Wrought and Cast Copper Alloys—SAE J461d

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PREPRINT

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General—For convenience, this SAE Information Report is presented in two parts as shown below. To avoid repetition, however, data applicable to both wrought and cast alloys is included only in Part I.

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PART I—WROUGHT COPPER AND COPPER ALLOYS

Factors influencing the uses of wrought copper and copper alloys concern electrical conductivity, thermal conductivity, machinability, formability, fatigue characteristics, strength, corrosion resistance, the ease with which alloys can be joined, and the fact that these materials are nonmagnetic. Copper and its alloys also have a wide range of rich, pleasing colors. The only other metal with such distinctive coloring is gold. These materials are all easily finished by buffing, scratch brushing, plating or chemically coloring, or clear protective coating systems.

When it is desired to improve one or more of the important properties of copper, alloying often solves the problem. A wide range of alloys, therefore, has been developed and commercially employed, such as the high copper alloys, brasses, leaded brasses, tin bronzes, heat treatable alloys, copper-nickel alloys, nickel silvers, and special bronzes.

The various types of copper and the principal alloys are listed in Tables 1 and 3, along with information describing composition, fabricating properties, and applications.

1. Types of Wrought Copper—C11000, C11100, C11300, C11400, C11500, and C11600 coppers[1] are either electrolytically or fire-refined, cast in the form of refinery shapes, containing a controlled amount of oxygen for the purpose of obtaining a level set on the top of the casting. It generally contains 0.01-0.04% oxygen, which exists as a copper-cuprous oxide eutectic surrounding the crystals of copper. Within these limits, the oxygen has only a very slight effect on the electrical, mechanical, and physical properties of copper. Because of the oxidizing effect of oxygen on impurities, its presence in copper indicates a reduction or elimination of certain impurities which would otherwise have adverse effects on conductivity.

C10200 copper is electrolytically refined and specially produced to be free from cuprous oxide although it is made without the use of residual metallic or metalloidal deoxidizers. Because of its freedom from residual deoxidizers, it has high electrical conductivity.

C12000 and C12200 copper is cast in the form of refinery shapes, free from cuprous oxide, produced through the use of metallic or metalloidal deoxidizers. Because it is necessary to use some excess of reducing agent, the electrical and thermal conductivity of the copper is lowered, and this fact should be considered when high conductivity is needed.

C10200, C12000 and C12200 coppers possess only slightly different mechanical properties from the C11XXX types. They differ little in respect to tensile strength when cold worked to similar extents, but do have somewhat higher ductility and also are not normally subject to hydrogen embrittlement.

2. Electrical Conductivity—The greatest single area of use for copper itself results from the high electrical conductivity of the metal. The combination of the property of high electrical conductivity with ease of forming and high corrosion resistance makes copper the preferred material for current-carrying members. The conductivity of copper for electrical conductors is 101% IACS (see Table 2) in the annealed or soft condition. The tensile strength of the soft copper, 220 MPa (32 ksi) can be increased to 345/380 MPa (50/55 ksi) by cold rolling, in which condition the electrical conductivity is decreased to about 97%. Heating such copper above 200°C for an extended period of time will soften it to a tensile strength of 205/240 MPa (30/35 ksi).

Silver is added to copper to increase its resistance to softening at elevated temperature without decreasing the electrical conductivity. Cold worked silver-bearing copper (see Table 4) can be heated to about 350°C for short periods of time without appreciable softening, and is less susceptible to creep rupture in highly stressed situations. Rolling mill practice and amount of silver have an effect upon the softening of such materials.

Cadmium added in small amounts (0.10%) to copper results in an alloy having superior resistance to softening at temperatures used in forming automotive radiators. Resistance to softening is retained even after the application of large amounts of cold work. The application of this material permits higher strength solders to be used and allows for the increase of soldering temperature range to a point not feasible with other high conductivity materials. Electrical and thermal conductivities are not appreciably different than for silver bearing copper.

Fig. 1 illustrates the softening characteristics of electrolytic copper and silver bearing and cadmium bearing copper alloys in terms of tensile strength for the times and temperatures indicated.

The 0.85% silver-bearing alloy is the best, of the three commonly available alloys, to resist creep rupture. The silver-bearing coppers find use in radiator construction where the material is subjected to slightly elevated temperature during soldering operations, also for commutators which are baked to set mica between the copper segments. Copper must not be softened by these treatments.

To prevent embrittlement which takes place with copper should be specified if the material is to be heated much above 425°C in an atmosphere of reducing gases such as hydrogen. Embrittlement results from the action of the reducing gases with the copper oxide normally present in all C11XXX types.

The addition of chromium to copper produces an alloy with a combination of high tensile strength (485 MPa [70ksi]) and electrical conductivity (80% IACS). This alloy C18400 has the ability to retain its mechanical properties and wear resistance to a high degree at elevated temperatures. The copper chromium alloys have found considerable use as fabricated into welding tips and seam welding wheels. Zirconium bearing copper (C15000) is also finding wide use in high temperature-high strength applications.

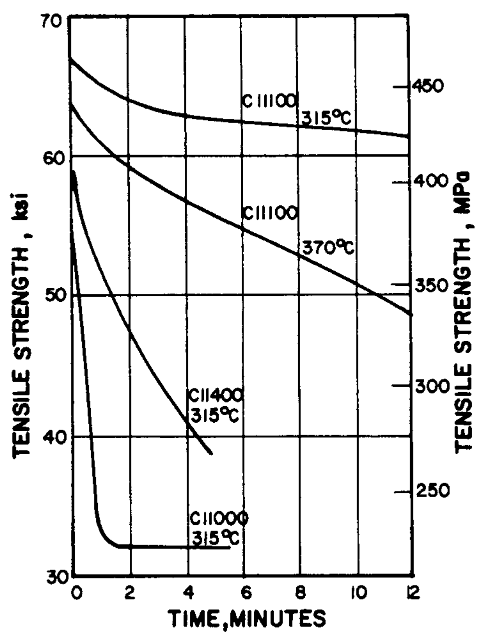

FIG. 1—SOFTENING CHARACTERISTICS OF THREE COPPER ALLOYS

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[1] Since the nomenclature used in the nonferrous metals trade is not always consistent, copper and copper base alloys are referenced by specification numbers described in SAE J463.

Heat treated beryllium bearing copper alloys having tensile strengths up to 1345 MPa (195 ksi) and fatigue strengths up to 345 MPa (50 ksi) are available; however, a drop in electrical conductivity to about 50% and high cost must be considered. Where repetitive or cycling operations must be performed, such properties have made application of these alloys economical.

Conducting contacts, springs or other stressed parts that are manufactured by forming may employ chromium or beryllium bearing coppers. The parts are formed by cold working and then strengthened by heat treatment.

The high degree of ductility and toughness of commercially pure copper usually make it unsuited for cutting or machining operations. Coppers with lead, tellurium and sulfur were developed to combine the properties of copper with improved machinability. Parts that must be formed by extensive machining and be highly conductive are made from the free machining coppers. Tellurium copper has a 95% electrical conductivity and a machinability rating of 80-90. Sulfur bearing copper has a 95% IACS electrical conductivity and the same machinability rating, whereas lead copper has an electrical conductivity of 98% IACS and a machinability rating of 80. The machinability rating for copper is 20.

Where higher tensile strength 620 MPa (90 ksi) is required along with good machinability (60) and lower electrical conductivity (10%) can be tolerated, aluminum silicon alloys may be used to advantage.

For applications requiring good fatigue properties, the nickel-silver, phosphor, or beryllium alloys will serve. These alloys, however, have relatively low electrical conductivity ranging from 5 to 50%.

C12000 is also a good choice in the selection of a conductor to be used where creep strength is to be considered, as may be the case when the material is to operate at slightly elevated temperature.

3. Thermal Conductivity—For the alpha solid solutions of copper alloys, at least, the thermal conductivity is a nearly linear function of the electrical conductivity multiplied by the absolute temperature. Good conductors of electricity are also good conductors of heat and poor conductors of electricity are poor conductors of heat.

When high thermal conductivity is of principal importance, the same considerations given electrical conductivity apply.

4. Mechanical Properties—Except for the heat treatable alloys, strength is determined mainly by composition and degree of cold work. Mechanical properties of the most important alloys are to be found in Table 10.

Copper and copper alloys containing aluminum, silicon, tin, iron, and manganese, in various combinations and concentrations, are much stronger by virtue of their chemistry than the other coppers or alloys. For heavy sections or parts requiring high strength, inherently stronger alloys should be specified. For lighter or smaller sections which can be made adequately from stronger tempers, other alloys are successful. For example, the tensile strength of C26000 used in the production of radiator tanks can be increased by adjusting the rollng mill procedure from 310 to 365 MPa (45 to 53 ksi) without a harmful reduction in ductility. Similarly C26000 strip 0.11 mm (.0045 in) intended for fabrication into lockseam tube, used in radiator construction, is available in an annealed temper having a tensile strength of about 440 MPa (64 ksi) and an elongation of 32% in 50 mm (2 in). This represents an 18.5% increase in tensile strength without any sacrifice of ductility, compared to material produced by rolled-to-temper methods.

The tensile strength of the copper-zinc series of alloys, the most widely used group in the industry, increases in general for any specific temper as the copper content decreases. The alloys also are characterized by extremely high ductility, excellent forming characteristics and ease of finishing. The relationship of the increase of properties with zinc content is shown in Fig. 2.

A series of heat treatable alloys are commercially available and have strength as high as 1380 MPa (200 ksi). These alloys are produced with carefully controlled compositions and contain such elements as chromium, beryllium, nickel, phosphorus and silicon. The attractive diversity of properties obtainable in heat treatable copper alloys can be observed in Table 10.

The zirconium alloy copper (C15000) might be included in this group because it does respond to heat treatment; however, its strength is developed primarily through the application of cold working. Heat treatment primarily restores high electrical conductivity and ductility and increases surface hardness. The alloy has found use in the production of welding tips and wheels, stud bases for rectifiers, commutators for motors and electrical switch parts.

One outstanding characteristic of the heat treatable alloys is that they may be formed into articles, such as complex springs, while in the soft or partially work hardened state, and the mechanical properties subsequently improved to their maximum by heat treatment.

5. Yield Strength—Yield strength is the stress at which a material exhibits a specified limiting deviation of strain. Ordinarily the yield strength of copper and copper alloys is taken at 0.5% extension under load (strain) although for some design purposes values taken at 0.1 or 0.2% offset may be used.

Where residual stresses, due to forming, approach or exceed the yield strength, stress corrosion cracking may occur. Also, stresses may reach levels

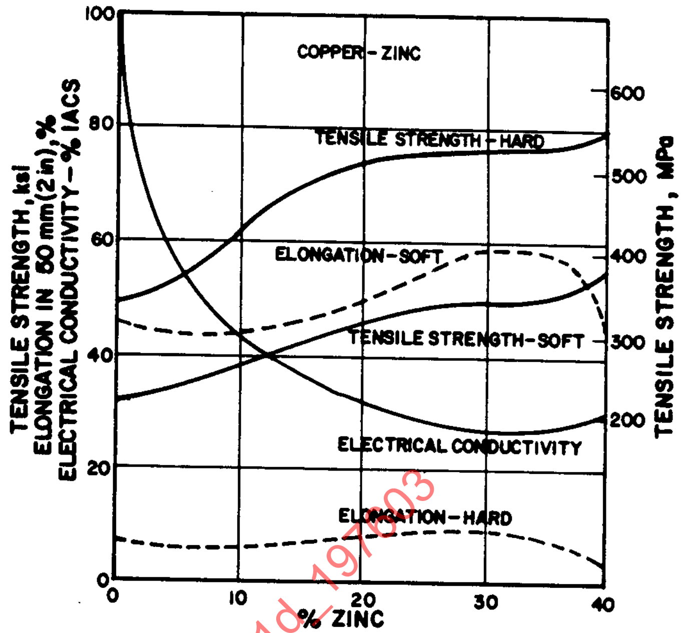

FIG. 2—RELATIONSHIP OF INCREASE OF PROPERTIES WITH ZINC CONTENT

high enough to cause elastic drift in springs. In either case, it may be advisable to apply a low temperature, stress relieving treatment. Suggested temperatures for accomplishing a stress relief are listed in Table 5.

The tendency of a formed part to stress crack can be determined by the application of ASTM B 154, Method of Mercurous Nitrate Test for Copper and Copper Alloys. The effectiveness of thermal stress relieving treatment can be judged by the same test.

6. Fatigue Strength—Materials subjected to alternating tensile and compressive stress, or shear stress alternating in direction, will fail by "fatigue" fracture at much lower values for maximum stress than if subjected to steady loads. The same effect applies, but to a lesser degree if the stresses are constant in direction but vary in magnitude. Springs, diaphragms, bellows, flexible hose and similar applications are frequently exposed to such conditions, and when this is the case, the maximum stress used in design calculations must be less than the safe tensile or shear stress applicable when the load is constant.

Generally, the harder the material the higher its fatigue strength, although fatigue strengths vary with surface and temper conditions and corrosion. The heat treatable alloys such as beryllium alloys, copper containing either nickel and silicon or nickel and phosphorus can be hardened by heat treatment and, therefore, optimum spring characteristics can be realized by such treatment after the spring has been formed. Phosphor alloys, nickel-silver alloys and other nonheat treatable alloys must always be used in a condition sufficiently soft to successfully cold form into the desired shape. Since the fatigue strength increases with the hardness of the material, the highest values for the precipitation hardening alloys must be compared with less than the highest values for other materials. Such a comparison indicates a marked superiority of the former alloys.

A comparison of the fatigue strengths of several alloys follows: C17000, 275 MPa (40 ksi); C67400, 215 MPa (31 ksi); C52100, 185 MPa (27 ksi); C65500, 160 MPa (23 ksi); C77000, 155 MPa (22.5 ksi); C51000, 150 MPa (22 ksi); C26800, 140 MPa (20 ksi); C11000, 70 MPa (10 ksi).

7. Formability—All coppers form easily and readily and work harden slowly. Generally, C10200 and C12200 may be best for severe cold forming, although for thin gage material, mill practices may be adjusted to develop extreme ductilities in C11000.

Best results in cold forming operations are obtained through the use of nonleaded alloys, including copper, silver-bearing alloys, and all nonleaded alloys containing more than 63% copper. Included in this list are the phosphor alloys, nickel-silver alloys (65-18) nickel alloys, and the age hardenable alloys in the solution treated condition. Some of the age hardenable alloys have excellent ductility even after fully heat treated and are capable of being cold formed to a high degree.

C26000 is the most widely used for operations such as cold drawing, upsetting, stamping, and bending. C23000, C22000 and C21000 are not as strong as C26000 but harden at a slower rate when cold worked, thereby allowing successive operations without intermediate annealing.

Forming operations such as deep drawing, eyelet work, coining, flanging, spinning, or similar cold working, all require annealed material usually ordered by specifying grain size. Care should be exercised to specify the grain size most suitable for the part to be made. Depending upon the severity of the cold forming operation during the production of a specific part, it is sometimes necessary for the fabricator to perform an anneal or soften the material before further press operations can be successfully applied. The grain size of any of these anneals must be controlled. Grain size that is too small can lead to breakage during forming, whereas excessively large grain sizes may also lead to breakage because of lowering tensile strength of the alloy, or, if the part does not fail, its surface may become excessively rough (a condition known as orange peel) and require costly finishing operations where polishing and plating are required. Table 6 suggests approximate annealing temperature ranges to apply for intermediate annealing. The alloy should be annealed at the lowest temperature experimentally in seeking the proper grain size and smoothest polishing surface. It should be remembered that insufficiently annealed work can always be reannealed at higher temperature. Overannealed damage is beyond salvage.

Currently the trend is toward the use of thinner gages of strip for fabrication purposes. Reduction of grain size to less than 0.010 mm makes available material of sufficient strength to withstand deeper drawing without intermediate annealing processes.

