
<td>Pipe/Tube</td>
<td>Outside diameter = D</td>
<td></td>
</tr>
<tr>
<td>(Round)</td>
<td>Inside diameter = d</td>
<td>$0.0031416 \cdot (D-t) \cdot p$, or $0.0031416 \cdot (d+t) \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Square/Rectangular Tube</td>
<td>Sides = $a_x$, $a_y$</td>
<td>$0.001 \cdot (2a_x + 2a_y - 4t) \cdot p$ Kg/m</td>
</tr>
<tr>
<td>Wire</td>
<td>Diameter = d</td>
<td>$0.78540 \cdot d \cdot p$ Kg/Km</td>
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### Comparative Properties

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<tr>
<th>Metal</th>
<th>Density</th>
<th>Melting Temp °C</th>
<th>Thermal Conductivity</th>
<th>Electrical Resistivity</th>
<th>UTS</th>
<th>Proof Stress</th>
<th>Elongation %</th>
<th>Typical Young’s Modulus GPa</th>
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<td>2.7</td>
<td>660</td>
<td>201</td>
<td>2.65</td>
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<td>260</td>
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Chemical Elements

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<td>Boron</td>
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<td>Cd</td>
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<td>Co</td>
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<td>Cb*</td>
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*D The American designation for Niobium

Densities

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<td>Stainless Steel – Austenitic</td>
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<td>INCOLOY® Alloy 800H</td>
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Comparative Densities

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<tr>
<td>Lead</td>
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INCOLOY and INCONEL are both registered trademarks of SMC
AALCO SERVICE CENTRES

ABERDEEN
Unit 9B, Peterseat Drive
Peterseat Park, Altens
Aberdeen AB12 3HT
Tel: 01224 854810
Fax: 01224 871982
e-mail: aberdeen@aalco.co.uk

AYLESBURY
Unit 1, Premus
Coldharbour Way, Aylesbury
Buckinghamshire HP19 8AP
Tel: 01296 461700
Fax: 01296 339923
e-mail: aylesbury@aalco.co.uk

BELFAST
The Belfast Metal Centre
20 McKinney Road
Newtownabbey
County Antrim BT36 4PE
Tel: 02890 838838
Fax: 02890 837837
e-mail: belfast@aalco.co.uk

BIRMINGHAM
Sheelah Road
Halesowen
West Midlands B63 3PH
Tel: 0121 585 3600
Fax: 0121 585 6864
e-mail: birmingham@aalco.co.uk

CHEPSTOW
Avenue West
Newhouse Park Estate
Chepstow
Monmouthshire NP16 6UD
Tel: 01291 638 638
Fax: 01291 638 600
e-mail: chepstow@aalco.co.uk

DYFED
Units 3-4
Capel Hendre Industrial Estate
Ammanford
Carmarthenshire SA18 3SJ
Tel: 01269 842044
Fax: 01269 845276
e-mail: dyfed@aalco.co.uk

ESSEX
Unit 2 Carnival Park
Festival Way
Basildon
Essex, SS14 3WN
Tel: 01268 884200
Fax: 01268 884220
e-mail: essex@aalco.co.uk

GLASGOW
117 Clydehill Place
Cambuslang Investment Park
Glasgow G32 8RF
Tel: 0141 646 3200
Fax: 0141 646 3260
e-mail: glasgow@aalco.co.uk

HULL
Saxon Way
Priory Park West
Hull
Hull HU13 9PB
Tel: 01482 626262
Fax: 01482 626263
e-mail: hull@aalco.co.uk

LEEDS
Unit 1
Revie Road off Elland Road
Leeds LS11 8JG
Tel: 0113 276 3300
Fax: 0113 276 0382
e-mail: leeds@aalco.co.uk

LIVERPOOL
207 Great Howard Street
Liverpool L5 9ZH
Tel: 0151 207 3551
Fax: 0151 207 2657
e-mail: liverpool@aalco.co.uk

MANCHESTER
Express Trading Estate
Stone Hill Road
Farnworth
Bolton BL4 9NN
Tel: 01204 863456
Fax: 01204 863430
e-mail: manchester@aalco.co.uk

NEWCASTLE
First Avenue
Team Valley Trading Estate
Gateshead, Tyne & Wear
NE11 0NU
Tel: 0191 491 1133
Fax: 0191 491 1177
e-mail: newcastle@aalco.co.uk

NORWICH
Roundtree Way
Mousehold Lane
Norwich NR7 8SR
Tel: 01603 787878
Fax: 01603 789999
e-mail: norwich@aalco.co.uk

NOTTINGHAM
Harrimans Lane
Dunkirk
Nottingham NG7 2SD
Tel: 0115 988 2600
Fax: 0115 988 2636
e-mail: nottingham@aalco.co.uk

SOUTHAMPTON
Test Lane, Nursling
Southampton SO16 9TA
Tel: 02380 875200
Fax: 02380 875275
e-mail: southampton@aalco.co.uk

STOKE
Unit F, Forge Way
Brown Lees Industrial Est
Biddulph
Stoke-on-Trent ST8 7DN
Tel: 01782 375700
Fax: 01782 375701
e-mail: stoke@aalco.co.uk

SWANLEY
Unit 7
Pedham Place Industrial Estate
Wested Lane,
Swanley
Kent BR8 8TE
Tel: 01322 610900
Fax: 01322 610910
e-mail: swanley@aalco.co.uk

www.aalco.co.uk