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INTRODUCTION

The Standards Handbook for Copper and Copper Alloy Mill Products is published by Copper Development Association Inc. as a technical service to the customers of the copper and brass industry. The Handbook has been prepared with the help of technical experts in the industry and is based on years of experience in the production, specification and purchase of copper mill products. This 1972 edition of Part 2 of the Handbook is the seventh edition of a publication that first appeared in 1941.

For convenient use, the Handbook is presented in seven separately bound parts:

Wrought Products (Brass Mill Products)

- Part 1 — Tolerances
- Part 2 — Alloy Data
- Part 3 — Terminology
- Part 4 — Engineering Data
- Part 5 — Sources
- Part 6 — Specifications Cross Index

Cast Products (Foundry Products)

- Part 7 — Data/Specifications

The Standards Handbook does not cover wire and cable for electrical transmission and distribution or for other power and electronic applications.

In this part of the Handbook, alloy data are presented for the standard wrought coppers and copper alloys. On page 1 a list of the standard designations for wrought coppers and copper alloys appears. This list contains the 34 coppers and 204 copper alloys which currently meet the criteria for assignment of a standard designation.

Data on the properties and characteristics of 27 of the most used wrought coppers and 94 of the most used wrought copper alloys make up the main part of this section of the Handbook. These Standard Data Sheets are preceded, on page 11, by a detailed index to them. Each data sheet includes the following: previous trade name; nominal composition and actual commercial composition limits; nearest applicable ASTM specifications; physical properties; typical uses; common fabrication processes; fabrication properties; forms and tempers most commonly used; and mechanical properties.

Property values shown in the Handbook are known to characterize generally the materials they describe. They are not intended for use in design. They can provide general guidance in the selection of alloys and of manufacturing processes.

Further alloy data can be obtained from any supplier of brass mill products (see Part 5/Sources) or from Copper Development Association Inc., 405 Lexington Avenue, New York, N. Y. 10017. Telephone (212) 867-6500.

Useful information for preparing purchase orders is shown on page III.

The use of the standards in this Standards Handbook by any member or non-member of the Copper Development Association Inc. is voluntary, and the issuance or existence of these standards does not in any respect prevent any member or non-member from manufacturing or supplying products not in conformance with these standards.

PURCHASE ORDER INFORMATION

Ordering Copper and Copper Alloy Wrought Mill Products can be greatly expedited if the purchaser will bear in mind that the following information is needed with each purchase order, preferably in the following sequence:

1. Quantity, total, in units such as pounds, pieces, total feet.
2. Copper or Copper Alloy, by number or nominal composition.
3. Cross-section shape, such as round, hexagonal, square, rectangular.
4. Product, such as sheet, strip, plate, bar, rod, shape, wire, pipe, tube.
See TERMINOLOGY, Part 3.
5. Nominal dimensions, such as width, thickness, length, distance across flats, diameter (O.D. or I.D. for tube), wall thickness, type of water tube or pipe. Use decimals of an inch instead of gage numbers.
6. How furnished, such as straight lengths, rolls, coils, spooled.
7. Length classification, such as specific, stock, mill, multiple. See TERMINOLOGY, Part 3.
8. Dimensional tolerances. CDA schedules will apply unless special values are stated.
9. Temper, such as nominal anneal or hardness.
10. Finish (if other than commercial).
11. Specifications, if any, such as ASTM, ANSI, SAE, Government.
12. Shipping date.
13. Special information, to aid in proper processing, such as use of product, drawing showing item to be fabricated, sample of fabricated product or previously used material, type of edges, coating, and any other requirements not covered by the above schedule.

* * *

Example: (1) 1000 pounds; (2) Copper Alloy No. 360 (*Free-cutting Brass*); (3) Hexagonal; (4) Rod; (5) 0.75" distance between parallel surfaces; (6) Straight lengths; (7) Specific lengths 20'-0"; (8) Commercial tolerances; (9) Half-hard temper; (10) Commercial finish; (11) ASTM B16-71a; (12) Ship January 2, 19—; (13) To be used in screw machine production of hexagonal nuts.

STANDARD DESIGNATIONS FOR COPPER AND COPPER ALLOYS

(Wrought Products only)

This is the accepted alloy designation system in North America for wrought copper and copper alloy products. Developed by the copper and brass industry in the United States, the system is now used by the U.S. Government, by the American Society for Testing and Materials (ASTM), by the Society of Automotive Engineers (SAE) and by nearly all producers of copper and copper alloy wrought products in North America.

The designation system is not a specification but is rather an orderly method of defining and identifying coppers and copper alloys. It eliminates the limitations and conflicts of alloy designations previously used and at the same time provides a workable method for the identification marking of mill products.

The designation system is administered by the Copper Development Association. New designations are assigned as new coppers and copper alloys come into commercial use, and designations are discontinued when an alloy composition ceases to be used commercially. Anyone may request changes in the list. New designations are assigned if a copper or copper alloy meets three criteria:

- (1) The complete chemical composition is disclosed
- (2) The copper or copper alloy is in commercial use
- (3) The composition does not fall within the limits of any designated composition already in the list

In the designation system, numbers from 100 through 799 describe wrought alloys. Within these numbers, the system groups the compositions into the following families of coppers and copper alloys:

Coppers — Metal which has a designated minimum copper content of 99.3%.

High Copper Alloys — For the wrought products, these are alloys with a designated copper content less than 99.3% but more than 96%, and which do not fall into the other copper alloy groups.

Brasses — These alloys contain zinc as the principal alloying element with or without other designated alloying elements such as iron, aluminum, nickel and silicon. The wrought alloys comprise three main families of brasses: copper-zinc alloys; copper-lead-zinc alloys (lead brasses); and copper-zinc-tin alloys (tin brasses).

Bronzes — Broadly speaking, bronzes are copper alloys in which the major alloying element is one other than zinc or nickel. Originally "bronze" described alloys with tin as the only or principal alloying element. Today, the term bronze is seldom used by itself in a technical sense. Rather it is used with a modifying adjective. For wrought alloys, there are four main families of bronzes: copper-tin-phosphorus alloys (phosphor bronzes); copper-tin-lead-phosphorus alloys (lead phosphor bronzes); copper-aluminum alloys (aluminum bronzes); and copper-silicon alloys (silicon bronzes).

Copper-Nickels — Alloys with nickel as the principal alloying element, with or without other designated alloying elements present.

Copper-Nickel-Zinc Alloys — Commonly known as "nickel silvers", these are alloys which contain zinc and nickel as the principal and secondary alloying elements, with or without other designated elements present.