Coining operations demand metal of large grain size for maximum sharpness of impression. Cold upsetting, particularly of screws, rivets and bolts should be performed on metal lightly cold drawn to develop some strength in unsupported sections to resist bending as the parts are being fabricated.

Where machining is an important factor in making the finished part and cold forming is part of the fabricating process, leaded alloys in light drawn tempers are logical choices. The presence of lead results in easier machining. Control of the lead content and temper allows the alloy to be cold worked as, for example, in thread rolling.

Table 3 lists cold workability ratings for various alloys. The ratings are arbitrary for their approximate relative suitability for being cold worked: the ratings being excellent, good, fair, or not recommended. It must be realized that such arbitrary ratings cannot be too precise, due to the multiplicity of cold working operations that must be considered. Operations taken into account in assigning the ratings include drawing, forming, stamping, spinning, bending, and heading. The ratings given take into account not only the relative power required to cold work the alloy, but also the amount of deformation which is possible without fracture.

8. Bending—Bending is often the controlling factor in selection of temper for strip products. For a particular alloy and thickness, the harder the temper the more generous the bending radius must be for successful bending. Bending characteristics of strip are more favorable when the axis of the bend is at a right angle to the rolling direction. Bending problems may be prevented when sharp or difficult bends must be made in more than one direction by designing the bending tools to accommodate blanks cut on some axis other than parallel to the direction of rolling. Table 7 recommends radii for forming 90 deg bends in respect to rolling direction, gage and temper for various alloys.

9. Hot Forming—Copper and a series of copper alloys lend themselves well to production by hot forming, die-pressed forging and extrusion. Where sufficient support is not provided by the tooling during hot working operations, the higher leaded alloys become susceptible to cracking.

Alloys specified for hot forming include many coppers, zinc alloys containing 58-63% copper, tin alloys, aluminum alloys, silicon alloys, and nickel-silver alloys. Table 8 lists the relative forgeability of the various alloys and takes into account such variables as pressure, die wear, and hot plasticity.

10. Machinability—The addition of lead to copper alloys greatly improves their machinability. The greater the amount of lead, the easier the alloy machines or cuts. Lead also improves the blanking quality in strip alloys by reducing their ductility, thereby providing a sharp, clean shear.

Lead does not dissolve in copper or its alloys and is finely dispersed throughout the alloy. During a cutting operation the presence of lead produces short or broken chips which are easily flushed away by lubricants. Excellent finishes can be attained with the use of proper tools and feeds, and machining rates are frequently as high as maximum machine capabilities. Screw machines often utilize speeds as high as 10,000 rpm producing parts from free cutting zinc alloy rod. The Copper Base Alloy Rod Handbook, published by the Copper Development Association (CDA), is recommended for information on tool shapes, feeds, speeds, and so forth.

Ordinarily, half hard C36000 containing about 3.25% lead is preferred for machining. For knurling or thread rolling operations demanding greater ductility, softer or lower leaded alloys should be specified.

Lead, tellurium, or sulfur added to copper combine the properties of pure copper with improved machinability, and all three alloys may be used where the basic properties of copper itself are required. Lead is insoluble in the copper and both tellurium and sulfur form insoluble compounds with copper thereby acting much in the same manner as lead in producing chips during machining operations. Table 3 lists the arbitrary relative machinability rating of many alloys. The numerical rating is a reasonable indication of the amount of power required for any given type and degree of cutting operation, and tool life will be found to vary in proportion to such a rating. The type of chip also plays an important part, for in certain operations almost any type of chip can be tolerated; whereas in others, for example deep drilling, box milling and tapping, long stringy chips may cause scoring of the stack and tool breakage. The table also lists the type of chip expected for each alloy by designating with the letters L, M, or S, indicating that the chips are long, medium, or short.

11. Joining—Copper and most of its alloys are readily joined by soldering and brazing and by most of the commonly used welding processes. Table 3 indicates the approximate relative suitability of alloys for being joined by various processes. The choice of method depends on shape of the work, composition of the metal, and the end use of the product. Thus, where welded joints of maximum strength are required, it is necessary to use C10200, C12000, C12200 or C14500 coppers instead of the C11XXX types. Arc welding of zinc-bearing alloys is hampered by the vaporization of zinc; so, if oxyacetylene welding is not feasible, the parts are designed for brazing or soldering. On aluminum alloys, soldering is impossible, and brazing is difficult because interfering oxides form even under very active fluxes; oxyacetylene welding is also impossible because of interfering oxides; therefore, arc welding processes are the only practicable joining methods. Brazing and soldering are the preferred methods for joining leaded alloys, because welding develops increasing porosity and cracking as lead content increases.

Methods most commonly used are:

11.1 Resistance Welding—Applicable on all nonleaded alloys. Flash butt welding successful on all. Spot and seam welding practicable on those with conductivities below 30%. Copper-silicon and copper-nickel alloys are the most weldable and coppers are the least weldable.

11.2. Gas Shielded Arc Welding—Widely employed on all. Silicon and aluminum alloys are readily welded by these processes. So are the nickel alloys if done with the specially alloyed filler metal developed for these processes.

11.3 Coated Metal Arc Welding—Excellent where good flux-coated electrodes are available, as for the nickel alloys. Coated electrodes are also available for aluminum and phosphor alloys. Process is not suitable for copper because of high heat requirements.

11.4. Carbon Arc Welding—Less costly than gas shielded arc welding and produces good results on silicon alloys. Also useful for welding copper with silicon or phosphor alloy rods.

11.5. Oxyacetylene Welding—Good results on deoxidized copper using specially alloyed welding rods, and on silicon alloys. Excellent for zinc alloys if low fuming rods are used. Not suitable for aluminum alloys.

11.6. Brazing—Generally useful with either silver alloys or phosphorus alloys. Latter are less costly. They are also considered self-fluxing on copper but best results require use of flux. Phosphorus alloys are often used to join the 90-10 nickel alloy but are not recommended for use on alloys with higher nickel contents. Tough pitch coppers are readily "gassed" and embrittled by exposure to hydrogen at high temperatures, therefore they are not suitable for parts to be furnace brazed in hydrogen-bearing atmospheres, and they cannot be safely brazed by flame processes if heating time is prolonged. Special fluxes are available to help in brazing of aluminum alloys.

11.7. Soldering—Readily done on all copper base metals except the aluminum alloys. Suitable fluxes are not available for use on these alloys.

12. Effect of Temperature—Copper and its alloys are not harmed by temperatures as low as -185°C, rather, a gain in mechanical properties is noticed with decreasing temperature.

Most copper alloys do not find application above 200°C since, dependent upon the amount of cold work applied during fabrication, most of the alloys soften between 200 and 425°C. Further, oxidation also must be considered above these temperatures.

13. Color—Copper alloys are the only large tonnage metals that have a wide red and yellow color range. Red and pink for the copper rich materials, gold shades for C21000, C22000 and C23000 although sometimes these alloys are also a pleasing red because of the formation of a superficial copper oxide on the surface. The series of alloys becomes more yellow at 80% copper, 20% zinc (C24000) and develop the familiar yellow at the 70-30 (C26000) composition. The color reverses at about 55% copper, 45% zinc.

14. Surface Finishing—A number of types of mechanical finishes and treatments can be applied rather easily to the copper alloys. Among these are deburring, bright rolling, ball burnishing, wheel polishing and buffing, belt polishing, scratch brushing, and sand blasting.

The highest luster that can be produced on copper alloys is by the combination of wheel polishing and buffing. Both manually operated and automatic buffing equipment together with an assortment of polishing and buffing wheels are available to accomplish this job.

C26000 lends itself extremely well to finishing such as just described and because of this and its excellent corrosion resistance, is often used for such items as automobile wheel covers or hub caps.

The ease with which a part can be polished can depend upon surface roughness termed orange peel which can develop on cold drawn parts if the base stock before forming has a grain size over 0.050 mm and the forming operation is severe. The degree of orange peel depends upon grain size and degree of forming. Therefore, when surface finish is important after the forming of a given part, attention must be directed to the grain size of the starting stock or to parts given an intermediate anneal in the fabrication sequence. Table 9 is a guide to specifying annealed tempers for strip in relation to type of operation being performed, gage of the material, and grain size.

Copper alloys in general offer a noncorroding surface for electroplating. A base electroplate of copper is usually not necessary under nickel or chromium used as decorative electroplates. Therefore, copper alloys, in general, allow thinner plates of such metals as tin, nickel, chromium, or silver, than do other metals.

Fused enamels are applied on C21000, C22000 and C23000 with very beautiful effects. Alloys containing much more than 7% zinc should not be used with transparent enamels as cloudiness or color change can result.

Tarnishing or discoloration of copper alloys may be retarded and, in many cases, delayed indefinitely by application of a lacquer selected with consideration to the service environment in which the object is to exist.

There are literally hundreds of transparent coatings which can be applied to copper articles. Perhaps in no other unit process of metal finishing is such a wide variety of materials available for use.

Lacquer or protective coating systems, which have very effectively protected the surface of copper alloys for both interior and exterior exposure for a number of years, have been developed and time tested.

*15. **Corrosion Resistance***—Copper and copper alloys have been extensively and successfully used for many years in a variety of corrosive conditions. Copper is highly resistant to the effects of atmosphere, naturally occurring fresh and salt waters, alkaline solutions (except those containing ammonia) and many organic chemicals. The severity of oxidizing conditions controls its behavior in acidic media. Many salt solutions are successfully handled. Sulfur and its sulfide compounds do combine with copper to produce copper sulfide as a corrosion product. As the zinc content of the copper alloys is increased over 15%, resistance to corrosion from sulfide compounds is markedly increased. This fact is important when radiator materials are selected for possible use on farm equipment that might come into contact with insecticide sprays that contain sulfur.

The commercial copper alloys vary widely in chemical composition; therefore, there is considerable variation in their resistance to corrosion. Many of the alloying elements improve corrosion resistance of the parent metal as well as enhance its mechanical properties.

Extensive use indicates the suitability and, often, superiority of copper and its alloys for many applications, including the following broad classifications: atmospheric exposures, such as hardware, building fronts, automotive radiators, and hub caps; fresh water supply lines, including those buried in soil; sea water applications; heat exchanges; and industrial and chemical plant equipment handling a variety of products.

TABLE 1—GENERAL INFORMATION—NAME, NOMINAL COMPOSITION, AND COMPARABLE STANDARDS OF WROUGHT COPPER ALLOYS

UNS No.[a]	Name[b]	Nominal Composition percent by weight		SAE No.	ASTM No.[c]	Former SAE No.
		Cu	Other			
C10200	Oxygen free copper (OF)	99.9	—	CA102	B75, B152, B280	—
C11000	Electrolytic tough pitch copper (ETP)	99.9	—	CA110	B3, B133, B152, B283	71, 83
C11100	Electrolytic tough pitch, anneal resistant copper	99.9	(Trace elements)	CA111	—	71
C11300	Tough pitch copper with Ag (STP)	99.9	0.03 Ag	CA113	B152	71
C11400	Tough pitch copper with Ag (STP)	99.9	0.04 Ag	CA114	B152	71
Ø C11500	Tough pitch copper with Ag (STP)	99.9	0.06 Ag	CA115	B152	—
C11600	Tough pitch copper with Ag (STP)	99.9	0.09 Ag	CA116	B152	71
C12000	Phosphorus deoxidized copper (DLP)	99.9	0.0008 P	CA120	B68, B75, B152, B280	75
C12200	Phosphorus deoxidized copper (DHP)	99.9	0.02 P	CA122	B68, B75 B152, B280	—
C14500	Phosphorus deoxidized tellurium copper (DPTE)	99.5	0.5 Te, 0.008 P	CA145	B283, B301	—
C14700	Sulfur bearing copper	99.7	0.3 S	CA147	B301	—
C15000	Zirconium copper	99.8	0.15 Zn	CA150		
C16200	Cadmium copper	99.0	1 Cd	CA162		
C17000	Beryllium copper	98.0	1.7 Be	CA170	B194	—
C17200	Beryllium copper	98.0	1.9 Be	CA172	B194, B196	
C17500	Beryllium copper	97.0	0.5 Be, 2.5 Co	CA175	B441, B534	
C17600	Beryllium copper	97.0	0.4 Be, 1.5 Co, 1 Ag	CA176	B441	
C18400	Chromium copper	99.0	0.8 Cr	CA184		—
C18700	Leaded copper	99.0	1 Pb	CA187	B301	
Ø C19200	High copper alloy	99.0	1 Fe, 0.03 P	CA192	B111	
C21000	Gilding, 95%	95.0	5 Zn	CA210	B36	
C22000	Commercial bronze, 90%	90.0	10 Zn	CA220	B36, B135	
C23000	Red brass, 85%	85.0	15 Zn	CA230	B36, B135	74D, 79A
C24000	Low brass, 80%	80.0	20 Zn	CA240	B36	79B
C26000	Cartridge brass, 70%	70.0	30 Zn	CA260	B36, B134 B135	70A, 74C, 80A
C26800	Yellow brass, 66%	66.0	34 Zn	CA268	B36	70C
C27000	Yellow brass, 65%	65.0	35 Zn	CA270	B134	80B
C33000	Low leaded brass, (tube)	66.0	34 Zn, 0.5 Pb	CA330	B135	74B
C33100	Leaded brass	66.0	33 Zn, 1 Pb	CA331		
C34200	High leaded brass	65.0	33 Zn, 2 Pb	CA342	B121	
C34500	Leaded brass	63.0	35 Zn, 2 Pb	CA345	B453	
C35000	Medium leaded brass, 62%	63.0	36 Zn, 1 Pb	CA350	B121, B453	
C36000	Free cutting brass	62.0	35 Zn, 3 Pb	CA360	B16	72
C37700	Forging brass	60.0	38 Zn, 2 Pb	CA377	B283	88
C46400	Naval brass, unhibited	60.0	39 Zn, 0.8 Sn	CA464	B21, B283	73
Ø C46500	Naval brass, arsenical	60.0	40 Zn, 0.5 As	CA465		
Ø C46600	Naval brass, antimonial	60.0	40 Zn, 0.5 Sb	CA466		
Ø C46700	Naval brass, phosphorized	60.0	40 Zn, 0.5 P	CA467		
C51000	Phosphor bronze, 5% A	95.0	5 Sn, 0.2 P	CA510	B103, B139, B159	77A, 81
Ø C51100	Phosphor bronze	96.0	4 Sn, 0.2 P	CA511	B103	
C52100	Phosphor bronze, 8% C	92.0	8 Sn, 0.2 P	CA521	B103	77C
Ø C52400	Phosphor bronze, 10% D	90.0	10 Sn, 0.2 P	CA524	B103	
C54400	Phosphor bronze, B-2	88.0	4 Sn, 4 Zn, 4 Pb	CA544	B103, B139	—
C60800	Aluminum bronze	95.0	5 Al	CA608	B111	
Ø C61400	Aluminum bronze, D	91.0	7 Al, 2 Fe	CA614	B150, B169	701D
Ø C61800	Aluminum bronze	89.0	10 Al, 1 Fe	CA618		
C62300	Aluminum bronze	88.0	9 Al, 3 Fe	CA623	B150, B283	701B
C62400	Aluminum bronze	86.0	11 Al, 3 Fe	CA624		701B
C63000	Aluminum bronze	82.0	10 Al, 3 Fe, 5 Ni	CA630	B150, B283	701C
Ø C64200	Aluminum silicon bronze	91.0	7 Al, 2 Si	CA642	B150, B283	
C65500	High silicon bronze, A	97.0	3 Si	CA655	B97, B98, B283	—
C67000	Manganese bronze, B	65.0	24 Zn, 4 Mn, 4 Al, 3 Fe	CA670	B138	—
C67300	Manganese bronze	60.0	34 Zn, 3 Mn, 2 Pb, 1 Si	CA673		
C67400	Manganese bronze	58.0	37 Zn, 3 Mn, 1 Al, 1 Si	CA674		
C67500	Manganese bronze, A	58.0	40 Zn, 0.3 Mn, 1 Fe, 1 Sn	CA675	B138	

TABLE 1—GENERAL INFORMATION—NAME, NOMINAL COMPOSITION, AND COMPARABLE STANDARDS OF WROUGHT COPPER ALLOYS (*continued*)

UNS No.[a]	Name[b]	Nominal Composition percent by weight		SAE No.	ASTM No.[c]	Former SAE No.
		Cu	Other			
C70600	Copper nickel, 10%	90.0	10 Ni	CA706	B111, B171	—
C71000	Copper nickel, 20%	80.0	20 Ni	CA710	B111, B122	
C71500	Copper nickel, 30%	70.0	30 Ni	CA715	B111, B122, B171	—
C75200	Nickel silver, 65-18	65.0	18 Ni, 17 Zn	CA752	B122, B151	—
C77000	Nickel silver, 55-18	55.0	18 Ni, 27 Zn	CA770	B122, B151	

[a] Unified numbering system.
[b] Alloy names are shown for information only, and should not be used. Use the appropriate designation only. (Example: UNS C21000 Copper Alloy).
[c] ASTM numbers listed are only those forms or shapes covered in the specification for wrought copper alloy.