Designations for the most widely used coppers and copper alloys are shown in bold-face type in the table of compositions. For each of these, a standard data sheet appears in Part 2 (wrought products) of the CDA Standards Handbook.

Copper Development Association Inc. does not undertake to insure anyone using this Standard Designation system against liability for infringement of letters patent nor does it assume any liability. This publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

* * *

Standard Chemical Composition Limits

The composition limits in this listing of Standard Designations for Copper and Copper Alloys are presented according to the following numerical convention, wherever practicable.

CONSTITUENT	CONVENTION FOR EXPRESSING COMPOSITION LIMITS
Copper Nos. 100-159 Incl.	
Copper	XX.XX
Alloying elements and impurities	
1/10 and over.....	.XX
1/100 and less than 1/10.....	.OXX
1/1000 and less than 1/100..	.OOX
less than 1/1000.....	.OOOX
Copper Alloy Nos. 160-799 Incl.	
Copper	XX.X
Alloying elements and impurities	
6/10 and over.....	.X, X.X, XX.X
1/10 and less than 6/10.....	.XX
1/100 and less than 1/10.....	.OX
1/1000 and less than 1/100..	.OOX
less than 1/1000.....	.OOOX

Chemical Symbols

Aluminum	Al
Antimony	Sb
Arsenic	As
Beryllium	Be
Bismuth	Bi
Boron	B
Cadmium	Cd
Calcium	Ca
Carbon	C
Chromium	Cr
Cobalt	Co
Columbium	Cb
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Phosphorus	P
Selenium	Se
Silicon	Si
Silver	Ag
Sulfur	S
Tellurium	Te
Titanium	Ti
Tin	Sn
Zinc	Zn
Zirconium	Zr

WROUGHT ALLOYS

COPPERS

COPPER NO.	DESIGNATION	TYPE	COMPOSITION, PER CENT MAXIMUM (UNLESS OTHERWISE INDICATED)							OTHER NAMED ELEMENTS
			Cu (incl. Ag) (% Min.)	Ag ⁽¹⁾ (% Min.)	As	Sb	P	Te		
101 ⁽²⁾	OFE	Oxygen Free Electronic.....	99.99 ⁽³⁾	—	(4)	(4)	.0003	.0010	(4)(5)	
102 ⁽²⁾	OF	Oxygen Free.....	99.95	—	—	—	—	—	—	
104 ⁽²⁾	OFS	Oxygen Free with Ag.....	99.95	.027(8)	—	—	—	—	—	
105 ⁽²⁾	OFS	Oxygen Free with Ag.....	99.95	.034(10)	—	—	—	—	—	
107 ⁽²⁾	OFS	Oxygen Free with Ag.....	99.95	.085(25)	—	—	—	—	—	
109 ⁽²⁾	BDHC	Boron Deoxidized High Conductivity	99.99 ⁽⁶⁾	—	(4)	(4)	.0005	(4)	(4)(7)	
110 ⁽²⁾	ETP	Electrolytic Tough Pitch	99.90	—	—	—	—	—	—	
	FRHC	Fire-Refined High Conductivity	99.90	—	—	—	—	—	—	
	CRTP	Chemically Refined Tough Pitch.....	99.90	—	—	—	—	—	—	
111 ⁽²⁾	—	Electrolytic Tough Pitch, Anneal Resistant	99.90	—	—	—	—	—	(8)	
113 ⁽²⁾⁽⁹⁾	STP	Tough Pitch with Ag.....	99.90	.027(8)	—	—	—	—	—	
114 ⁽²⁾⁽⁹⁾	STP	Tough Pitch with Ag.....	99.90	.034(10)	—	—	—	—	—	
115 ⁽²⁾⁽⁹⁾	STP	Tough Pitch with Ag.....	99.90	.054(16)	—	—	—	—	—	
116 ⁽²⁾⁽⁹⁾	STP	Tough Pitch with Ag.....	99.90	.085(25)	—	—	—	—	—	
117	—	.....	99.9 ⁽⁶⁾	—	—	—	.04	—	.004-.02 B	
119	PHC	.....	99.93	—	—	—	.002-.010	—	—	
120	DLP	Phosphorus Deoxidized, Low Residual Phosphorus	99.90	—	—	—	.004-.012	—	—	
121	—	.....	99.90	.014(4)	—	—	.005-.012	—	—	
122 ⁽¹⁰⁾	DHP	Phosphorus Deoxidized, High Residual Phosphorus	99.90	—	—	—	.015-.040	—	—	
123	—	.....	99.90	.014(4)	—	—	.015-.025	—	—	
125 ⁽¹¹⁾	FRTF	Fire-Refined Tough Pitch.....	99.88	—	.012	.003	—	.025 ⁽¹²⁾	.050 Ni .003 Bi .004 Pb	
127 ⁽¹¹⁾	FRSTP	Fire-Refined Tough Pitch with Ag	99.88	.027(8)	.012	.003	—	.025 ⁽¹²⁾	.050 Ni .003 Bi .004 Pb	
128 ⁽¹¹⁾	FRSTP	Fire-Refined Tough Pitch with Ag	99.88	.034(10)	.012	.003	—	.025 ⁽¹²⁾	.050 Ni .003 Bi .004 Pb	
129 ⁽¹¹⁾	FRSTP	Fire-Refined Tough Pitch with Ag	99.88	.054(16)	.012	.003	—	.025 ⁽¹²⁾	.050 Ni .003 Bi .004 Pb	
130 ⁽¹¹⁾	FRSTP	Fire-Refined Tough Pitch with Ag	99.88	.085(25)	.012	.003	—	.025 ⁽¹²⁾	.050 Ni .003 Bi .004 Pb	
134 ⁽²⁾	—	Boron Deoxidized, High Conductivity with Silver.....	99.99 ⁽⁶⁾	.027(8)	(4)	(4)	.0005	(4)	(4)(7)	
135 ⁽²⁾	—	Boron Deoxidized, High Conductivity with Silver.....	99.99 ⁽⁶⁾	.034(10)	(4)	(4)	.0005	(4)	(4)(7)	
136 ⁽²⁾	—	Boron Deoxidized, High Conductivity with Silver.....	99.99 ⁽⁶⁾	.054(16)	(4)	(4)	.0005	(4)	(4)(7)	
137 ⁽²⁾	—	Boron Deoxidized, High Conductivity with Silver.....	99.99 ⁽⁶⁾	.085(25)	(4)	(4)	.0005	(4)	(4)(7)	
141	ATP	Arsenical, Tough Pitch	99.40	—	.15-.50	—	—	—	—	
142	DPA	Phosphorus Deoxidized, Arsenical	99.40	—	.15-.50	—	.015-.040	—	—	
143	—	Cadmium Copper, Deoxidized	99.90 ⁽¹³⁾	—	—	—	—	—	.05-.15 Cd	
145 ⁽¹⁴⁾	DPTE	Phosphorus Deoxidized, Tellurium Bearing.....	99.90 ⁽¹⁵⁾	—	—	—	.004-.012 ⁽¹⁶⁾	.40-.6	—	
147	—	Sulfur Bearing	99.90 ⁽¹⁷⁾	—	—	—	—	—	.20-.50 S	
150	—	Zirconium Copper.....	99.80	—	—	—	—	—	.10-.20 Zr	
155	—	.....	99.75	.027-10 (8-30)	—	—	.040-.080	—	.10-.12 Mg	