TABLE 2A—TYPICAL PHYSICAL PROPERTIES OF WROUGHT COPPER ALLOYS

Metric (SI) Units

UNS No.	Melting Point °C		Density g/cm³ at 20°C	Coefficient of Thermal Expansion/°C x 10^{-5}			Thermal Conductivity W/m·K	Electrical Resistivity nΩ·m[a]	Specific Heat J/kg·K	Modulus GPa	
	Liquidus	Solidus		20-100°C	20-200°C	20-300°C				Elastic	Rigid
C10200	1083	—	8.94	1.70	1.73	1.77	391	17.1	385	117	44
C11000	1083	1065	8.91	1.70	1.73	1.77	391	17.1	385	117	44
C11100	1083	1065	8.91	1.70	1.73	1.77	388	17.2	385	117	44
C11300	1082	—	8.91	1.70	1.73	1.77	388	17.2	385	117	44
C11400	1082	—	8.91	1.70	1.73	1.77	388	17.2	385	117	44
C11500	1082	—	8.91	1.70	1.73	1.77	388	17.2	385	117	44
C11600	1082	—	8.91	1.70	1.73	1.77	388	17.2	385	117	44
C12000	1083	—	8.94	1.70	1.73	1.77	386	17.6	385	117	44
C12200	1083	—	8.94	1.70	1.73	1.77	339	20.3	385	117	44
C14500	1075	1051[b]	8.94	1.71	1.74	1.78	355	18.6	385	117	44
C14700	1076	1067	8.94	1.70	1.73	1.77	374	18.1	385	117	44
C15000	1080	980	8.89	1.63	1.80	2.01	367[d]	18.6[d]	385	117	44
C16200	1076	1030	8.89	1.70	1.73	1.77	360	19.2	385	117	44
C17000	980	865	8.26	1.67	1.70	1.78	118	76.8	420	131	50
C17200	980	865	8.26	1.67	1.70	1.78	118	76.8	420	131	50
C17500	1075	1070	8.75	—	1.76	—	234	37.9	420	124	47
C17600	1054	1010	8.75	—	—	—	—	31.6	—	124	47
C18400	1075	1070	8.89	1.76	—	—	324[d]	21.6[d]	385	131	50
C18700	1080	953[c]	8.94	—	—	1.76	377	17.9	385	117	44
C19200	1084	—	8.87	1.62	—	—	216	34.5	385	117	44
C21000	1065	1050	8.86	—	—	1.81	234	30.8	377	117	44
C22000	1045	1020	8.80	—	—	1.84	189	39.2	377	117	44
C23000	1025	990	8.75	—	—	1.87	159	46.6	377	117	44
C24000	1000	965	8.67	—	—	1.91	140	53.9	377	110	41
C26000	955	915	8.53	—	—	1.99	121	61.6	377	110	41
C26800	930	905	8.47	—	—	2.03	116	63.9	377	103	39
C27000	930	905	8.47	—	—	2.03	116	63.9	377	103	39
C33000	940	905	8.50	—	—	2.02	116	66.3	377	103	39
C33100	940	905	8.50	—	—	2.02	116	66.3	377	103	39
C34200	910	885	8.47	—	—	2.02	116	66.3	377	103	39
C34500	915	885	8.45	—	—	2.03	119	66.3	—	69	—
C35000	915	895	8.47	—	—	2.03	116	66.3	377	97	37
C36000	900	885	8.50	—	—	2.05	116	66.3	377	97	37
C37700	895	880	8.44	—	—	2.07	119	63.9	377	103	39
C46400	900	885	8.41	—	—	2.12	116	66.3	377	103	39
C46500	900	885	8.41	—	—	2.12	116	66.3	377	103	39
C46600	900	885	8.41	—	—	2.12	116	66.3	377	103	39
C46700	900	885	8.41	—	—	2.12	116	66.3	377	103	39
C51000	1050	950	8.86	—	—	1.78	69	115.0	377	110	41
C51100	1060	975	8.86	—	—	1.78	83	87.0	377	110	41
C52100	1020	880	8.80	—	—	1.82	62	133.0	377	110	41
C52400	1000	845	8.78	—	—	1.84	50	157.0	377	110	41
C54400	1000	930	8.89	—	—	1.73	87	90.7	377	103	39
C60800	1063	1050	8.17	—	—	1.81	80	100.0	377	121	46
C61400	1045	1040	7.89	—	—	1.62	67	123.0	377	117	44
C61800	1045	1040	7.53	—	—	1.62	64	133.0	377	117	44
C62300	1045	1040	7.66	—	—	1.62	61	144.0	377	117	44
C62400	1040	1025	7.45	—	—	1.92	54	144.0	377	117	44
C63000	1054	1035	7.58	—	—	1.62	38	192.0	377	117	44
C64200	1005	985	7.69	—	—	1.81	45	186.0	377	110	41
C65500	1025	970	8.53	—	—	1.80	36	246.0	377	103	39
C67000	930	905	7.81	—	—	2.00	24	75.0	—	103	39
C67300	890	845	8.28	—	—	2.00	—	75.0	—	103	39
C67400	885	865	8.08	—	—	2.00	100	75.0	377	97	37
C67500	890	865	8.36	—	—	2.12	106	71.8	377	103	39
C70600	1150	1100	8.94	—	—	1.71	45	191.0	377	124	47
C71000	1200	1150	8.94	—	—	1.64	36	266.0	377	138	52
C71500	1240	1170	8.94	—	—	1.62	29	375.0	377	152	57
C75200	1110	1070	8.73	—	—	1.62	33	287.0	377	124	47
C77000	1055	—	8.70	—	—	1.67	29	314.0	377	124	47

[a] See Table 2B for percent IACS electrical conductivity.
[b] Small amounts of tellurium-rich constituent remains liquid down to 490°C.
[c] Small amounts of lead-rich constituent remains liquid down to 325°C.
[d] After precipitation-hardening treatment.

TABLE 2B—TYPICAL PHYSICAL PROPERTIES OF WROUGHT COPPER ALLOYS

Customary Units

UNS No.	Melting Point, °F		Density[a]	Coefficient of Thermal Expansion			Thermal Conductivity[c]	Electrical Resistivity[d]	Electrical Conductivity[e]	Thermal Capacity[f]	Modulus	
	Liquidus	Solidus		68–212°F	68–392°F	68–572°F					Elastic[g]	Rigid[h]
C10200	1981	—	.323	9.4	9.6	9.8	226	10.3	101	.092	17	6.4
C11000	1981	1949	.322	9.4	9.6	9.8	226	10.3	101	.092	17	6.4
C11100	1981	—	.322	9.4	9.6	9.8	224	10.3	101	.092	17	6.4
C11300	1981	—	.322	9.4	9.6	9.8	224	10.3	100	.092	17	6.4
C11400	1981	—	.322	9.4	9.6	9.8	224	10.4	100	.092	17	6.4
Ø C11500	1981	—	.322	9.4	9.6	9.8	224	10.4	100	.092	17	6.4
C11600	1981	—	.322	9.4	9.6	9.8	224	10.4	99	.092	17	6.4
C12000	1981	—	.323	9.4	9.6	9.8	223	10.7	97	.092	17	6.4
C12200	1981	—	.323	9.4	9.5	9.8	196	12.2	85	.092	17	6.4
C14500	1960	1931[i]	.323	9.4	9.6	9.8	205	10.9	95	.092	17	6.4
C14700	1970	1953	.323	9.4	9.6	9.8	216	10.9	95	.092	17	6.4
C15000	1979	—	.323	9.4	9.6	9.8	212[k]	11.2[k]	93[k]	.092	17	6.4
C16200	1969	—	.321	9.4	9.6	9.8	208	11.9	87	.092	17	6.4
C17000	1800	1600	.298	9.3	9.4	9.9	—	47.2	22	—	19	7.3
C17200	1800	1600	.298	9.3	9.4	9.9	—	47.2	22	.100	19	7.3
C17500	1955	1885	.316	—	9.8	—	—	23.1	45	—	18	6.8
C17600	1930	1850	.316	—	9.8	—	—	19.0	50	—	18	6.8
C18400	1967	—	.321	9.4	9.6	9.8	187[k]	13.0[k]	80[k]	.092	19	7.2
C18700	1976	1747[j]	.323	9.4	9.6	9.8	218	10.6	98	.092	17	6.4
Ø C19200	1983	—	.320	9.0	—	—	125	20.8	50	.092	17	6.4
C21000	1950	1920	.320	—	—	10.0	135	18.5	00	.090	17	6.4
C22000	1910	1870	.318	—	—	10.2	109	23.6	44	.090	17	6.4
C23000	1880	1810	.316	—	—	10.4	92	28.0	37	.090	17	6.4
C24000	1830	1770	.313	—	—	10.6	81	32.4	32	.090	16	6.0
C26000	1750	1680	.308	—	—	11.1	70	37.0	28	.090	16	6.0
C26800	1710	1660	.306	—	—	11.3	67	38.4	27	.090	15	5.6
C27000	1710	1660	.306	—	—	11.3	67	38.4	27	.090	15	5.6
C33000	1720	1660	.307	—	—	11.2	67	39.9	26	.090	15	5.6
C33100	1720	1660	.307	—	—	11.2	67	39.9	26	.090	15	5.6
C34200	1670	1630	.306	—	—	11.3	67	39.9	26	.090	15	5.6
C34500	1650	1625	.305	—	—	11.4	69	39.9	26	—	10	—
C35000	1650	1630	.305	—	—	11.4	67	39.9	26	.090	14	5.3
C36000	1650	1630	.307	—	—	11.4	67	39.9	26	.090	14	5.3
C37700	1640	1620	.305	—	—	11.5	69	38.4	27	.090	15	5.6
Ø C46400	1650	1630	.304	—	—	11.8	67	39.9	26	.090	15	5.6
Ø C46500	1650	1630	.304	—	—	11.8	67	39.9	26	.090	15	5.6
Ø C46600	1650	1630	.304	—	—	11.8	67	39.9	26	.090	15	5.6
Ø C46700	1650	1630	.304	—	—	11.8	67	39.9	26	.090	15	5.6
C51000	1920	1750	.320	—	—	9.9	40	69.1	15	.090	16	6.0
Ø C51100	1945	1785	.320	—	—	9.9	48	52.0	20	.090	16	6.0
C52100	1880	1620	.318	—	—	10.1	36	79.8	13	.090	16	6.0
Ø C52400	1830	1550	.317	—	—	10.2	29	94.3	11	.090	16	6.0
C54400	1830	1700	.321	—	—	9.6	50	54.6	19	.090	15	5.6
C60800	1945	1920	.295	—	—	10.0	46	60.0	17	.090	17.5	6.6
Ø C61400	1915	1905	.285	—	—	9.0	39	74.1	14	.090	17	6.4
Ø C61800	1910	1900	.274	—	—	9.0	37	79.8	13	—	17	—
C62300	1910	1890	.274	—	9.0	9.4	31	79.8	13	—	16	—
C62400	1910	1895	.274	—	9.0	9.2	34	79.8	13	—	16	—
C63000	1930	1890	.274	—	9.0	9.4	22	138.0	8	.090	17	6.4
Ø C64200	1840	1800	.278	—	—	10.0	26	113.0	8	.090	16	6.0
C65500	1880	1780	.308	—	—	10.0	21	148.0	7	.090	15	5.6
C67000	1710	1665	.282	—	—	11.0	14	86.4	12	—	15	—
C67300	1620	1555	.299	—	—	11.0	—	86.4	12	—	15	—
C67400	1625	1550	.292	—	—	11.0	58	86.4	12	—	14	—
C67500	1630	1590	.302	—	—	11.8	61	43.2	24	.090	15	5.6
C70600	2100	2010	.323	—	—	9.5	26	115.0	9	.090	18	6.8
C71000	2192	2066	.323	—	—	9.1	21	160.0	6	.090	20	7.5
C71500	2260	2140	.323	—	—	9.0	17	225.0	5	.090	22	8.3
C75200	2030	1960	.316	—	—	9.0	19	173.0	6	.090	18	6.8
C77000	1930	—	.314	—	—	9.3	17	189.0	6	.090	18	6.8

[a] lb/in.^{3} at 68°F. See Table 2A for specific gravity (g/cm^3 at 20°C).
[b] Per F at temperature range indicated (multiply factor given by 10^{-6}).
[c] Btu/ft^2/ft h F at 68°F.
[d] (Annealed) ohms (circular mil/ft) at 68°F.
[e] (Annealed) percent IACS at 68°F (volume basis).
[f] (Specific heat) Btu/lb/F at 68°F.
[g] (Tension) psi (multiply factor given by 10^6).
[h] Psi (multiply factor given by 10^6).
[i] Small amount of tellurium-rich constituent remains liquid down to 1575°F.
[j] Small amount of lead-rich constituent remains liquid down to 619°F.
[k] After precipitation-harding heat treatment.

TABLE 3—FABRICATION PROPERTIES, OTHER CHARACTERISTICS AND TYPICAL USES

UNS No	Approximate Relative Suitability For Being Worked: Cold	Approximate Relative Suitability For Being Worked: Hot	Best Temperature For Hot Working, °C	Approximate Relative Suitability For Being Joined By: Soldering	Brazing	Oxyacetylene Welding	Carbon Arc Welding	Gas Shielded Arc Welding	Coated Metal Arc Welding	Resistance Welding: Spot	Seam	Butt	Machinability	Type of Chip	Typical Uses	Characteristics
C10200	E	E	760-870	E	E	F	F	G	NR	NR	NR	G	20	L	Thermal and electrical conductors, electronic parts, glass-to-metal seals.	Oxygen-free 100% minimum electrical conductivity, excellent ductility, high purity, no out gassing. Not subject to hydrogen embrittlement. Designated for use where processing involves heating in a reducing atmosphere.
C11000	E	E	760-870	E	G	NR	F	F	NR	NR	NR	G	20	L	Electrical wiring and components, radiator fins, gaskets, washers, cold heading wire, water deflectors, heat plugs, clock cases, plating anodes, screen wire.	Minimum electrical conductivity 100%, highest electrical conductivity of any metal except silver, has very high ductility. Will embrittle when heated to redness in a reducing atmosphere.
C11100	E	E	760-870	E	G	NR	F	F	NR	NR	NR	G	20	L	Radiator fins.	Has a softening temperature higher than the silver bearing coppers and electrolytic tough pitch copper.
C11300	E	E	760-780	E	G	NR	F	F	NR	NR	NR	G	20	L	Commutator bars, segments, collector rings and contacts, core and fin stock for radiators	Minimum electrical conductivity 98%. Resistance to softening increased by presence of silver. Effect increases with increased silver added. Higher silver-content copper used for continued exposure to somewhat higher temperature.
C11400	E	E	760-780	E	G	NR	F	F	NR	NR	NR	G	20	L		
ø C11500	E	E	760-870	E	G	NR	F	F	NR	NR	NR	G	20	L		
C11600	E	E	760-870	E	G	NR	F	F	NR	NR	NR	G	20	L		
C12000	E	E	760-870	E	E	G	G	E	NR	NR	NR	G	20	L	Electrical conductors, applications involving welding or brazing.	Regarded as an alternate to C10200. More resistant to embrittlement than C11000 high electrical conductivity.
C12200	E	E	760-870	E	E	G	G	E	NR	NR	NR	G	20	L	Tube, all types of hydraulic systems, fuel lines, vacuum lines, air conditioning, heat exchangers, anodes, air, gasoline, hydraulic and oil lines, oil coolers, gage lines.	Slightly improved mechanical properties. Electrical conductivity about 85%. Not subject to hydrogen embrittlement.
C14500	E	E	760-845	E	E	F	F	G	NR	NR	NR	G	80	S	Forgings and screw machine parts requiring high electrical and thermal conductivity, furnace brazing. Electrical connectors, motor and switch parts, soldering coppers and welding torch tips	Free machining copper, combined with high electrical conductivity (90-96%).
C14700	E	E	760-870	E	E	NR	NR	NR	NR	NR	NR	G	80	S	Transformer and circuit-breaker terminals, studs, bolts, nuts and current carrying parts requiring fine machining	Free machining copper, combined with high electrical conductivity (90-96%)
C15000	E	E	760-870	E	G	F	F	F	NR	NR	NR	G	20	L	Resistance welding electrodes. Miscellaneous current carrying components at elevated temperatures.	Precipitation hardened. Combined high strength and conductivity, and resistance to softening at elevated temperatures
C16200	E	G	760-870	E	E	F	F	G	NR	NR	NR	G	20	L	Electrical contacts and terminals, signal relays. Hard temper used for spring contact in small apparatus and resistance welding electrodes.	Moderate high strength and high electrical conductivity
C17000	G	G	705-775	G	G	NR	F	G	NR	NR	NR	G	20	L	Leaf springs, electrical contacts, coil springs and bellows requiring severe forming distributor breaker arm, welding tips and welding wheels	C17000, C17200, C17500, and C17600 can develop the highest mechanical properties by heat treatment. Complete range of properties.
C17200	G	G	705-775	G	G	NR	F	G	NR	NR	NR	G	20	L		
C17500	G	G	760-925	G	G	NR	F	G	NR	NR	NR	G	20	L		
C17600	G	G	760-925	G	G	NR	F	G	NR	NR	NR	G	20	L	Clips, welder tips and wheels.	
C18400	E	E	900-925	G	G	NR	F	G	NR	NR	NR	G	20	L	Spot welding electrodes and wheels, flash welding dies and commutator segments.	Precipitation hardened. Fairly high electrical conductivity. Resistance to softening at elevated temperatures.
C18700	G	NR	—	E	G	NR	NR	NR	NR	NR	NR	F	80	S	Screw machine parts requiring high electrical and thermal conductivity	Free machining copper, high electrical conductivity. Unsuited for hot working.
ø C19200	E	E	815-950	E	E	G		E	NR	NR	NR	G	20		Flexible hose, electrical terminals, fuse clips, gaskets, air-conditioning and heat exchanger tubing.	Resistance to softening and also stress corrosion
C21000	E	G	760-870	E	E	G	F	G	NR	NR	NR	G	20	L	Emblems, vitreous enamel base, ornamental trim and jewelry	C21000, C22000 and C23000 are generally reddish in color, soft and malleable, higher annealing point than copper and slightly stronger and similar in corrosion resistance. Good for drawing and forming. Resistance to dezincification and season cracking is excellent.
C22000	E	G	760-870	E	E	G	F	G	NR	NR	NR	G	20	L	Emblems, vitreous enamel base, ornamental trim, jewelry, expansion plugs, valve parts, escutcheon fasteners and spring clips.	
C23000	E	G	790-900	E	E	G	F	G	NR	F	NR	G	30	L	Radiator parts, heat exchanger tubes, tube bends.	
C24000	E	F	815-900	E	E	G	F	G	NR	F	NR	G	30	L	Bellows and water temperature switch housing, flexible hose, pump lines.	Color is light golden, strength and ductility continue to increase

TABLE 3—FABRICATION PROPERTIES, OTHER CHARACTERISTICS AND TYPICAL USES (continued)

UNS No.	Approximate Relative Suitability For Being Worked		Best Temperature For Hot Working, °C	Approximate Relative Suitability For Being Joined By						Resistance Welding			Machinability	Type of Chip	Typical Uses	Characteristics
	Cold	Hot		Soldering	Brazing	Oxyacetylene Welding	Carbon Arc Welding	Gas Shielded Arc Welding	Coated Metal Arc Welding	Spot	Seam	Butt				
C26000	E	F	730-845	E	E	G	F	F	NR	G	NR	G	30	L	Radiator tanks and lockseam tubes, header plates, reflectors, lamp bases, terminals, ground straps, baffles, ammeter shells and speedometer counter weights, washers, wheel covers, trim, carburetor parts.	Color is brass yellow. Greatest ductility of the copper zinc series. Strength is higher than any of the preceding cop per zinc alloys
C26800	E	NR	—	E	E	G	F	F	NR	G	NR	G	30	L	Radiator cores and tanks, lamp fixtures, socket shells, eyelets, fasteners and grommets, hinges, locks, pins, rivets, screws and springs	Strength increases and ductility decreases, but is still very good
C27000	E	NR	--	E	E	G	F	F	NR	G	NR	G	30	L		
C33000	E	NR	—	E	G	F	F	F	NR	F	NR	F	60	M	Tube carburetor parts, oil cooler tube, radiator and ornamental work, pump and power cylinders and liners	Provides some degree of machinability, together with moderate cold working properties
C33100	E	NR	—	E	G	NR	NR	NR	NR	NR	NR	F	70	M	Keys	Intended for blanking, piercing, and machining
C34200	E	NR	—	E	G	NR	NR	NR	NR	NR	NR	F	90	S	Clock plates and nuts, clock and watch backs, keys, gears and wheels	Provides increased machinability with moderate cold working properties
C34500	F	F	705-790	E	G	NR	NR	NR	NR	NR	NR	F	90	S	Screw machine parts requiring roll threads, knurls or staking operations	Best combination of machinability and cold working properties
C35000	F	NR	--	E	G	NR	NR	NR	NR	NR	NR	F	70	M	Keys	Intended for blanking, piercing, and [illegible]
C36000	NR	F	709-790	E	G	NR	NR	NR	NR	NR	NR	F	100	S	Automatic screw machine parts and carburetor, magneto parts, radiator drums and other fittings, plugs, inserts, gears, pinions, locks	The standard free cutting brass and its machinability has become the standard by which other alloys are rated.
C37700	NR	E	650-815	E	G	NR	NR	NR	NR	NR	NR	F	80	S	Forgings and pressings of all kinds. Headings, air conditioning tube fittings, convertible top hardware latches, hinges, etc.) forged valve bodies	Excellent hot working properties and widely used as forging rod. At ordinary temperatures it is strong, hard and free cutting
C46400	F	E	650-815	E	E	G	F	F	NR	G	F	G	30	L	Aircraft turnbuckle barrels and balls, cold headed parts, forgings screw machine parts, marine hardware, condenser plates, welding rod, nozzles and fittings	Excellent hot and fair cold working properties of somewhat higher strength, good salt water corrosion resistance
Ø C46500	F	E	650-815	E	E	G	F	F	NR	G	F	G	30	L		
Ø C46600	F	E	650-815	E	E	G	F	F	NR	G	F	G	30	L		
Ø C46700	F	E	650-815	E	E	G	F	F	NR	G	F	G	30	L		
C51000	E	NR	—	E	E	F	G	G	F	G	F	E	20	L	Springs, bearings clips, contacts, switch parts diaphragms, welding rod, thermostats, bellows, clutch disks, lock washers, fasteners	C51000 and C52100 have a remarkable combination of strength, ductility and resilience, and fatigue resistance.
Ø C51100	E	NR	—	E	E	F	G	G	F	G	F	E	20	L		
C52100	G	NR	—	E	E	F	G	G	F	G	F	E	20	L	Springs, clips, contacts, terminal wire and bushings, diaphragms and bellows	
Ø C52400	G	NR	..	E	E	F	G	G	F	G	F	E	20	L		
C54400	G	NR	—	E	G	NR	NR	NR	NR	NR	NR	F	80	S	Bearings bushings, gears, pinions shafts, thrust washers, valve parts	Free cutting, good cold working properties also suitable for blanking, forming and bending
C60800	G	F	790-870	NR	F	NR	—	G	G	G	G	G	20	—	Condenser, evaporator and heat exchanger tubes, ferrules	
Ø C61400	G	G	785-925	NR	F	NR	G	See Note d	G	G	G	G	20	L	Gibs, wear strips, gears, bushings, nuts, bolts and threaded members	Good cold working properties and corrosion resistance. High strength and ductility
Ø C61800	F	G	760-885	F	G	NR	—	G	G	G	G	G	40	—	Bushings, bearings, corrosion applications, welding rod	
C62300	NR	G	730-815	NR	F	NR	G	See Note d	G	G	G	G	30	L	Valve guides, spark plug inserts, gears, valve seat inserts, oil plugs and shifter forks.	Good hot working properties, high strength retained well at elevated temperatures; acid and oxidation resistant
C62400	NR	F	720-775	NR	F	NR	G	See Note d	G	G	G	G	30	L	Valve guides, spark plug inserts, gears, valve seat inserts, oil plugs, shifter forks, wear strips, ball bearings and hydraulic valve components.	Excellent hot working, poor cold working properties; heat treated for high mechanical properties
C63000	NP	G	705-760	NR	F	NR	G	See Note d	G	G	G	G	20	L	Retractable landing gear, propeller gears, large valve seat inserts, spacer bearings, high pressure pump components.	Very high mechanical properties in the heat treated condition, difficult to cold work, good hot working properties, excellent corrosion resistance
Ø C64200	NR	E	705-760	NR	F	NR	—	F	F	F	F	F	60	—	Valve stems, gears, bolts, nuts, valve bodies and components.	Free machining, high strength, high corrosion resistance.
C65500	E	F	705-760	G	E	G	G	E	F	E	E	E	30	L	Hydraulic pressure lines, bolts, clamps, piston rings, rivets and shafting	Relatively high strength, marked ductility and capability for being both hot and cold worked and joined by all procedures. Excellent corrosion resistance.

TABLE 3—FABRICATION PROPERTIES, OTHER CHARACTERISTICS AND TYPICAL USES (continued)

UNS No.	Approximate Relative Suitability For Being Worked		Best Temperature For Hot Working, °C	Approximate Relative Suitability[a] For Being Joined By									Machinability	Type of Chip	Typical Uses	Characteristics
	Cold	Hot		Soldering	Brazing	Oxyacetylene Welding	Carbon Arc Welding	Gas Shielded Arc Welding	Coated Metal Arc Welding	Resistance Welding: Spot	Resistance Welding: Seam	Resistance Welding: Butt				
C67000	NR	E	565–745	NR	F	NR	NR	See Note d	G	G	F	G	30	S	Diesel injector nozzles; high pressure hydraulic applications, cams, pistons and other components involving high mechanical loads and sliding contact.	High strength and good wear resistant properties.
C67300	F	E	625–745	NR	G	NR	NR	NR	NR	NR	NR	F	70	S	Forged water pump impellers; gears, axial piston pump components, bushings and bearings.	Hot forgeable free cutting alloy having fairly high strength and good corrosion resistant properties.
C67400	F	E	565–745	NR	F	NR	NR	See Note d	G	G	F	G	30	L	Connecting rods, transmission synchronizing stop ring, door striker plates, shifter shoes, differential idler pins, forged water pump impellers, axial piston pump parts, bushings and bearings.	Hot forgeable; high strength alloy with good wear resistant properties and good corrosion resistance.
C67500	NR	E	625–790	E	E	G	F	F	NR	G	F	G	30	L	Clutch disks, pump rods, shafting, balls, valve stems and bodies.	Strong, rigid and abrasion resistant; adopted to hot forging and pressing, hot-heading and upsetting.
C70600	G	G	760–980	E	E	F	NR	E	G	G	G	E	20	L	Condenser and heat exchanger tubes.	Used where requirements are severe. Strong, tough and very resistant to general corrosion as well as stress corrosion cracking; also serviceable at higher temperatures than copper and brasses. Well suited for condenser and heat exchanger tube.
C71000	G	G	760–980	E	E	G	NR	E	E	E	E	E	20	L	Condenser and heat exchanger tubes, ferrules.	C71000 and C71500 are used where requirements are severe. Strong, tough and very resistant to general corrosion as well as stress corrosion cracking; also; serviceable at higher temperatures than copper and brasses. Well suited for condenser and heat exchanger tube.
C71500	G	G	925–1035	E	E	G	NR	E	E	E	E	E	20	L	Automatic oil coolers, heat exchanger tube.	
C75200	E	NR	—	E	E	G	NR	F	NR	G	F	G	20	L	Rivets, screws, name plates, radio dials, etching stock, trim.	C75200 and C77000 are manufactured in a wide range of nickel contents. Higher the nickel the more silver white the alloy. 65% copper alloys have good cold working properties and are used for cold drawing, spinning, forming and stamping. The lower copper content alloys (55% Cu) are used for spring application.
C77000	G	NR	—	E	E	G	NR	F	NR	G	F	G	30	L	Springs, resistance wire.	

[a] E = Excellent; G = Good; F = Fair; NR = Not Recommended.
[b] S = Short; M = Medium; L = Long.
[c] Approximate relative machinability rating (Free Cutting Brass = 100).
[d] Consumable electrode excellent. Tungsten are good with AC preferred.