(1) NOTES APPEAR ON PAGES 9-10 AT THE END OF THE TABLE

HIGH COPPER ALLOYS

COPPER ALLOY NO.	PREVIOUS TRADE NAME	(18) Cu (incl. Ag) + ELEMENTS WITH SPEC. LIM. (% Min.)	COMPOSITION, PERCENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)										OTHER NAMED ELEMENT
			Fe	Sn	Ni	Co	Cr	Si	Ba	Pb	Cd		
162	Cadmium Copper.	99.8	.02	—	—	—	—	—	—	—	.7-1.2	—	
164	.....	99.8	.02	.20-.40	—	—	—	—	—	—	.6-.9	—	
165	.....	99.8	.02	.50-.7	—	—	—	—	—	—	.6-1.0	—	
170	Beryllium Copper.	99.5	(19)	—	(19)	(19)	—	—	1.60-1.79	—	—	—	
172	Beryllium Copper.	99.5	(19)	—	(19)	(19)	—	—	1.80-2.00	—	—	—	
173	.....	99.5	(19)	—	(19)	(19)	—	—	1.80-2.00	.20-.6	—	—	
175	Beryllium Copper.	99.5	.10	—	—	2.4-2.7	—	—	.40-.7	—	—	—	
176	.....	99.5	.10	—	—	1.4-1.7	—	—	.25-.50	—	—	.9-1.1 Ag	
177	.....	99.5	.10	—	—	2.4-2.7	—	—	.40-.7	—	—	.40-.6 Te	
182	Chromium Copper	99.5	.10	—	—	—	.6-1.2	.10	—	.05	—	—	
184	Chromium Copper	99.8	.15	—	—	—	.40-1.2	.10	—	—	—	.005 As .005 Ca .05 Li .05 P .7 Zn	
185	Chromium Copper	99.8	—	—	—	—	.40-1.0	—	—	.015	—	.04 P .08-.12 Ag	
187	Leaded Copper.....	99.9	—	—	—	—	—	—	—	.8-1.5	—	—	
189	.....	99.9	—	.6-.9	—	—	—	.15-.40	—	.02	—	.05 P .01 Al .10-.30 Mn .10 Zn .8 Zn .15-.35 P .35-.6 Te .15-.35 P	
190	.....	99.5	.10	—	.9-1.3	—	—	—	—	.05	—	—	
191	.....	99.5	.20	—	.9-1.3	—	—	—	—	.10	—	—	

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)										TOTAL OTHER ELE- MENTS(20)
PREVIOUS TRADE NAME	Cu	Fe	Sn	Zn	Al	Pb	P	Co		
192	98.7 min.	.8-1.2	—	—	—	—	.01-.04	—	.10	
193	92.0-94.0	2.0-2.6	.03	Rem.	.02	.03	—	—	.05	
194	97.0 min.	2.1-2.6	.03	.05-.20	—	.03	.015-.15	—	.15	
195	Rem.	1.3-1.7	.40-.7	.20	.10	.02	.08-.12	.6-1.0	.10	

COPPER-ZINC ALLOYS (BRASSES)

COPPER-ZINC ALLOYS (BRASSES)		COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM).						
COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Zn	P	OTHER NAMED ELEMENTS	TOTAL OTHER ELE- MENTS ⁽²⁰⁾
205	.....	97.0-98.0	.02	.05	Rem.	—	—	.05
210	Gilding, 95%.....	94.0-96.0	.05	.05	Rem.	—	—	.10
220	Commercial Bronze, 90%.....	89.0-91.0	.05	.05	Rem.	—	—	.10
226	Jewelry Bronze, 87½%.....	86.0-89.0	.05	.05	Rem.	—	—	.15
230	Red Brass, 85%.....	84.0-86.0 ⁽²¹⁾	.05 ⁽²¹⁾	.05	Rem.	—	—	.15
234	.....	81.0-84.0	.05	.05	Rem.	—	—	.15
240	Low Brass, 80%.....	78.5-81.5	.05	.05	Rem.	—	—	.15
250	.....	74.0-76.0	.05	.05	Rem.	—	—	.15
260	Cartridge Brass, 70%.....	68.5-71.5	.07	.05	Rem.	—	—	.15
261	.....	68.5-71.5	.05	.05	Rem.	.02-.05	—	.15
262	.....	67.0-70.0	.07	.05	Rem.	—	—	.15
268	Yellow Brass, 66%.....	64.0-68.5	.15	.05	Rem.	—	—	.15
270	Yellow Brass, 65%.....	63.0-68.5	.10	.07	Rem.	—	—	.20
272	.....	62.0-65.0	.07	.07	Rem.	—	—	.20
274	Yellow Brass, 63%.....	61.0-64.0	.10	.05	Rem.	—	—	.20
280	Muntz Metal, 60%.....	59.0-63.0	.30	.07	Rem.	—	—	.20
282	.....	58.0-61.0	.03	.05	Rem.	.12-.22	.005 Al ⁽²²⁾	.10
298	Brazing Alloy.....	49.0-52.0	.50	.10	Rem.	—	.05 Sn .10 Al	—

COPPER-ZINC-LEAD ALLOYS (LEADED BRASSES)