TABLE 4—TYPICAL SOFTENING TEMPERATURE

UNS No.	Temperature °C
C11000	230
C10200	280
C11400	315
C12200	340
C11100	355

TABLE 5—TYPICAL THERMAL STRESS RELIEVING TREATMENTS

SAE No.	Temperature °C	Time, h
C24000	260	1
C26000	260	1
C26800	245	1
C27000	245	1
C51000	190	1
C71500	480	1

TABLE 6—APPROXIMATE ANNEALING TEMPERATURE RANGES FOR INTERMEDIATE ANNEALING OF FABRICATED PARTS

UNS No.	Metal Temperature °C	Average Grain Size, mm
C11000	400–480 345–400	0.025 0.020
C22000	405–635 440–565	0.040 0.025
C23000	480–610 400–480	0.040 0.025
C26000	455–595 370–480	0.040 0.025
C26800	455–595 370–455	0.040 0.025
C51000	565–650 480–565	0.030 0.015
C75200	595–705 480–620	0.035 0.020

TABLE 7—RECOMMENDED RADII FOR FORMING 90 DEG BENDS

UNS No.	Temper	Thickness mm	Thickness in	Bend Perpendicular To Rolling Direction mm	Bend Perpendicular To Rolling Direction in	Bend At 45 Deg To Rolling Direction mm	Bend At 45 Deg To Rolling Direction in	Bend Parallel To Rolling Direction mm	Bend Parallel To Rolling Direction in
C11000	Half Hard	0.50	.020	Sharp		Sharp		1.6	.06
	Extra Hard			1.2	.05	1.2	.05	1.6	.06
C17200	Annealed	0.10	.004					0.4	.02
	Quarter Hard							0.4	.02
	Half Hard							0.8	.03
	Hard							0.8	.03
	Annealed	0.25	.010					1.2	.05
	Quarter Hard							1.6	.06
	Half Hard							2.4	.09
	Hard							4.0	.16
	Annealed	0.50	.020					2.8	.11
	Quarter Hard							3.2	.12
	Half Hard							4.8	.19
	Hard							8.0	.31
C23000	Soft	0.13/	.005/	Sharp		Sharp		Sharp	
		1.60	.063						
	Half-Hard	0.50/	.020/	Sharp		Sharp		Sharp	
		1.30	.050						
	Hard	0.65	.025	Sharp		0.4	.02	1.2	.05
		1.00	.040	0.4	.02	.12	.05	1.6	.06
		1.60	.063	1.2	.05	2.4	.09	3.2	.12
	Extra Hard	0.30	.012	0.4	.02	1.2	.05	1.6	.06
		0.65	.025	0.8	.03	1.6	.06	3.2	.12
		1.00	.040	1.6	.06	3.2	.12	4.8	.19
	Spring	0.30	.012	1.2	.05	2.4	.09	4.8	.19
		0.65	.025	1.6	.06	4.8	.19	6.4	.25
		1.00	.040	2.4	.09	6.4	.25	6.4	.25
C24000	Hard	0.50	.020	Sharp		0.8	.03	1.2	.05
	Spring	0.50	.020	1.6	.06	4.8	.19	6.4	.25
C26000	Half Hard	0.13/	.005/	Sharp		Sharp		Sharp	
		0.80	.032						
		0.81/	.033/	Sharp		Sharp		0.4	.02
		1.30	.050						
	Hard	1.31/	.005/	Sharp		0.4	.02	0.8	.03
		0.48	.019						
		0.65	.025	0.4	.02	0.8	.03	1.6	.06
		1.00	.040	0.8	.03	1.6	.06	2.4	.09
		1.60	.063	1.6	.06	3.2	.12	4.8	.19
	Extra Hard	0.40	.106	0.8	.03	1.6	.06	3.2	.12
		0.65	.025	1.6	.06	2.4	.09	4.8	.19
		1.00	.040	2.4	.09	3.2	.12	6.4	.25
	Spring	0.25	.010	1.6	.06	3.2	.12	4.8	.19
		0.65	.025	2.4	.09	4.8	.19	6.4	.25
		1.00	.040	3.2	.12	6.4	.25	6.4	.25
	Extra Spring	0.25	.010	1.6	.06	3.2	.12	6.4	.25
		0.65	.025	2.4	.09	6.4	.25	6.4	.25
		1.00	.040	3.2	.12	6.4	.25	6.4	.25
C26800	Half Hard	0.13/	.005/	Sharp		Sharp		Sharp	
		0.80	.032						
		0.81/	.033/	Sharp		Sharp		0.4	.02
		1.30	.050						
	Hard	0.13/	.005/	Sharp		0.4	.02	0.8	.03
		0.30	.012						
		1.00	.040	0.8	.03	1.6	.06	2.4	.09
		1.60	.063	1.6	.06	3.2	.12	4.8	.19
C51000	Half Hard	0.50/	.020/	Sharp		Sharp		0.4	.02
		0.80	.032						
	Hard	1.00	.040	1.2	.05	2.4	.09	4.8	.19
	Extra Hard	1.00	.040	1.6	.06	3.2	.12	6.4	.25
	Spring	0.30	.012	0.8	.03	1.6	.06	4.8	.19
		0.65	.025	1.6	.06	3.2	.12	6.4	.25
		1.00	.040	2.4	.09	4.8	.19	6.4	.25
	Extra Spring	0.30	.012	1.2	.05	2.4	.09	6.4	.25
		0.50	.020	2.4	.09	4.8	.19	6.4	.25
C52100	Half Hard	0.13/	.005/	Sharp		Sharp		0.4	.02
		0.48	.019						
	Hard	0.50	.020	0.4	.02	1.2	.05	2.4	.09
		1.00	.040	1.2	.05	2.4	.09	4.8	.19
		1.60	.063	2.4	.09	4.8	.19	>6.4	>.25
	Extra Hard	1.00	.040	2.4	.09	4.8	.19	>6.4	>.25
	Spring	1.00	.040	3.2	.12	6.4	.25	>6.4	>.25
	Extra Spring	1.60	.063	6.4	.25	6.4	.25	>6.4	>.25
C75200	Half Hard	1.00	.040			0.4	.02	0.8	.03
	Hard	1.00	.040	1.6	.06	1.6	.06	1.6	.06
	Extra Hard	1.00	.040	3.2	.12	3.2	.12	4.8	.19
	Spring	1.00	.040	4.0	.16	4.8	.19	5.6	.22
	Extra Spring	1.00	.040	4.0	.16	5.6	.22	6.4	.25

TABLE 8—RELATIVE FORGEABILITY RATING OF TYPICAL ALLOYS AS HOT PRESSED

UNS No.	Relative Forgeability Rating
C11000	65
C12200	65
C37700	100
C46400	85
C67500	80
C65500	40
C63700	70
C62400	75
C67400	90

TABLE 9—ANNEALED TEMPERS OF STRIP NOMINAL GRAIN SIZE, mm

UNS No.	Thickness mm Over	Thickness mm Thru	Thickness in Over	Thickness in Thru	Type of Operation: Eyelet Type Forming	Deep Drawing, Spinning	Embossing, Severe Forming	Coining, Extremely Severe Drawing
C24000, C26000, and C26800	—	0.50	—	.020	0.015	0.025	0.035	—
	0.50	1.30	.020	.050	0.025	0.035	0.050	0.050
	1.30	2.30	.050	.090	0.035	0.050	0.070	0.070
	2.30	4.60	.090	.180	0.050	0.070	0.070	0.120
	4.60	—	.180	—	0.070	0.120	0.120	0.120
C21000, C22000, and C23000	—	0.50	—	.020	0.015	0.025	0.025	—
	0.50	1.30	.020	.050	0.025	0.035	0.050	0.050
	1.30	4.60	.050	.180	0.035	0.035	0.050	0.050
	4.60	—	.180	—	0.035	0.050	0.050	0.070
C10200, C11000, C11300 thru C12000, and C12200	—	0.50	—	.020	0.015	0.025	0.025	—
	0.50	1.30	.020	.050	0.015	0.025	0.025	0.035
	1.30	4.60	.050	.180	0.015	0.025	0.035	0.035
	4.60	—	.180	—	0.025	0.035	0.035	0.035

TABLE 10A—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation In 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C10200	Plate, Sheet,	Soft Anneal	1.0	220	70	45	—	40	—	—	150	—	—
C11000	Strip, and	Deep-Drawing Anneal	1.0	235	75	45	—	45	—	—	160	75	100
C11100	Rolled Bar												
C11300		Light Cold Rolled	1.0	250	195	30	—	60	10	25	170	—	—
C11400													
C11500		1/2 Hard	1.0	290	250	14	—	84	40	50	180	90	100
C11600		Hard	1.0	345	310	6	—	90	50	57	195	90	100
C12000		Spring	1.0	380	345	4	—	94	60	63	200	90	100
C12200		Extra Spring	1.0	385	365	4	—	95	62	64	200	—	—
		Hot Rolled	1.0	235	70	45	—	45	—	—	160	—	—
		Hot Rolled and Annealed	1.0	230	70	45	—	42	—	—	150	—	—
C10200	Rod, Bar	Soft Anneal	25.0	220	70	55	70	40	—	—	150	—	—
C11000	and Shapes	Hard	6.0[e]	380	345	10	—	95	60	—	260	—	—
C12000			25.0[e]	330	305	16	55	87	47	—	185	17	300
C12200			50.0[e]	310	275	20	—	85	45	—	180	—	—
			12.0[h]	330	305	16	—	87	47	—	185	—	—
			12.0[i]	275	220	30	—	—	35	—	180	—	—
C10200	Tube	Soft Anneal	25.0 x 1.6	220	70	45	—	40	—	—	150	75[g]	20
C12000		Light Anneal	25.0 x 1.6	235	75	45	—	45	—	—	160	—	—
C12200		Light Drawn	25.0 x 1.6	275	220	25	—	77	35	45	180	95[h]	20
		Drawn	25.0 x 1.6	275	220	25	—	77	35	45	—	—	—
		Hard Drawn	25.0 x 1.6	380	345	8	—	95	60	63	200	130[g]	20
			50.0 x 1.6	380	345	8	—	95	60	63	—	—	—
			100.0 x 1.6	380	345	8	—	95	60	63	—	—	—
C10200	Wire	Annealed	2.0	240	—	35[i]	—	—	—	—	165	—	—
C11000													
C14500	Rod	1/2 Hard	6.0	295	260	20	—	—	38	—	170	—	—
			25.0	290	250	25	—	—	38	—	165	—	—
C14700			50.0	285	240	25	—	—	35	—	165	—	—
		Hard	6.0	365	330	10	—	—	52	—	200	—	—
			25.0	330	290	15	—	—	50	—	185	—	—
C15000	Round Rod	Drawn and Heat Treated	25 0	415	345	12	—	—	67	—	—	195	100
C16200	Round Rod	Drawn	25.0	450	345	25	—	—	70	—	—	—	—
			50.0	415	240	30	—	—	65	—	—	—	—
			75.0	380	170	35	—	—	60	—	—	—	—
	Square, Rectangular and Hex Rod and Bar	Drawn	25.0	450	345	25	—	—	70	—	—	—	—
			Over 25.0	380	240	30	—	—	65	—	—	—	—
	Forging	As Forged	25.0	450	—	25	—	—	60	—	—	—	—
			50.0	380	—	30	—	—	55	—	—	—	—
			Over 50 0	380	—	30	—	—	55	—	—	—	—
C17000	Strip	A Soft[i]	—	475	220[j]	48	—	—	62	56	—	—	—
		1/4 Hard[i]	—	565	485[j]	22	—	—	79	68	—	—	—
		1/2 Hard[i]	—	635	565[j]	15	—	—	92	76	—	—	—
		Hard[i]	—	760	715[j]	5	—	—	99	81	—	—	—
									RC	R30N			
		AT (3h at 315°C)[k]	—	1140	1000[j]	3	—	—	36	56	—	260	100
		1/4 HT (2h at 315°C)[k]	—	1185	1035[j]	2	—	—	37	57	—	275	100
		1/2 HT (2h at 315°C)[k]	—	1255	1105[j]	1	—	—	38	58	—	290	100
		HT (2h at 315°C)[k]	—	1310	1170[j]	1	—	—	40	60	—	295	100
		AM[i]	—	745	565[j]	20	—	—	20	40	—	—	—
		1/4 HM[i]	—	815	635[j]	17	—	—	24	44	—	—	—
		1/2 HM[i]	—	850	725[j]	14	—	—	28	48	—	—	—
		HM[i]	—	985	840[j]	11	—	—	32	52	—	—	—
		XHM[i]	—	1160	1020[j]	4	—	—	34	54	—	—	—
C17200	Strip	A (Soft)[i]	—	475	220[j]	48	—	—	62	56	—	—	—
		1/4 Hard[i]	—	565	485[j]	22	—	—	79	68	—	—	—
		1/2 Hard[i]	—	635	550[j]	15	—	—	92	76	—	—	—
		Hard[i]	—	760	715[j]	5	—	—	99	81	—	—	—
									RC	R30N			
		AT (3h at 315°C)[k]	—	1230	1070[j]	6	—	—	38	58	—	260	100
		1/4 H (2h at 315°C)[k]	—	1295	1140[j]	4	—	—	40	60	—	275	100
		1/2 H (2h at 315°C)[k]	—	1365	1205[j]	3	—	—	42	62	—	295	100
		HT (2h at 315°C)[k]	—	1390	1240[j]	2	—	—	43	63	—	305	100

TABLE 10A—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS (continued)

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation In 50 mm, %	Reduction of area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C17200 continued	Rod and Bar	A (Soft)[d]	—	495	170[j]	48	—	—	RB 62	R30T —	—	—	—
		1/2 Hard[d]	Under 25.0	760	620[j]	15	—	—	96	—	—	—	—
		1/2 Hard[d]	Over 25.0	690	620[j]	15	—	—	96	—	—	—	—
		AT (3h at 315°C)[k]	—	1230	1105[j]	6	—	—	RC 38	—	—	345	100
		1/2 HT (2h at 315°C)[k]	Under 25.0	1380	1255[j]	4	—	—	42	—	—	350	100
		1/2 HT (2h at 315°C)[k]	Over 25.0	1325	1205[j]	4	—	—	42	—	—	350	100
C17500	Strip and Plate	A (Soft)[d]	—	310	170[j]	28	—	—	RB 32	37	—	—	—
		1/2 Hard[d]	—	470	385[j]	8	—	—	70	64	—	—	—
		Hard[d]	—	540	485[j]	5	—	—	83	72	—	—	—
		AT (3h at 480°C)[k]	—	760	620[j]	12	—	—	96	80	—	230	100
		1/2 HT (2h at 480°C)[k]	—	825	745[j]	8	—	—	98	81	—	240	100
		HT (2h at 480°C)[k]	—	825	745[j]	8	—	—	98	81	—	240	100
C17500 C17600	Rod, Bar Shapes and Tubing	A (Soft)[d]	—	310	170[j]	28	—	—	35	—	—	—	—
		1/2 Hard[d]	—	495	450[j]	12	—	—	68	—	—	—	—
		AT (3h at 480°C)[k]	—	760	620[j]	18	—	—	96	—	—	275	100
		1/2 HT (2h at 480°C)[k]	—	825	760[j]	14	—	—	98	—	—	275	100
C18400	Round Rod	Drawn	25.0	485	—	20	—	—	80	—	—	—	—
			50.0	450	—	20	—	—	75	—	—	—	—
			75.0	415	—	20	—	—	70	—	—	—	—
	Hex Rod and Bar	Drawn	25.0	485	—	20	—	—	75	—	—	—	—
			Over 25.0	415	—	20	—	—	70	—	—	—	—
	Forgings	As Forged	25.0	485	—	20	—	—	80	—	—	—	—
			50.0	415	—	20	—	—	75	—	—	—	—
			Over 50.0	415	—	20	—	—	70	—	—	—	—
C18700	Rod	Hard	6.0	415	380	10	—	—	55	—	220	—	—
			12.0	380	345	11	—	—	50	—	205	—	—
			18.0	365	330	12	—	—	50	—	200	—	—
			25.0	350	315	14	—	—	50	—	195	—	—
C19200	Tube	A (Soft)	48.0 x 2.4	255	80	40	—	—	—	—	—	—	—
		Light Drawn	4.8 x 0.8	290	215	3	—	—	—	—	—	—	—
C21000	Plate, Sheet, Strip and Rolled Bar[c]	Annealed											
		0.050 mm	1.0	235	70	45	—	46	—	—	185	—	—
		0.035 mm	1.0	240	75	45	—	52	—	4	195	—	—
		0.025 mm	1.0	250	85	43	—	56	—	9	200	—	—
		0.015 mm	1.0	260	95	42	—	60	—	15	205	—	—
		1/4 Hard	1.0	290	220	25	—	—	38	44	220	—	—
		1/2 Hard	1.0	330	275	12	—	—	52	54	235	—	—
		3/4 Hard	1.0	350	310	8	—	—	59	58	240	—	—
		Hard	1.0	385	345	5	—	—	64	60	255	—	—
		Extra Hard	1.0	420	380	4	—	—	70	64	270	—	—
		Springs	1.0	440	400	4	—	—	73	66	275	—	—
		Extra Spring	1.0	450	—	—	—	—	74	68	—	—	—
C22000	Plate, Sheet, Strip and Rolled Bar[c]	Annealed											
		0.050 mm	1.0	255	70	45	—	53	—	6	195	—	—
		0.035 mm	1.0	260	85	45	—	57	—	12	205	—	—
		0.025 mm	1.0	270	95	44	—	60	—	16	215		
		0.015 mm	1.0	285	105	42	—	65	—	26	220	—	—
		1/4 Hard	1.0	310	240	25	—	—	42	44	230	—	—
		1/2 Hard	1.0	360	310	11	—	—	58	56	240	—	—
		3/4 Hard	1.0	395	345	8	—	—	67	63	250	—	—
		Hard	1.0	420	370	5	—	—	70	63	260	—	—
		Extra Hard	1.0	460	400	4	—	—	75	67	275	—	—
		Spring	1.0	495	425	3	—	—	78	69	275	145	15
		Extra Spring	1.0	525	—	—	—	—	82	73	290	—	—
	Tube	Soft Anneal	25.0 x 1.6	260	70	52	—	55	—	10	—	—	—
		Light Anneal	25.0 x 1.6	285	105	42	—	65	—	35	—	—	—
		Drawn (General Purpose)	25.0 x 1.6	310	240	25	—	—	50	50	—	—	—
		Hard Drawn	25.0 x 1.6	415	365	6	—	—	69	62	—	—	—