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Sn	Zn	OTHER NAMED ELEMENTS	TOTAL OTHER ELE- MENTS(20)
310	Leaded Commercial Bronze (Low Lead)	89.0-91.0	.30-.7	.10	—	Rem.	—	.50
314	Leaded Commercial Bronze.....	87.5-90.5	1.3-2.5	.10	—	Rem.	.7 Ni	.50
316	Leaded Commercial Bronze (Nickel Bearing)	87.5-90.5	1.3-2.5	.10	—	Rem.	.7-1.2 Ni .04-.10 P	.50
320	Leaded Red Brass.....	83.5-86.5	1.5-2.2	.10	—	Rem.	.25 Ni	.50
325	.....	72.0-74.5	2.5-3.0	.10	—	Rem.	—	.50
330	Low Leaded Brass (Tube).....	65.0-68.0	.20-.8 (23)	.07	—	Rem.	—	.50
331	.....	65.0-68.0	.7-1.2	.06	—	Rem.	—	.50
332	High Leaded Brass (Tube)	65.0-68.0	1.3-2.0	.07	—	Rem.	—	.50
335	Low Leaded Brass	62.5-66.5	.30-.8	.10	—	Rem.	—	.50
340	Medium Leaded Brass, 64½%.....	62.5-66.5	.8-1.4	.10	—	Rem.	—	.50
342	High Leaded Brass, 64½%.....	62.5-66.5	1.5-2.5	.10	—	Rem.	—	.50
344	.....	62.0-66.0	.50-1.0	.10	—	Rem.	—	.50
345	.....	62.0-64.0	1.5-2.8	.10	—	Rem.	—	.50
347	.....	62.5-64.5	1.0-1.8	.10	—	Rem.	—	.50
348	.....	61.5-63.5	.40-.8	.10	—	Rem.	—	.50
349	.....	61.0-64.0	.10-.50	.10	—	Rem.	—	.50
350	Medium Leaded Brass, 62%.....	59.0-64.0 (24)	.8-1.4	.10	—	Rem.	—	.50
353	High Leaded Brass, 62%	59.0-64.5 (24)	1.3-2.3	.10	—	Rem.	—	.50
356	Extra High Leaded Brass	59.0-64.5 (25)	2.0-3.0	.10	—	Rem.	—	.50
360	Free Cutting Brass.....	60.0-63.0	2.5-3.7	.35	—	Rem.	—	.50
362	.....	60.0-63.0	3.5-4.5	.15	—	Rem.	—	.50
365	Leaded Muntz Metal, Uninhibited.....	58.0-61.0	.40-.9	.15	.25	Rem.	—	.10
366	Leaded Muntz Metal, Arsenical	58.0-61.0	.40-.9	.15	.25	Rem.	.02-.10 As	.10
367	Leaded Muntz Metal, Antimonial	58.0-61.0	.40-.9	.15	.25	Rem.	.02-.10 Sb	.10
368	Leaded Muntz Metal, Phosphorized.	58.0-61.0	.40-.9	.15	.25	Rem.	.02-.10 P	.10
370	Free Cutting Muntz Metal.....	59.0-62.0	.9-1.4	.15	—	Rem.	—	.50
371	.....	58.0-62.0	.6-1.2	.15	—	Rem.	—	.50
377	Forging Brass	58.0-62.0	1.5-2.5	.30	—	Rem.	—	.50
380	.....	55.0-60.0	1.5-2.5	.35	.30	Rem.	.50 Al	.50
385	Architectural Bronze	55.0-60.0	2.0-3.8	.35	—	Rem.	—	.50

COPPER-ZINC-TIN ALLOYS (TIN BRASSES)

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Sn	Zn	P	OTHER NAMED ELEMENTS	TOTAL OTHER ELE- MENTS(20)
405		94.0-96.0	.05	.05	.7-1.3	Rem.	—	—	.15
408		94.0-96.0	.05	.05	1.8-2.2	Rem.	—	—	.15
409		92.0-94.0	.05	.05	.50-.8	Rem.	—	—	.15
410		91.0-93.0	.05	.05	2.0-2.8	Rem.	—	—	.15
411		89.0-92.0	.10	.05	.30-.7	Rem.	—	—	.15

COPPER-ZINC-TIN ALLOYS (TIN BRASSES) (Continued)

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Sn	Zn	P	As	Sb	OTHER NAMED ELEMENTS	TOTAL OTHER ELE- MENTS ⁽²⁾
413	.....	89.0-93.0	.10	.05	7-1.3	Rem.	—	—	—	—	.15
415	.....	89.0-93.0	.10	.05	1.5-2.2	Rem.	—	—	—	—	.15
419	.....	89.0-92.0	.10	.05	4.8-5.5	Rem.	—	—	—	—	.15
420	.....	88.0-91.0	—	—	1.5-2.0	Rem.	.25	—	—	—	.15
421	.....	87.5-89.0	.05	.05	2.2-3.0	Rem.	.35	—	—	.15-.35 Mn	.15
422	.....	86.0-89.0	.05	.05	.8-1.4	Rem.	.35	—	—	—	.15
425	.....	87.0-90.0	.05	.05	1.5-3.0	Rem.	.35	—	—	—	.15
430	.....	85.0-89.0	.10	.05	1.7-2.7	Rem.	—	—	—	—	.15
432	.....	85.0-88.0	.05	.05	.40-.6	Rem.	.35	—	—	—	.15
434	.....	84.0-86.0	.05	.05	.50-1.0	Rem.	—	—	—	—	.15
435	.....	79.0-83.0	.10	.05	.6-1.2	Rem.	—	—	—	—	.15
436	.....	80.0-83.0	.05	.05	.20-.50	Rem.	—	—	—	—	.15
438	.....	79.0-82.0	.05	.05	1.0-1.5	Rem.	—	—	—	—	.15
443	Admiralty, Arsenical	70.0-73.0	.07	.06	9-1.2 ⁽²⁶⁾	Rem.	—	.02-.10	—	—	.15
444	Admiralty, Antimonial	70.0-73.0	.07	.06	9-1.2 ⁽²⁶⁾	Rem.	—	—	.02-.10	—	.15
445	Admiralty, Phosphorized	70.0-73.0	.07	.06	9-1.2 ⁽²⁶⁾	Rem.	.02-.10	—	—	—	.15
462	Naval Brass, 63½%	62.0-65.0	.20	.10	.50-1.0	Rem.	—	—	—	—	.10
464	Naval Brass, Uninhibited	59.0-62.0	.20	.10	.50-1.0	Rem.	—	—	—	—	.10
465	Naval Brass, Arsenical	59.0-62.0	.20	.10	.50-1.0	Rem.	—	.02-.10	—	—	.10
466	Naval Brass, Antimonial	59.0-62.0	.20	.10	.50-1.0	Rem.	—	—	.02-.10	—	.10
467	Naval Brass, Phosphorized	59.0-62.0	.20	.10	.50-1.0	Rem.	.02-.10	—	—	—	.10
470	Naval Brass Welding & Brazing Rod	57.0-61.0	.05	—	.25-1.0	Rem.	—	—	—	.01 Al	.50 ⁽²⁷⁾
472	Brazing Alloy	49.0-52.0	.50	.10	3.0-4.0	Rem.	—	—	—	—	—
476	.....	86.0-88.0	1.8-2.2	.05	1.8-2.2	Rem.	.03-.07	—	—	.05-.15 Mn	.15
482	Naval Brass, Medium Leaded	59.0-62.0	.40-1.0	.10	.50-1.0	Rem.	—	—	—	—	.10
485	Naval Brass, High Leaded	59.0-62.0	1.3-2.2	.10	.50-1.0	Rem.	—	—	—	—	.10