TABLE 10A—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS *(continued)*

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation In 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C23000	Sheet and Strip	Annealed											
		0.070 mm	1.0	270	70	48	—	56	—	10	215	—	—
		0.050 mm	1.0	275	85	47	—	59	—	14	215	—	—
		0.035 mm	1.0	285	95	46	—	63	—	22	215	—	—
		0.025 mm	1.0	295	110	44	—	66	—	28	220	—	—
		0.015 mm	1.0	310	125	42	—	71	—	38	230	—	—
		1/4 Hard	1.0	345	270	25	—	—	55	54	240	—	—
		1/2 Hard	1.0	395	340	12	—	—	65	60	255	—	—
		3/4 Hard	1.0	425	360	8	—	—	73	67	270	—	—
		Hard	1.0	495	395	5	—	—	77	68	290	—	—
		Extra Hard	1.0	540	420	4	—	—	83	72	305	—	—
		Spring	1.0	580	435	3	—	—	86	74	315	—	—
		Extra Spring	1.0	595	—	—	—	—	88	77	—	—	—
	Tube	Soft Anneal	25.0 x 1.6	275	85	55	—	60	—	15	—	—	—
		Light Anneal	25.0 x 1.6	305	125	45	—	71	—	38	—	—	—
		Light Drawn	25.0 x 1.6	345	275	30	—	—	55	54	—	—	—
		Drawn (General Purpose)	25.0 x 1.6	385	315	25	—	—	62	60	—	—	—
		Hard Drawn	25.0 x 1.6	455	400	8	—	—	77	68	—	—	—
C24000	Sheet and Strip	Annealed											
		0.070 mm	1.0	290	85	52	—	57	—	8	—	—	—
		0.050 mm	1.0	305	95	50	—	61	—	16	220	—	—
		0.035 mm	1.0	315	105	48	—	66	—	28	—	—	—
		0.025 mm	1.0	330	115	47	—	69	—	32	—	—	—
		0.015 mm	1.0	345	140	46	—	75	—	42	230	—	—
		1/4 Hard	1.0	365	275	30	—	—	55	54	250	—	—
		1/2 Hard	1.0	420	345	18	—	—	70	64	270	—	—
		3/4 Hard	1.0	455	370	12	—	—	76	68	285	—	—
		Hard	1.0	510	405	7	—	—	82	71	295	—	—
		Extra Hard	1.0	570	425	5	—	—	87	75	310	—	—
		Spring	1.0	625	450	3	—	—	91	77	330	165	20
		Extra Spring	1.0	640	—	—	—	—	92	78	—	—	—
C26000	Plate, Sheet, Strip, Rolled Bar and Wire''	Annealed											
		0.120 mm	1.0	305	75	66	—	54	—	11	—	90	100
		0.070 mm	1.0	315	95	65	—	58	—	15	220	90	100
		0.050 mm	1.0	325	105	62	—	64	—	26	—	—	—
		0.035 mm	1.0	340	115	57	—	68	—	31	235	95	100
		0.025 mm	1.0	350	130	55	—	72	—	36	—	—	—
		0.015 mm	1.0	365	150	54	—	78	—	43	240	105	100
		1/4 Hard	1.0	370	275	43	—	—	55	54	250	—	—
		1/2 Hard	1.0	425	360	23	—	—	70	65	275	125	100
		3/4 Hard	1.0	475	395	15	—	—	79	70	290	—	—
		Hard	1.0	525	435	8	—	—	82	73	305	145	100
		Extra Hard	1.0	595	450	5	—	—	88	76	315	—	—
		Spring	1.0	650	450	3	—	—	91	77	330	160	100
		Extra Spring	1.0	695	450	3	—	—	93	78	—	—	—
	Tube	Soft Anneal	25.0 x 1.6	325	105	65	—	64	—	26	—	—	—
		Light Anneal	25.0 x 1.6	360	140	55	—	75	—	40	—	—	—
		Hard Drawn	25.0 x 1.6	540	440	8	—	—	82	73	—	—	—
C26800	Plate, Sheet, Strip and Rolled Bar''	Annealed											
		0.120 mm	1.0	—	—	—	—	56	—	5	—	—	—
		0.070 mm	1.0	315	95	65	—	58	—	15	220	80	100
		0.050 mm	1.0	325	105	62	—	64	—	26	230	105	100
		0.035 mm	1.0	340	115	57	—	68	—	31	235	—	—
		0.025 mm	1.0	350	130	55	—	72	—	36	240	—	—
		0.015 mm	1.0	365	150	54	—	78	—	43	240	—	—
		1/4 Hard	1.0	370	275	43	—	—	55	54	250	—	—
		1/2 Hard	1.0	420	345	23	—	—	70	65	275	—	—
		3/4 Hard	1.0	460	380	15	—	—	77	69	285	—	—

TABLE 10A—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS *(continued)*

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation in 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C26800 continued	Plate, Sheet, Strip and Rolled Bar	Hard	1.0	510	415	8	—	—	80	70	295	95	100
		Extra Hard	1.0	585	425	5	—	—	87	74	310	—	—
		Spring	1.0	625	425	3	—	—	90	76	325	140	100
		Extra Spring	1.0	655	—	—	—	—	92	78	—	140	100
C27000	Wire	Annealed 0.035 mm	2.0	345	—	60	—	—	—	—	235	—	—
		1/8 Hard	2.0	400	—	35	—	—	—	—	260	—	—
		1/4 Hard	2.0	485	—	20	—	—	—	—	290	150	300
		1/2 Hard	2.0	605	—	15	—	—	—	—	315	—	—
		3/4 Hard	2.0	690	—	12	—	—	—	—	345	—	—
		Hard	2.0	760	—	8	—	—	—	—	380	—	—
		Extra Hard	2.0	825	—	4	—	—	—	—	400	—	—
		Spring	2.0	835	—	3	—	—	—	—	415	—	—
C33000	Tube	Soft Anneal	25.0 x 1.6	325	105	60	—	64	—	26	—	—	—
C33100		Light Anneal	25.0 x 1.6	360	140	50	—	75	—	37	—	—	—
		Hard Drawn	25.0 x 1.6	515	415	7	—	—	80	69	—	—	—
C34200 C35000	Plate, Sheet, Strip and Rolled Bar	Annealed 0.035 mm	1.0	340	115	52	—	68	—	31	235	—	—
		1/4 Hard	1.0	370	275	38	—	—	55	54	250	—	—
		1/2 Hard	1.0	420	345	20	—	—	70	65	275	—	—
		Hard	1.0	510	415	7	—	—	80	69	295	—	—
		Extra Hard	1.0	585	425	5	—	—	87	74	310	—	—
C34500 C35000	Rod	1/2 Hard	12.0	395	205	20	—	—	68	—	250	—	—
			25.0	380	205	25	—	—	68	—	240	—	—
			50.0	345	170	30	—	—	65	—	220	—	—
C36000	Rod	Soft	25.0	340	125	53	58	68	—	—	205	—	—
		1/2 Hard	6.0	470	360	18	48	—	80	—	260	—	—
			25.0	400	310	25	50	—	78	—	235	—	—
			50.0	380	305	32	52	—	75	—	220	140 95	100 300
		Hard	3.0	585	345	—	—	—	—	—	—	—	—
			6.0	515	275	5	—	—	—	—	—	—	—
			18.0	485	240	10	—	—	—	—	—	—	—
	Flat Products	Soft	25.0 x 150.0	330	140	25	—	—	—	—	205	—	—
			Over 25.0 x 150.0	310	125	30	—	—	—	—	195	—	—
		1/2 Hard	6.0 x 25.0	385	310	20	—	—	62	—	230	—	—
			12.0 x 150.0	345	205	20	—	—	—	—	205	—	—
			50.0 x 50.0	340	205	25	—	—	—	—	205	—	—
			50.0 x 150.0	310	170	25	—	—	—	—	185	—	—
			Over 50.0 x 100.0	310	170	25	—	—	—	—	185	—	—
C37700	Die Forgings	As Extruded	1.0	360	140	45	65	78	—	—	—	—	—
		As Forged	4 kg	400	160	40	—	—	—	—	—	—	—
C46400 C46500 C46600 C46700	Rod and Bar	Soft	6.0	400	185	45	60	—	56	—	275	—	—
			25.0	395	170	47	60	—	56	—	275	—	—
			50.0	385	170	47	60	—	55	—	275	—	—
			Over 50.0	375	150	—	—	—	—	—	—	—	—
		1/2 Hard or Light Annealed	6.0	435	205	40	55	—	60	—	290	—	—
			25.0	435	205	40	55	—	60	—	290	—	—
			50.0	425	195	43	55	—	60	—	290	—	—
			75.0	395	180	—	—	—	—	—	—	—	—
			Over 75.0	395	165	—	—	—	—	—	—	—	—
		Hard	6.0	550	395	20	45	—	85	—	310	—	—
			25.0	515	365	20	45	—	82	—	305	—	—
			50.0	460	275	35	50	—	75	—	295	—	—
	Shapes	As Extruded	—	400	170	40	—	—	—	—	275	—	—
C51000	Sheet and Strip	Annealed 0.050 mm	1.0	325	130	64	—	73	26	—	250	—	—
		0.035 mm	1.0	340	140	58	—	75	28	—	255	—	—
		0.025 mm	1.0	345	145	52	—	77	30	—	260	—	—
		0.015 mm	1.0	365	150	50	—	79	34	—	275	—	—
		1/2 Hard	1.0	470	380	28	—	—	78	69	340	—	—
		Hard	1.0	560	515	10	—	—	87	75	—	170	100
		Extra Hard	1.0	635	550	6	—	—	93	78	—	—	—
		Spring	1.0	690	550	4	—	—	95	79	—	150	100
		Extra Spring	1.0	740	550	3	—	—	97	80	—	—	—

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation in 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C51000 continued	Rod	Hard	12.0	515	450	25	—	—	80	—	370	—	—
			25.0	485	400	25	—	—	78	—	345	200	300
	Wire	Soft, 0.035 mm	2.0	345	140	58	—	—	38	—	—	—	—
		1/4 Hard	2.0	470	415	24	—	—	49	—	—	—	—
		1/2 Hard	2.0	585	550	8	—	—	—	—	—	—	—
		Hard	2.0	760	—	5	—	—	—	—	—	185	100
		Extra Hard	2.0	895	—	3	—	—	—	—	—	205	100
		Spring	2.0	905	—	2	—	—	—	—	—	—	—
C51100 C54400	Sheet and Strip	Annealed 0.050 mm	1.0	315	—	48	—	70	—	—	—	—	—
		0.035 mm	1.0	330	—	47	—	73	—	—	—	—	—
		0.025 mm	1.0	345	—	46	—	75	—	—	—	—	—
		0.015 mm	1.0	350	—	46	—	76	—	—	—	—	—
		1/2 Hard	1.0	425	370	19	—	—	70	65	—	—	—
		Hard	1.0	550	510	7	—	—	86	74	—	—	—
		Extra Hard	1.0	635	—	4	—	—	91	78	—	—	—
		Spring	1.0	675	550	3	—	—	93	79	—	—	—
		Extra Spring	1.0	710	550	2	—	—	95	80	—	—	—
C52100	Sheet and Strip	Soft	1.0	475	165	63	—	82	50	—	—	—	—
		1/2 Hard	1.0	525	380	32	—	—	84	73	350	—	—
		Hard	1.0	640	495	10	—	—	93	78	—	150	100
		Extra Hard	1.0	730	550	4	—	—	96	80	—	—	—
		Spring	1.0	770	—	3	—	—	98	81	—	—	—
		Extra Spring	1.0	825	—	2	—	—	100	82	—	—	—
C52400	Sheet and Strip	Soft 0.035 mm	1.0	455	195	68	—	—	55	—	—	—	—
		1/2 Hard	1.0	570	—	32	—	—	92	—	—	—	—
		Hard	1.0	690	—	13	—	—	97	—	—	—	—
		Extra Hard	1.0	795	—	7	—	—	100	—	—	—	—
		Spring	1.0	840	—	4	—	—	101	—	—	—	—
		Extra Spring	1.0	845	—	3	—	—	103	—	—	—	—
C54400	Sheet and Strip	See C51100											
	Rod	Hard	12.0	515	435	15	—	—	83	—	—	—	—
			25.0	470	385	20	—	—	80	—	—	—	—
	Flat Products	Hard	8.0	415	310	20	—	—	70	—	—	—	—
			18.0	380	240	25	—	—	—	—	—	—	—
C60800	Tube	Annealed	25.0 x 1.6	415	185	—	—	77	—	—	—	—	—
C61400	Plate, Sheet, Strip and Rolled Bar	Soft	3.0	560	310	40	35	—	84	—	310	205	100
			8.0	550	275	40	35	—	83	—	290	195	100
			12.0	540	240	42	40	—	82	—	275	180	100
			25.0	525	230	45	40	—	81	—	275	170	100
		Hard	3.0	615	415	32	—	—	87	—	345	—	—
			8.0	585	400	35	—	—	86	—	330	—	—
			12.0	550	370	38	—	—	85	—	275	—	—
			25.0	540	310	40	—	—	84	—	260	—	—
	Rod and Bar	—	12.0	585	310	35	55	—	91	—	330	—	—
			25.0	565	275	35	55	—	90	—	310	—	—
			50.0	550	240	35	60	—	88	—	275	—	—
C61800	Rod	1/2 Hard	25.0	585	295	23	—	—	88	—	325	195	100
			50.0	570	270	25	—	—	88	—	310	195	100
			75.0	550	270	28	—	—	88	—	295	180	100
									BHN (1000 kg)				
C62300	Rod and Bar	Drawn	12.0	655	415	15	—		180		—	—	—
			25.0	635	380	20	—		—		—	—	—
			75.0	620	310	25	—		—		—	—	—
	Shapes	—	—	585	230	25	—		170		—	—	—
	Forgings	As Forged	Thru 40.0	585	230	25	—		140		—	—	—
			Over 40.0	565	215	30	—		—		—	—	—
									BHN (3000 kg)				
C62400	Rod	As Extruded	All Sizes	655	345	12			200		—	—	—
	Forgings	As Forged	—	655	345	12			200		—	—	—