COPPER-TIN ALLOYS (PHOSPHOR BRONZES)

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu + Sn + P (% Min.)	Pb	Fe	Sn	Zn	P	Mn	Al
502	.....	99.5	.05	.10	1.0-1.5	—	.04	—	—
505	Phosphor Bronze, 1.25% E	99.5	.05	.10	1.0-1.7	.30	.03-.35	—	—
507	.....	99.5	.05	.10	1.5-2.0	—	.30	—	—
508	.....	99.5	.05	.10	2.6-3.4	—	.01-.07	—	—
509	.....	99.5	.05	.10	2.5-3.8	.30	.03-.30	—	—
510	Phosphor Bronze, 5% A	99.5	.05	.10	4.2-5.8	.30	.03-.35	—	—
511	.....	99.5	.05	.10	3.5-4.9	.30	.03-.35	—	—
518	Phosphor Bronze	99.5	.02	—	4.0-6.0	—	.10-.35	—	.01
519	.....	99.5	.05	.10	5.0-7.0	.30	.03-.35	—	—
521	Phosphor Bronze, 8% C	99.5	.05	.10	7.0-9.0	.20	.03-.35	—	—
524	Phosphor Bronze, 10% D	99.5	.05	.10	9.0-11.0	.20	.03-.35	—	—
526	.....	99.5 ⁽²⁸⁾	.05	.10	2.2-3.3	.20	.03-.35	1.0-2.0	—
529	.....	99.5 ⁽²⁸⁾	.05	.10	7.0-9.0	.20	.03-.35	1.0-2.0	—

COPPER-TIN-LEAD ALLOYS (LEADED PHOSPHOR BRONZES)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)					
		Cu + Sn + P + Pb (% MIN.)	Pb	Fe	Sn	Zn	P
532	Phosphor Bronze B	99.5	2.5-4.0	.10	4.0-5.5	.20	.03-.35
534	Phosphor Bronze B-1	99.5	.8-1.2	.10	3.5-5.8	.30	.03-.35
544	Phosphor Bronze B-2	99.5 (29)	3.5-4.5	.10	3.5-4.5	1.5-4.5	.01-.50
546	Phosphor Bronze B-2 (P .50 max.)	99.5 (29)	3.5-4.5	.10	3.5-4.5	1.5-4.5	.50
548	.....	99.5 (29)	4.0-6.0	.10	4.0-6.0	.30	.03-.35

COPPER-ALUMINUM ALLOYS (ALUMINUM BRONZES)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	(18) Cu + ELE- MENTS WITH SPEC. LIM- ITS (% Min.)	COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)									OTHER NAMED ELEMENTS
			Pb	Fe	Sn	Zn	Al	As	Mn	Si	Ni	
606		99.5	—	.50	—	—	4.0-7.0	—	—	—	—	—
607		99.5	.01	—	1.7-2.0	—	2.3-2.9	—	—	—	—	—
608	Aluminum Bronze, 5%	99.5	.10	.10	—	—	5.0-6.5	.02-.35	—	—	—	—
610		99.5	.02	.50	—	.20	6.0-8.5	—	—	.10	—	—
613		99.5	—	3.5	.20-.50	—	6.0-8.0	—	.50	—	.50	—
614	Aluminum Bronze D	99.5	.01	1.5-3.5	—	.20	6.0-8.0	—	1.0	—	—	.015 P
618		99.5	.02	.50-1.5	—	.02	8.5-11.0	—	—	.10	—	—
619		99.5	.02	3.0-4.5	.6	.8	8.5-10.0	—	—	—	—	—
622		99.5	.02	3.0-4.2	—	.02	11.0-12.0	—	—	.10	—	—
623		99.5	—	2.0-4.0	.6	—	8.5-11.0	—	.50	.25	1.0	—
624		99.5	—	2.0-4.5	.20	—	10.0-11.5	—	.30	.25	—	—
625		99.5	—	3.5-5.0	—	—	12.5-13.5	—	2.0	—	—	—
630		99.5	—	2.0-4.0	.20	.30	9.0-11.0	—	1.5	.25	4.0-5.5	—
632		99.5	.02	3.0-5.0 ⁽³⁰⁾	—	—	8.5-9.5	—	3.5	.10	4.0-5.5 ⁽³⁰⁾	—
634		99.5	.05	.10	.20	.35	2.6-3.2	.15	—	.25-.45	.15	—
636		99.5	.05	.10	.20	.35	3.0-4.0	.15	—	.7-1.3	.15	—
638		99.5	.05	.05	—	.50	2.5-3.1	—	.10	1.5-2.1	.10	.25-.55 Co
642		99.5	.05	.30	.20	.50	6.3-7.6	.15	.10	1.5-2.2	.25	—

COPPER-SILICON ALLOYS (SILICON BRONZES)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	(18) Cu + ELE- MENTS WITH SPEC. LIM- ITS (% Min.)	COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)							
			Pb	Fe	Sn	Zn	Al	Mn	Si	Ni
647	.....	99.5	.10	.10	—	.50	—	—	.40-.8	1.6-2.2
649	.....	99.5	.05	.10	1.2-1.6	.20	.10	—	.8-1.2	.10
651	Low Silicon Bronze B	99.5	.05	.8	—	1.5	—	.7	.8-2.0	—
655	High Silicon Bronze A	99.5	.05	.8	—	1.5	—	1.5	2.8-3.8	.6
656	.....	99.5	.02	.50	1.5	1.5	.01	1.5	2.8-4.0	—
658	.....	99.5	.05	.6	—	—	.01	.50-1.3	2.8-3.6	—
661	.....	99.5	.20-.8	.25	—	1.5	—	1.5	2.8-3.5	—

MISCELLANEOUS COPPER-ZINC ALLOYS

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Sn	Zn	Ni	Al	Mn	Si	OTHER NAMED ELEMENTS	TOTAL OTHER ELE- MENTS(2)
667	Manganese Brass	68.5-71.5	.07	.10	—	Rem.	—	—	.8-1.5	—	—	.50
668	.....	60.0-63.0	.50	.35	.30	Rem.	.25	.25	2.0-3.5	.50-1.5	—	.10
669	.....	62.5-64.5	.05	.25	—	Rem.	—	—	11.5-12.5	—	—	.20
670	Manganese Bronze B.	63.0-68.0	.20	2.0-4.0	.50	Rem.	—	3.0-6.0	2.5-5.0	—	—	.10
672	.....	57.5-61.0	.05	.25	—	Rem.	4.0-6.0	—	6.0-8.0	—	—	.20
673	.....	58.0-63.0	.40-3.0	.50	.30	Rem.	.25	.25	2.0-3.5	.50-1.5	—	.10
674	.....	57.0-60.0	.50	.35	.30	Rem.	.25	.50-2.0	2.0-3.5	.50-1.5	—	.10
675	Manganese Bronze A	57.0-60.0	.20	.8-2.0	.50-1.5	Rem.	—	.25	.05-50	—	—	.10
676	.....	57.0-60.0	.50-1.0	.40-1.3	.50-1.5	Rem.	—	—	.05-50	—	—	.30
677	.....	55.5-58.0	.50-1.0	.7-1.5	—	Rem.	1.5-2.3	—	.05-30	—	.40-.8 As	.50
678	.....	56.0-59.0	.30	.7-1.5	.20	Rem.	—	.50-1.5	.20-.6	—	—	.10
680	Bronze, Low Fuming (Nickel)	56.0-60.0	.05	.25-1.25	.75-1.10	Rem.	.20-.8	.01	.01-.50	.04-.15	—	.50 ⁽²⁷⁾
681	Bronze, Low Fuming	56.0-60.0	.05	.25-1.25	.75-1.10	Rem.	—	.01	.01-.50	.04-.15	—	.50 ⁽²⁷⁾
687	Aluminum Brass, Arsenical	76.0-79.0	.07	.06	—	Rem.	—	1.8-2.5	—	—	.02-.10 As	.15
688	.....	72.3-74.7	.05	.05	—	Rem.	—	3.0-3.8	—	—	.25-.55 Co	.10
689	Silicon Red Brass.....	80.0-83.0	.30	.20	—	Rem.	—	—	—	3.5-4.5	—	.50
697	.....	75.0-80.0	.50-1.5	.20	—	Rem.	—	—	.40	2.5-3.5	—	.50

COPPER-NICKEL ALLOYS

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	(18) Cu + ELE- MENTS WITH SPEC. LIM- ITS (% Min.)	Pb	Fe	Zn	Ni	Mn	OTHER NAMED ELEMENTS
701	.....	99.7	—	.05	.25	3.0-4.0	.25-.50	—
702	.....	99.7	.05	.10	—	2.0-3.0	.40	—
703	.....	99.5	—	.05	—	4.7-5.7	.50	—
704	Copper Nickel, 5%.....	99.6	.05	1.3-1.7	1.0	4.8-6.2	.30-.8	—
705	Copper Nickel, 7%.....	99.5	.05	.10	.20	5.8-7.8	.15	—
706	Copper Nickel, 10%.....	99.5	.05	1.0-1.8	1.0	9.0-11.0	1.0	—
707	.....	99.5	—	.05	—	9.5-10.5	.50	—
708	Copper Nickel, 11%.....	99.5	.05	.10	.20	10.5-12.5	.15	—
709	.....	99.5	.05	.6	1.0	13.5-16.5	.6	—
710	Copper Nickel, 20%.....	99.5	.05	1.0	1.0	19.0-23.0	1.0	—
711	.....	99.5	.05	.10	.20	22.0-24.0	.15	—
713	.....	99.5	.05	.20	1.0	23.5-26.5	1.0	—
715	Copper Nickel, 30%.....	99.5	.05	.40-.7	1.0	29.0-33.0	1.0	—
717	.....	99.5	—	.40-1.0	—	29.0-33.0	—	.30-.7 Be
719	.....	99.5	—	.25	—	29.0-32.0	.50-1.0	2.6-3.2 Cr
								.08-.20 Zr
								.02-.08 Ti
								.01 C
725	.....	99.8	.05	.6	.50	8.5-10.5	.20	1.8-2.8 Sn

COPPER-NICKEL-ZINC ALLOYS (NICKEL SILVERS)

COMPOSITION, PER CENT MAXIMUM (UNLESS SHOWN AS A RANGE OR MINIMUM)

COPPER ALLOY NO.	PREVIOUS TRADE NAME	Cu	Pb	Fe	Zn	Ni	Mn	OTHER NAMED ELEMENTS	TOTAL OTHER ELEMENTS(20)
732	.....	70.0 (Min.)	.05	.6	3.0-6.0	19.0-23.0	1.0	—	.50
735	.....	70.5-73.5	.10	.25	Rem.	16.5-19.5	.50	—	.50
736	.....	70.5-73.5	.05	.25	Rem.	14.0-16.0	.50	—	.50
738	Nickel Silver, 70-12.....	68.5-71.5	.05	.25	Rem.	11.0-13.0	.50	—	.50
740	.....	69.0-73.5	.10	.25	Rem.	9.0-11.0	.50	—	.50
745	Nickel Silver, 65-10.....	63.5-68.5	.10	.25	Rem.	9.0-11.0	.50	—	.50
752	Nickel Silver, 65-18.....	63.0-66.5	.10	.25	Rem.	16.5-19.5	.50	—	.50
754	Nickel Silver, 65-15.....	63.5-66.5	.10	.25	Rem.	14.0-16.0	.50	—	.50
757	Nickel Silver, 65-12.....	63.5-66.5	.05	.25	Rem.	11.0-13.0	.50	—	.50
760	.....	60.0-63.0	.10	.25	Rem.	7.0-9.0	.50	—	.50
761	.....	59.0-63.0	.10	.25	Rem.	9.0-11.0	.50	—	.50
762	.....	57.0-61.0	.10	.25	Rem.	11.0-13.5	.50	—	.10
764	.....	58.5-61.5	.05	.25	Rem.	16.5-19.5	.50	—	.50
766	.....	55.0-58.0	.10	.25	Rem.	11.0-13.5	.50	—	.50
767	Nickel Silver, 56.5-15.....	55.0-58.0	—	—	Rem.	14.0-16.0	.50	—	.50
770	Nickel Silver, 55-18.....	53.5-56.5	.10	.25	Rem.	16.5-19.5	.50	—	.50
773	.....	46.0-50.0	.05	—	Rem.	9.0-11.0	—	.01 Al .25 P .04-.25 Si	.50
774	.....	43.0-47.0	.20	—	Rem.	9.0-11.0	—	—	.50
776	Nickel Silver, 43.5-13.....	42.0-45.0	.25	.20	Rem.	12.0-14.0	.25	.15 Sn	.50
782	.....	63.0-67.0	1.5-2.5	.35	Rem.	7.0-9.0	.50	—	.10
784	.....	60.0-63.0	.8-1.4	.25	Rem.	9.0-11.0	.50	—	.50
786	.....	60.0-63.0	1.2-1.8	.35	Rem.	8.5-11.0	.50	—	.10
788	.....	63.0-67.0	1.5-2.0	.25	Rem.	9.0-11.0	.50	—	.50
790	.....	63.0-67.0	1.5-2.2	.35	Rem.	11.0-13.0	.50	—	.10
792	.....	59.0-66.5	.8-1.4	.25	Rem.	11.0-13.0	.50	—	.50
794	.....	59.0-66.5	.8-1.2	.25	Rem.	16.5-19.5	.50	—	.50
796	Leaded Nickel Silver, 10%.....	43.5-46.5	.8-1.2	—	Rem.	9.0-11.0	1.5-2.5	—	.50
798	.....	45.5-48.5	1.5-2.5	.25	Rem.	9.0-11.0	1.5-2.5	—	.50
799	.....	47.5-50.5	1.0-1.5	.25	Rem.	6.5-8.5	.50	—	.50