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load, MPa	Elongation In 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C62400 continued	Forgings	Hardened and H_2O Quenched	—	655	345	—			265		—	—	—
		Hardened, H_2O Quenched and Tempered	—	690	—	12			210		—	—	—
C63000	Rod and Bar	Annealed	25.0	725	415	12	—	—	100	—	—	—	—
			50.0	655	345	15	—	—	—	—	—	—	—
			100.0	620	310	17	—	—	—	—	—	—	—
	Shapes	As Extruded	All Sizes	620	310	17	—	—	—	—	—	—	—
C64200	Rod and Bar	Drawn	18.0	705	470	22	—	—	94	—	405	345	100
			40.0	640	415	26	—	—	90	—	—	—	—
C65500	Plate, Sheet, Strip and Rolled Bar	Annealed 0.070 mm	1.0	385	145	63	—	76	40	—	290	—	—
		0.040 mm	1.0	415	170	60	—	85	62	—	295	110	100
		1/4 Hard	1.0	470	240	30	—	—	75	67	325	—	—
		1/2 Hard	1.0	540	310	17	—	—	87	75	345	—	—
		Hard	1.0	650	400	8	—	—	93	78	395	160	100
		Extra Hard	1.0	715	415	6	—	—	96	80	415	—	—
		Spring	1.0	760	425	4	—	—	97	81	435	—	—
		Hot Rolled	1.0	435	170	—	—	—	—	—	—	—	—
		Hot Rolled and Cold Rolled Finish	1.0	450	205	—	—	—	70	—	—	—	—
	Rod, Bar and Shapes	Soft 0.050 mm	25.0	400	150	60	80	—	60	—	295	130	300
		1/4 Hard	—	415	170	55	—	—	—	—	—	—	—
		1/2 Hard	25.0	540	310	35	65	—	85	—	360	—	—
		Hard	12.0	670	—	—	—	—	—	—	—	230	300
			25.0	635	380	22	62	—	90	—	400	—	—
		Extra Hard	25.0	745	415	13	60	—	95	—	425	—	—
	Rod	Soft	—	400	150	50	—	—	60	—	295	—	—
		Hard	25.0	485	275	25	—	—	—	—	345	—	—
			40.0	450	240	30	—	—	—	—	—	—	—
			75.0	415	195	30	—	—	—	—	—	—	—
C67000	Rod and Bar	Soft	All Sizes	620	345	20	—	—	—	—	—	—	—
		1/2 Hard	All Sizes	770	460	13	—	—	—	—	—	—	—
		Hard	All Sizes	815	485	12	—	—	—	—	—	—	—
	Forgings	Soft	—	620	345	20	—	—	—	—	—	—	—
		1/2 Hard	—	770	460	13	—	—	—	—	—	—	—
		Hard	—	815	485	12	—	—	—	—	—	—	—
C67300	Rod and Bar	As Extruded	All Sizes	485	275	25	—	—	70	—	—	—	—
		Soft	All Sizes	450	240	25	—	—	60	—	—	—	—
		1/2 Hard[c]	25.0	495	360	18	—	—	82	—	—	215	100
			75.0	485	345	22	—	—	80	—	—	215	100
			Over 75.0	485	310	25	—	—	75	—	—	—	—
		1/2 Hard[h]	All Sizes	485	310	25	—	—	75	—	—	—	—
		Hard[c]	25.0	550	415	15	—	—	86	—	—	—	—
			50.0	495	345	19	—	—	84	—	—	—	—
	Shapes	As Extruded	All Sizes	485	275	25	—	—	70	—	—	—	—
	Forgings	As Forged	—	485	275	25	—	—	70	—	—	—	—
		Forged and Heat Treated	—	515	310	20	—	—	85	—	—	—	—
C67400	Rod and Bar	As Extruded	All Sizes	505	260	16	—	—	80	—	—	—	—
		Extruded and Drawn	25.0	675	425	15	—	—	90	—	—	215	100
			50.0	635	385	18	—	—	88	—	—	—	—
			75.0	605	345	22	—	—	85	—	—	—	—
	Shapes	As Extruded	All Sizes	505	260	16	—	—	80	—	—	—	—
	Forgings	As Forged	—	470	235	18	—	—	75	—	—	—	—
C67500	Rod and Bar	Soft	25.0	450	205	33	—	—	65	—	290	—	—
		1/2 Hard	25.0	530	310	23	—	—	83	—	325	—	—
			50.0	495	290	27	—	—	77	—	305	—	—
			65.0	485	240	30	—	—	—	—	—	—	—
		Hard	25.0	590	415	10	—	—	90	—	330	—	—
			40.0	550	380	12	—	—	—	—	—	—	—
			65.0	515	345	15	—	—	—	—	—	—	—
	Shapes	Soft	—	450	205	33	—	—	65	—	290	—	—

TABLE 10A—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS *(continued)*

Metric (SI) Units

UNS No.	Form	Temper	Size Section, mm	Tensile Strength, MPa	Yield Strength, 0.5% Ext Under Load MPa	Elongation In 50 mm, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, MPa	Fatigue Strength MPa	Fatigue Strength Million Cycles
C70600	Condenser Tube Plate	—	25.0	290	125	35	—	—	15	—	—	—	—
	Tube	Annealed	25.0 x 1.6	305	110	42	—	65	15	26	—	—	—
		Light Drawn	25.0 x 1.6	415	395	10	—	100	72	70	—	—	—
C71000	Tube	Annealed	25.0 x 1.6	345	150	45	—	—	35	—	—	—	—
	Plate, Sheet, Strip and Rolled Bar[e]	Annealed											
		0.035 mm	1.0	305	95	37	—	72	27	34	—	—	—
		0.015 mm	1.0	325	115	38	—	83	47	48	—	—	—
		1/4 Hard	1.0	380	—	—	—	—	59	56	—	—	—
		1/2 Hard	1.0	435	395	7	—	—	71	64	—	—	—
		Hard	1.0	505	—	—	—	—	80	70	—	—	—
		Extra Hard	1.0	540	—	—	—	—	83	72	—	—	—
		Spring	1.0	565	—	—	—	—	85	73	—	—	—
C71500	Condenser Tube Plate	—	25.0	380	140	45	—	—	35	—	—	—	—
	Tube	Annealed	25.0 x 1.6	415	170	45	—	80	45	—	—	—	—
		Drawn and Stress Relieved	25.0 x 1.6	515	380	20	—	—	—	—	—	—	—
	Plate, Sheet, Strip and Rolled Bar[e]	Annealed											
		0.035 mm	1.0	310	190	45	—	78	34	39	—	—	—
		0.015 mm	1.0	415	150	40	—	84	50	49	—	—	—
		1/4 Hard	1.0	450	345	20	—	—	74	66	—	—	—
		1/2 Hard	1.0	505	470	12	—	—	81	71	—	—	—
		Hard	1.0	565	510	4	—	—	86	74	—	—	—
		Extra Hard	1.0	595	545	2	—	—	88	75	—	—	—
		Spring	1.0	615	565	2	—	—	89	76	—	—	—
C75200	Plate, Sheet, Strip and Rolled Bar	Annealed											
		0.035 mm	1.0	400	170	40	—	85	40	47	—	—	—
		0.015 mm	1.0	415	205	32	—	90	55	55	—	—	—
		1/4 Hard	1.0	450	345	20	—	—	73	65	—	—	—
		1/2 Hard	1.0	510	425	8	—	—	83	72	—	—	—
		Hard	1.0	535	510	3	—	—	87	75	—	—	—
		Extra Hard	1.0	635	—	—	—	—	91	77	—	—	—
		Spring	1.0	660	—	—	—	—	93	78	—	—	—
	Rod and Bar	Annealed											
		0.035 mm	12.0	385	170	42	—	—	—	—	—	—	—
		0.015 mm	12.0	400	180	35	—	—	—	—	—	—	—
		1/4 Hard	12.0	485	415	20	—	—	78	—	—	—	—
		Hard	6.0[k]	620	515	10	—	—	—	—	—	—	—
			12.0[k]	550	470	12	—	—	—	—	—	—	—
			25.0	515	425	15	—	—	—	—	—	160	300
			Over 25.0[i]	485	380	20	—	—	—	—	—	—	—
C77000	Plate, Sheet, Strip and Rolled Bar	Annealed											
		0.035 mm	1.0	415	185	40	—	90	55	49	—	110	100
		0.015 mm	1.0	—	—	—	—	91	60	56	—	—	—
								RG					
		1/4 Hard	1.0	540	—	—	—	43	79	69	—	—	—
		1/2 Hard	1.0	600	—	—	—	60	87	75	—	—	—
		Hard	1.0	690	585	3	—	72	91	77	—	145	100
		Extra Hard	1.0	745	620	2	—	77	96	80	—	—	—
		Spring	1.0	795	—	2	—	80	99	81	—	—	—
	Rod and Bar	Annealed											
		0.035 mm	12.0	415	185	45	—	—	—	—	—	—	—
		1/4 Hard	12.0[m]	585	—	—	—	—	—	—	—	—	—
		Hard	6.0[k]	690	—	—	—	—	—	—	—	—	—
			12.0[k]	620	—	—	—	—	—	—	—	—	—
			25.0	585	—	—	—	—	—	—	—	—	—
			Over 25.0[k]	550	—	—	—	—	—	—	—	—	—

[a] Rotating beam tests on rod.
[b] Independent rotating beam tests, diameter of test sections 8.89 mm.
[c] Elongation in 4X diameter or thickness of specimen.
[d] Capable of being hardened by further heat treatment.
[e] Plate generally available in only annealed, 1/4 hard, and 1/2 hard.
[f] Elongation in 250 mm.
[g] Rods only
[h] Bars only.
[i] Shapes only.
[j] Yield strength measured at 0.2% offset.
[k] After heat treatment.
[l] Mill heat treated.
[m] Rounds only.

TABLE 10B—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS

Customary Units

UNS No.	Form	Temper	Size Section, in	Tensile Strength, ksi	Yield Strength, 0.5% Ext Under Load, ksi	Elongation in 2 in, %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
C10200 C11000 C11100 C11300 C11400 C11500 C11600 C12000 C12200	Plate, Sheet, Strip, and Rolled Bar	Soft, Anneal	0.04	32	10	45	—	40	—	—	22	—	—
		Deep Drawing Anneal	0.04	34	11	45	—	45	—	—	23	11	100
		Light Cold Rolled	0.04	36	28	30	—	60	10	25	25	—	
		1/2 Hard	0.04	42	36	14	—	84	40	50	26	13	100
		Hard	0.04	50	45	6	—	90	50	57	28	13	100
		Spring	0.04	55	50	4	—	94	60	63	29	14	100
		Extra Spring	0.04	57	53	4	—	95	62	64	29	—	—
		Hot Rolled	0.04	34	10	45	—	45	—	—	23	—	—
		Hot Rolled and Annealed	0.04	33	10	45	—	42	—	—	22	—	—
C10200 C11000 C12000 C12200	Rod, Bar and Shapes	Soft Anneal	1.0	32	10	55	70	40	—	—	22	—	—
		Hard	0.25[e]	55	50	10	—	94	60	—	29	—	—
			1.00[f]	48	44	16	55	87	47	—	27	17	300
			2.00[g]	45	40	20	—	85	45	—	26	—	—
			0.50[h]	48	44	16	—	87	47	—	27	—	—
			0.50[i]	40	32	30	—	—	35	—	28	—	—
C10200 C12000 C12200	Tube	Soft Anneal	1 x 0.06	32	10	45	—	40	—	—	22	11[a]	20
		Light Anneal	1 x 0.06	34	11	45	—	45	—	—	23	—	—
		Light Drawn	1 x 0.06	40	32	25	—	77	35	45	26	14[a]	20
		Drawn	1 x 0.06	40	32	25	—	77	35	45		—	—
		Hard Drawn	1 x 0.06	55	50	8	—	95	60	63	29	19[a]	20
			1 x 0.06	55	50	8	—	95	60	63	—	—	—
			1 x 0.06	55	50	8	—	95	60	63	—	—	—
C10200 C11000	Wire	Annealed	0.08	35	—	35	—	—	—	—	24	—	—
C14500 C14700	Rod	1/2 Hard	0.25	43	38	20	—	—	38	—	25	—	—
			1.00	42	36	25	—	—	38	—	24	—	—
			2.00	41	35	25	—	—	35	—	24	—	—
		Hard	0.25	53	48	10	—	—	52	—	29	—	—
			1.00	48	42	15	—	—	50	—	27	—	—
C15000	Round Rod	Drawn and Heat Treated	1.00	60	50	12	—	—	67	—	—	28	100
C16200	Round Rod	Drawn	1.00	65	50	25	—	—	70	—	—	—	—
			2.00	60	35	30	—	—	65	—	—	—	—
			3.00	55	25	35	—	—	60	—	—	—	—
	Square, Rectangular and Hex Rod and Bar	Drawn	1.00	65	50	25	—	—	70	—	—	—	—
			Over 1.00	55	35	30	—	—	65	—	—	—	—
	Forging	As Forged	1.00	65	—	25	—	—	60	—	—	—	—
			2.00	55	—	30	—	—	55	—	—	—	—
			Over 2.00	55	—	30	—	—	55	—	—	—	—
C17000	Strip	A Soft[d]	—	69	32[j]	48	—	—	62	56	—	—	—
		1/4 Hard[d]	—	82	70[j]	22	—	—	79	68	—	—	—
		1/2 Hard[d]	—	92	82[j]	15	—	—	92	76	—	—	—
		Hard[d]	—	110	104[j]	5	—	—	99	81	—	—	—
									RC	R30N			
		AT (3 h at 600°F)[k]	—	165	145	3	—	—	36	56	—	38	100
		1/4 HT (2 h at 600°F)[k]	—	172	150	2	—	—	37	57	—	40	100
		1/2 HT (2 h at 600°F)[k]	—	182	160	1	—	—	38	58	—	42	100
		HT (2 h at 600°F)[k]	—	190	170[j]	1	—	—	40	60	—	43	100
		AM[l]	—	108	82[j]	20	—	—	20	40	—	—	—
		1/4 HM[l]	—	118	92[j]	17	—	—	24	44	—	—	—
		1/2 HM[l]	—	123	105[j]	14	—	—	28	48	—	—	—
		HM[l]	—	143	122[j]	11	—	—	32	52	—	—	—
		XHM[l]	—	168	148[j]	4	—	—	34	54	—	—	—
C17200	Strip	A (Soft)[d]	—	69	32[j]	48	—	—	62	56	—	—	—
		1/4 Hard[d]	—	82	70[j]	22	—	—	79	68	—	—	—
		1/2 Hard[d]	—	92	82[j]	15	—	—	92	76	—	—	—
		Hard[d]	—	110	104[j]	5	—	—	99	81	—	—	—
									RC	R30N			
		AT (3 h at 600°F)[k]	—	178	155[j]	6	—	—	38	58	—	38	100
		1/4 H (2 h at 600°F)[k]	—	188	165[j]	4	—	—	40	60	—	40	100
		1/2 H (2 h at 600°F)[k]	—	198	175[j]	3	—	—	42	62	—	43	100
		HT (2 h at 600°F)[k]	—	202	180[j]	2	—	—	43	63	—	44	100
									RB	R30T			
	Rod and Bar	A (Soft)[d]	—	72	25[j]	48	—	—	62	—	—	—	—
		1/2 Hard[d]	Under 1.00	110	90[j]	15	—	—	96	—	—	—	—
		1/2 Hard[d]	Over 1.00	100	90[j]	15	—	—	96	—	—	—	—

TABLE 10B—TYPICAL MECHANICAL PROPERTIES OF WROUGHT COPPER AND COPPER ALLOYS (continued)