NOTES

- (1) Figures in parentheses are troy ounces per avoirdupois ton.
- (2) These are high conductivity coppers which have in the annealed condition a minimum conductivity of 100% IACS.
- (3) The 99.99 value for Cu is exclusive of Ag.
- (4) The total of the seven following elements, Se, Te, Bi, As, Sb, Sn and Mn not to exceed 40 ppm (.0040%).
- (5) Hg, max., 1 ppm (.0001%); Zn, max., 1 ppm (.0001%); Cd, max., 1 ppm (.0001%); S, max., 18 ppm (.0018%); Pb, max., 10 ppm (.0010%); Se, max., 10 ppm (.0010%); Bi, max., 10 ppm (.0010%); Oxygen, max., 10 ppm (.0010%).
- (6) The value includes Cu + Ag + B.
- (7) S, max., 15 ppm (.0015%); Cd, max., 3 ppm (.0003%); Zn, max., 5 ppm (.0005%); Hg, max., 1 ppm (.0001%); Pb, max., 10 ppm (.0010%); B, (.005-0.15%).
- (8) Small amounts of Cd or other elements may be added by agreement to improve resistance to softening at elevated temperatures.
- (9) This includes Low Resistance Lake Copper and Electrolytic Copper.
- (10) This includes Oxygen-Free Copper which contains P in an amount agreed upon.
- (11) This includes High Resistance Lake Copper.
- (12) This includes permissible Se.
- (13) This includes Cu + Ag + Cd; deoxidized with small amounts of Li or other suitable elements as agreed upon.
- (14) This includes Oxygen-Free Tellurium Bearing Copper which contains P in an amount agreed upon.
- (15) This includes Cu + Ag + Te.
- (16) Other deoxidizers may be used as agreed upon, in which case P need not be present.
- (17) This includes Cu + Ag + S.
- (18) Specific limits are defined as any numerical values, whether maximum only, minimum only, or ranges.

- (19) Ni + Co, 20% min.
Ni + Fe + Co, .6% max.
- (20) Analysis is regularly made for the elements for which specific limits are listed except Zn. If, however, the presence of other elements is suspected or indicated in the course of routine analysis, further analysis shall be made to determine that the total of these "other" elements is not in excess of the limits specified.
- (21) For pipe and tube, the Cu limit may be 83.0% min. and the Pb .06 max.
- (22) Al + Si, .005% max.
- (23) For tube over 5 inches O.D., the Pb may be less than .20%.
- (24) Copper, 61.0% min. for rod.
- (25) Copper, 60.0% min. for rod.
- (26) For flat products, the minimum tin content may be .8%.
- (27) Including Al and Pb.
- (28) Including Mn.
- (29) Including Zn.
- (30) Iron content shall not exceed nickel content.

INDEX TO STANDARD COPPERS AND COPPER ALLOYS .....	11

The standard commercial wrought coppers and copper alloys listed hereon are standard in the sense that over a period of years they have been the ones most commonly ordered, in the forms indicated, in large

quantities by consumers.

In addition to these alloys, there are many special and proprietary alloys which can be and are produced by the mills for various uses.

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT	FORMS MOST COMMONLY ORDERED					
			Indicated by (✓) or by reference to nearest applicable A S T M Specifications					
			Flat Products	Pipe	Rod	Shapes	Tube	Wire (except Flat)
101	19	Cu, 100	B48, B133, B152, B187, B272, B432, F68	B42, B188, F68	B12, B49, B133, B187, F68	B133, B187, F68	B68, B75, B188, B280, B372, F68	B1, B2, B3, F68
102	21	Cu, 100	B48, B133, B152, B187, B272, B370, B432	B42, B188	B12, B49, B124, B133, B187	B124, B133, B187	B68, B75, B88, B111, B188, B280, B359, B372, B395, B447	B1, B2, B3, B33, B47, B116, B189, B246, B286, B298, B355
104, 105 and 107	23	Cu + Ag, 100	B48, B133, B152, B187, B272	B42, B188	B12, B49, B133, B187	B133, B187	B68, B75, B188, B280, B372	B1, B2, B3
109	25	Cu + B + P, 100	B48, B133, B152, B187, B272, B432	B42, B188	B12, B49, B133, B187	B133, B187	B68, B75, B188, B280, B372	B1, B2, B3
110	27	Cu + O, 100	B11, B48, B101, B124, B133, B152, B187, B272, B370	B188	B12, B49, B124, B133, B187	B124, B133, B187, B283	B111, B188, B447	B1, B2, B3, B8, B33, B47, B49, B116, B189, B246, B286, B298, B355
111	29	Cu + O + Cd, 100	B272					B1
113, 114, 115 and 116	31	Cu + O + Ag, 100	B48, B101, B124, B133, B152, B187, B272	B188	B12, B49, B124, B133, B187	B124, B133, B187	B188	B1, B2, B3, B33, B47, B49, B116, B189, B246, B286, B298, B355
119, 120 and 121	33	Cu + P, 100	B133, B152, B187, B272	B42, B188, B302	B12, B133, B187	B133, B187	B68, B75, B88, B111, B188, B280, B306, B359, B372, B395, B447	
122	35	Cu + P, 100	B11, B101, B124, B133, B152, B370, B432	B42, B302	B12, B124, B133	B124, B133	B68, B75, B88, B111, B280, B306, B359, B360, B395, B447, B543	B260
125, 127, 128, 129 and 130	37	Cu + Ag, 100	B11, B124, B133, B152, B272		B12, B124, B133	B124, B133		
142	39	Cu + P + Ar, 100	B11		B12		B75, B111, B359, B395, B447	
143	41	Cu + Ag + Cd, 100	✓					