Customary Units

UNS No.	Form	Temper	Size Section, in.	Tensile Strength, ksi	Yield Strength, 0.5% Ext Under Load ksi	Elongation in 2 in., %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
C17200 continued	Rod and Bar	AT (3 h at 600°F)[k]	—	178	160[j]	6	—	—	RC 38	—	—	50	100
		1/2 HT (2 h at 600°F)[k]	Under 1.00	200	182[j]	4	—	—	42	—	—	51	100
		1/2 HT (2 h at 600°F)[k]	Over 1.00	192	175[j]	4	—	—	42	—	—	51	100
C17500	Strip and Plate	A (Soft)[d]	—	45	25[j]	28	—	—	RB 32	37	—	—	—
		1/2 Hard[d]	—	68	56[j]	8	—	—	70	64	—	—	—
		Hard[d]	—	78	70[j]	5	—	—	83	72	—	—	—
		AT (3 h at 900°F)[k]	—	110	90[j]	12	—	—	96	80	—	33	100
		1/2 HT (2 h at 900°F)[k]	—	120	108[j]	8	—	—	98	81	—	35	100
		HT (2 h at 900°F)[k]	—	120	108[j]	8	—	—	98	81	—	35	100
C17500 C17600	Rod, Bar Shapes and Tubing	A (Soft)[d]	—	45	25[j]	28	—	—	35	—	—	—	—
		1/2 Hard[d]	—	72	65[j]	12	—	—	68	—	—	—	—
		AT (3 h at 900°F)[k]	—	110	90[j]	18	—	—	96	—	—	40	100
		1/2 HT (2 h at 900°F)[k]	—	120	110[j]	14	—	—	98	—	—	40	100
C18400	Round Rod	Drawn	1.00	70	—	20	—	—	80	—	—	—	—
			2.00	65	—	20	—	—	75	—	—	—	—
			3.00	60	—	20	—	—	70	—	—	—	—
	Hex Rod and Bar	Drawn	1.00	70	—	20	—	—	75	—	—	—	—
			Over 1.00	60	—	20	—	—	70	—	—	—	—
	Forgings	As Forged	1.00	70	—	20	—	—	80	—	—	—	—
			2.00	60	—	20	—	—	75	—	—	—	—
			Over 2.00	60	—	20	—	—	70	—	—	—	—
C18700	Rod	Hard	0.25	60	55	10	—	—	55	—	32	—	—
			0.50	55	50	11	—	—	50	—	30	—	—
			0.75	53	48	12	—	—	50	—	29	—	—
			1.00	51	46	14	—	—	50	—	28	—	—
C19200	Tube	A (Soft)	1.88 x 0.09	37	12	40	—	—	—	—	—	—	—
		Light Drawn	1.88 x 0.09	42	31	3	—	—	—	—	—	—	—
C21000	Plate, Sheet, Strip and Rolled Bar[c]	Annealed											
		0.050 mm	0.04	34	10	45	—	46	—	--	27	—	—
		0.035 mm	0.04	35	11	45	—	52	—	4	28	—	—
		0.025 mm	0.04	36	12	43	—	56	—	9	29	—	—
		0.015 mm	0.04	38	14	42	—	60	—	15	30	—	—
		1/4 Hard	0.04	42	32	25	—	—	38	44	32	—	—
		1/2 Hard	0.04	48	40	12	—	—	52	54	34	—	—
		3/4 Hard	0.04	51	45	8	—	—	59	58	35	—	—
		Hard	0.04	56	50	5	—	—	64	60	37	—	—
		Extra Hard	0.04	61	55	4	—	—	70	64	39	—	—
		Springs	0.04	64	58	4	—	—	73	66	40	—	—
		Extra Spring	0.04	65	—	—	—	—	74	68	—	—	—
C22000	Plate, Sheet Strip and Rolled Bar[c]	Annealed											
		0.050 mm	0.04	37	10	45	—	53	—	6	28	—	—
		0.035 mm	0.04	38	12	45	—	57	—	12	30	—	—
		0.025 mm	0.04	39	14	44	—	60	—	16	31	—	—
		0.015 mm	0.04	41	15	42	—	65	—	26	32	—	—
		1/4 Hard	0.04	45	35	25	—	—	42	44	33	—	—
		1/2 Hard	0.04	52	45	11	—	—	58	56	35	—	—
		3/4 Hard	0.04	57	50	8	—	—	67	63	36	—	—
		Hard	0.04	61	54	5	—	—	70	63	38	—	—
		Extra Hard	0.04	67	58	4	—	—	75	67	40	—	—
		Spring	0.04	72	62	3	—	—	78	69	42	21	15
		Extra Spring	0.04	76	—	—	—	—	82	73	—	—	—
	Tube	Soft Anneal	1 x 0.06	38	10	52	—	55	—	10	—	—	—
		Light Anneal	1 x 0.06	41	15	42	—	65	—	35	—	—	—
		Drawn (General Purpose)	1 x 0.06	45	35	25	—	—	50	50	—	—	—
		Hard Drawn	1 x 0.06	60	53	6	—	—	69	62	—	—	—
C23000	Sheet and Strip	Annealed											
		0.070 mm	0.04	39	10	48	—	56	—	10	—	—	—
		0.050 mm	0.04	40	12	47	—	59	—	14	—	—	—
		0.035 mm	0.04	41	14	46	—	63	—	22	—	—	—
		0.025 mm	0.04	43	16	44	—	66	—	28	—	—	—
		0.015 mm	0.04	45	18	42	—	71	—	38	—	—	—
		1/4 Hard	0.04	50	39	25	—	—	55	54	—	—	—

Customary Units

UNS No.	Form	Temper	Size Section, in.	Tensile Strength, ksi	Yield Strength, 0.5% Ext Under Load, ksi	Elongation in 2 in., %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
C23000 continued	Sheet and Strip	1/2 Hard	0.04	57	49	12	—	—	65	60	—	—	—
		3/4 Hard	0.04	62	52	8	—	—	73	67	—	—	—
		Hard	0.04	70	57	5	—	—	77	68	—	—	—
		Extra Hard	0.04	78	61	4	—	—	83	72	44	—	—
		Spring	0.04	84	63	3	—	—	86	74	46	—	—
		Extra Spring	0.04	86	—	—	—	—	88	77	—	—	—
	Tube	Soft Anneal	1 x 0.06	40	12	55	—	60	—	15	—	—	—
		Light Anneal	1 x 0.06	44	18	45	—	71	—	38	—	—	—
		Light Drawn	1 x 0.06	50	40	30	—	—	55	54	—	—	—
		Drawn (General Purpose)	1 x 0 06	56	46	25	—	—	62	60	—	—	—
		Hard Drawn	1 x 0.06	70	58	8	—	—	77	68	—	—	—
C24000	Sheet and Strip	Annealed											
		0.070 mm	0.04	42	12	52	—	57	—	8	—	—	—
		0.050 mm	0.04	44	14	50	—	61	—	16	32	—	—
		0.035 mm	0.04	46	15	48	—	66	—	28	—	—	—
		0.025 mm	0.04	48	17	47	—	69	—	32	—	—	—
		0.015 mm	0.04	50	20	46	—	75	—	42	33	—	—
		1/4 Hard	0.04	53	40	30	—	—	55	54	36	—	—
		1/2 Hard	0.04	61	50	18	—	—	70	64	39	—	—
		3/4 Hard	0.04	66	54	12	—	—	76	68	41	—	—
		Hard	0.04	74	59	7	—	—	82	71	43	—	—
		Extra Hard	0.04	83	62	5	—	—	87	75	45	—	—
		Spring	0.04	91	65	3	—	—	91	77	48	24	20
		Extra Spring	0.04	93	—	—	—	—	92	78	—	—	—
C26000	Plate, Sheet, Strip, Rolled Bar and Wire	Annealed											
		0.120 mm	0.04	44	11	66	—	54	—	11	—	13	100
		0.070 mm	0.04	46	14	65	—	58	—	15	32	13	100
		0.050 mm	0.04	47	15	62	—	64	—	26	—	—	—
		0.035 mm	0.04	49	17	57	—	68	—	31	34	14	100
		0.025 mm	0.04	51	19	55	—	72	—	36	—	—	—
		0.015 mm	0.04	53	22	54	—	78	—	43	35	15	100
		1/4 Hard	0 04	54	40	43	—	—	55	54	36	—	—
		1/2 Hard	0.04	62	52	23	—	—	70	65	40	18	100
		3/4 Hard	0.04	69	57	15	—	—	79	70	42	—	—
		Hard	0.04	76	63	8	—	—	82	73	44	21	100
		Extra Hard	0.04	86	65	5	—	—	88	76	46	—	—
		Spring	0.04	94	65	3	—	—	91	77	48	23	100
		Extra Spring	0.04	99	65	3	—	—	93	78	—	—	—
	Tube	Soft Anneal	1 x 0.06	42	15	65	—	64	—	26	—	—	—
		Light Anneal	1 x 0.06	57	20	55	—	75	—	40	—	—	—
		Hard Drawn	1 x 0.06	78	64	8	—	—	82	73	—	—	—
C26800	Plate, Sheet, Strip and Rolled Bar	Annealed											
		0.120 mm	0.04	—	—	—	—	56	—	5	—	—	—
		0.070 mm	0.04	46	14	65	—	58	—	15	32	12	100
		0.050 mm	0.04	47	15	62	—	64	—	26	33	15	100
		0.035 mm	0.04	49	17	57	—	68	—	31	34	—	—
		0.025 mm	0 04	51	19	55	—	72	—	36	35	—	—
		0.015 mm	0.04	53	22	54	—	78	—	43	35	—	—
		1/4 Hard	0.04	54	40	43	—	—	55	54	35	—	—
		1/2 Hard	0 04	61	50	23	—	—	70	65	40	—	—
		3/4 Hard	0.04	67	55	15	—	—	77	69	41	—	—
		Hard	0.04	74	60	8	—	—	80	70	43	14	100
		Extra Hard	0.04	85	62	5	—	—	87	74	45	—	—
		Spring	0.04	91	62	3	—	—	90	76	47	20	100
		Extra Spring	0.04	95	—	—	—	—	92	78	—	20	100
C27000	Wire	Annealed											
		0.035 mm	0.08	50	—	60	—	—	—	—	34	—	—
		1/8 Hard	0.08	58	—	35	—	—	—	—	38	—	—
		1/4 Hard	0.08	70	—	20	—	—	—	—	42	22	300
		1/2 Hard	0.08	88	—	15	—	—	—	—	46	—	—
		3/4 Hard	0.08	100	—	12	—	—	—	—	50	—	—
		Hard	0.08	110	—	8	—	—	—	—	55	—	—
		Extra Hard	0.08	120	—	4	—	—	—	—	58	—	—
		Spring	0.08	128	—	3	—	—	—	—	60	—	—

Customary Units

UNS No.	Form	Temper	Size Section, in.	Tensile Strength, ksi	Yield Strength, 0.5% Ext Under Load, ksi	Elongation in 2 in., %	Reduction of Area, %	Hardness RF	Hardness RB	Hardness R30T	Shear Strength, ksi	Fatigue Strength ksi	Fatigue Strength Million Cycles
C33000	Tube	Soft Anneal	1 x 0.06	47	15	60	—	64	—	26	—	—	—
C33100		Light Anneal	1 x 0.06	52	20	50	—	75	—	37	—	—	—
		Hard Drawn	1 x 0.06	75	60	7	—	—	80	69	—	—	—
C34200 C35000	Plate, Sheet, Strip and Rolled Bar	Annealed 0.035 mm	0.04	49	17	52	—	68	—	31	34	—	—
		1/4 Hard	0.04	54	40	38	—	—	55	54	36	—	—
		1/2 Hard	0.04	61	50	20	—	—	70	65	40	—	—
		Hard	0.04	74	60	7	—	—	80	69	43	—	—
		Extra Hard	0.04	85	62	5	—	—	87	74	45	—	—
C34500 C35000	Rod	1/2 Hard	0.50	57	30	20	—	—	68	—	36	—	—
			1.00	55	30	25	—	—	68	—	35	—	—
			2.00	50	25	30	—	—	65	—	...	—	—
C36000	Rod	Soft	1.00	49	18	53	58	68	—	—	30	—	—
		1/2 Hard	0.25	68	52	18	48	—	80	—	38	—	—
			1.00	58	45	25	50	—	78	—	34	—	—
			2.00	55	44	32	52	—	75	—	32	20[b] 14[b]	100 300
		Hard	0.12	85	50	—	—	—	—	—	—	—	—
			0.25	75	40	5	—	—	—	—	—	—	—
			0.75	70	35	10	—	—	—	—	—	—	—
	Flat Products	Soft	1 x 6	48	20	25	—	—	—	—	30	—	—
			Over 1 x 6	45	18	30	—	—	—	—	28	—	—
		1/2 Hard	0.25 x 1	56	45	20	—	—	62	—	33	—	—
			0.50 x 6	50	30	20	—	—	—	—	30	—	—
			2.00 x 2	50	30	25	—	—	—	—	30	—	—
			2.00 x 6	45	25	25	—	—	—	—	27	—	—
			Over 2.00 x 4	45	25	25	—	—	—	—	27	—	—
C37700	Die Forgings	As Extruded	0.04	52	20	45	65	78	—	—	—	—	—
		As Forged	2 lbs	58	23	40	—	—	—	—	—	—	—
C46400 ∅ C46500 ∅ C46600 ∅ C46700	Rod and Bar	Soft	0.25	58	27	45	60	—	56	—	40	—	—
			1.00	57	25	47	60	—	56	—	40	—	—
			2.00	56	25	47	60	—	55	—	40	—	—
			Over 2.00	54	22	—	—	—	—	—	—	—	—
		1/2 Hard or Light Annealed	0.25	63	30	40	55	—	60	—	42	—	—
			1.00	63	30	40	55	—	60	—	42	—	—
			2.00	62	28	43	55	—	60	—	42	—	—
			3.00	57	26	—	—	—	—	—	—	—	—
			Over 3.00	57	24	—	—	—	—	—	—	—	—
		Hard	0.25	80	57	20	45	—	85	—	45	—	—
			1.00	75	53	20	45	—	82	—	44	—	—
			2.00	67	40	35	50	—	75	—	43	—	—
	Shapes	As Extruded	—	58	25	40	—	—	—	—	40	—	—
C51000	Sheet and Strip	Annealed 0.050 mm	0.04	47	19	64	—	73	26	—	36	—	—
		0.035 mm	0.04	49	20	58	—	75	28	—	37	—	—
		0.025 mm	0.04	50	21	52	—	77	30	—	38	—	—
		0.015 mm	0.04	53	22	50	—	79	34	—	40	—	—
		1/2 Hard	0.04	68	55	28	—	—	78	69	49	—	—
		Hard	0.04	81	75	10	—	—	87	75	—	25	100
		Extra Hard	0.04	92	80	6	—	—	93	78	—	—	—
		Spring	0.04	100	80	4	—	—	95	79	—	22	100
		Extra Spring	0.04	107	80	3	—	—	97	80	—	—	—
	Rod	Hard	0.50	75	65	25	—	—	80	—	54	—	—
			1.00	70	58	25	—	—	78	—	50	29	300
	Wire	Soft, 0.035 mm	0.08	50	20	58	—	—	38	—	—	—	—
		1/4 Hard	0.08	68	60	24	—	—	49	—	—	—	—
		1/2 Hard	0.08	85	80	8	—	—	—	—	—	—	—
		Hard	0.08	110	—	5	—	—	—	—	—	27	100
		Extra Hard	0.08	130	—	3	—	—	—	—	—	30	100
		Spring	0.08	140	—	2	—	—	—	—	—	—	—
∅ C51100 C54400	Sheet and Strip	Annealed 0.050 mm	0.04	46	—	48	—	70	—	—	—	—	—
		0.035 mm	0.04	48	—	47	—	73	—	—	—	—	—
		0.025 mm	0.04	50	—	46	—	75	—	—	—	—	—
		0.015 mm	0.04	51	—	46	—	76	—	—	—	—	—
		1/2 Hard	0.04	62	54	19	—	—	70	65	—	—	—
		Hard	0.04	80	74	7	—	—	86	74	—	—	—
		Extra Hard	0.04	92	—	4	—	—	91	78	—	—	—
		Spring	0.04	98	80	3	—	—	93	79	—	—	—
		Extra Spring	0.04	103	80	2	—	—	95	80	—	—	—