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					Wire (except Flat)
				Flat Products	Pipe	Rod	Shapes	Tube	
145	43	Cu 99.5 Te .50		B124, B301		B124, B301	B124, B301		✓
147	45	Cu 99.6 S .40		B301		B301			✓
150	47	Cu + Ag 99.80 Zr .15				✓			✓
155	49	Cu + Ag 99.83 P .06 Mg .11		✓					
162	51	Cu 99 Cd 1		✓		✓			B105
165	53	Cu 98.6 Cd .8 Sn .6		✓		✓			B105
170	55	Cu 98.3 Be 1.7		B194, B196		B196			
172	57	Cu 98.1 Be 1.9		B194, B196		B196	✓	✓	B197
173	57	Cu 97.7 Be 1.9 Pb .40		B196		B196	✓		
175	59	Cu 96.9 Co 2.5 Be .6		B441, B534		B441	✓	✓	
182	61	Cu 99.1 Cr .9		✓		✓	✓	✓	F9
184	61	Cu 99.2 Cr .8		✓		✓	✓	✓	F9
185	61	Cu 99.2 Cr .7 Ag .10		✓		✓	✓	✓	F9
187	63	Cu 99 Pb 1		B301		B301			
189	65	Cu 98.7 Sn .8 Si .3 Mn .2				✓			✓
190	67	Cu 98.65 Ni 1.1 P .25		✓		✓			✓
191	69	Cu 98.15 Ni 1.1 Te .50 P .25				✓			
192	71	Cu 98.97 Fe 1 P .03						B111, B359, B395, B469	
194	73	Cu 97.43 Fe 2.4 Zn .13 P .04		B465				B543	

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					Wire (except Flat)
				Indicated by (✓) or by reference to nearest applicable A S T M Specifications					
				Flat Products	Pipe	Rod	Shapes	Tube	
195	75	Cu 97.0 Fe 1.5 Sn .6 P .10 Co .8		✓					
210	77	Cu 95 Zn 5		B36, B134					B134
220	79	Cu 90 Zn 10		B36, B130, B131, B134		✓	B130, B131	B135, B372	B134
226	81	Cu 87.5 Zn 12.5		✓					✓
230	83	Cu 85 Zn 15		B36, B134	B43			B111, B135, B359, B395, B543	B134
240	85	Cu 80 Zn 20		B36, B134					B134
260	87	Cu 70 Zn 30		B19, B36, B134		✓	B129	B135	B134
268	89	Cu 66 Zn 34		B36, B134		✓		B135	B134
270	89	Cu 65 Zn 35		B36, B134		✓		B135	B134
280	91	Cu 60 Zn 40		✓		✓		B111, B135, B395	
314	93	Cu 89 Pb 1.9 Zn 9.1		B140		B140	B140		
316	95	Cu 89 Pb 1.9 Zn 8.1 Ni 1		B140		B140	B140		
330	97	Cu 66 Pb .5 Zn 33.5		B121		B453		B135	
332	99	Cu 66.5 Pb 1.7 Zn 31.8		B121		B453		B135	
335	101	Cu 64.5 Pb .5 Zn 35		B121		B453			
340	103	Cu 65 Pb 1 Zn 34		B121		B453			✓
342	105	Cu 64.5 Pb 2 Zn 33.5		B121		B453			
349	107	Cu 62.2 Pb .35 Zn 37.45				✓			✓

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					Wire (except Flat)
				Indicated by (✓) or by reference to nearest applicable A S T M Specifications					
				Flat Products	Pipe	Rod	Shapes	Tube	
350	109	Cu 62.5 Pb 1.1 Zn 36.4		B121		B453			
353	105	Cu 62 Pb 1.8 Zn 36.2		B121		B453			
356	111	Cu 62 Pb 2.5 Zn 35.5		B121		B453			
360	113	Cu 61.5 Pb 3 Zn 35.5		B16		B16	B16		
365, 366, 367 and 368	115	Cu 60 Pb .6 Zn 39.4		B171, B432					
370	117	Cu 60 Pb 1 Zn 39						B135	
377	119	Cu 60 Pb 2 Zn 38		B124		B124	B124, B283		
385	121	Cu 57 Pb 3 Zn 40				✓	B455		
411	123	Cu 90 Sn .5 Zn 9.5		B508					B105
413	125	Cu 90 Sn 1 Zn 9		✓		✓			✓
425	127	Cu 88.5 Sn 2 Zn 9.3 P .20		✓					
435	129	Cu 81 Sn .9 Zn 18.1		✓				✓	
443, 444 and 445	131	Cu 71 Sn 1 Zn 28		B171, B432				B111, B359, B395	✓
464, 465, 466 and 467	133	Cu 60 Sn .8 Zn 39.2		B21, B124, B171, B432		B21, B124	B21, B124, B283	✓	
482	135	Cu 60.5 Pb .7 Sn .8 Zn 38		B21		B21	B21		
485	137	Cu 60 Pb 1.8 Sn .7 Zn 37.5		B21, B124		B21, B124	B21, B124, B283		

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					Wire (except Flat)
				Indicated (✓) or by reference to nearest applicable A S T M Specifications					
				Flat Products	Pipe	Rod	Shapes	Tube	
505	139	Cu 98.7 Sn 1.3		B508					B105
510	141	Cu 95 Sn 5		B100, B103, B139		B139	B139		B159
511	143	Cu 95.6 Sn 4.2 P .2		B103					
521	145	Cu 92 Sn 8		B103, B139		B139	B139		B159
524	147	Cu 90 Sn 10		B103, B139		B139	B139		B159
544	149	Cu 88 Pb 4 Sn 4 Zn 4		B103, B139		B139	B139		
608	151	Cu 95 Al 5						B111, B359, B395	
610	153	Cu 92 Al 8				✓			✓
613	155	Cu 92.65 Sn .35 Al 7.0		B169, B171		B150			
614	157	Cu 91 Fe 2 Al 7		B150, B169, B171, B432	✓	B150	B150	✓	✓
618	159	Cu 89 Fe 1 Al 10				✓			
619	161	Cu 86.5 Fe 4 Al 9.5		✓					
623	163	Cu 87 Fe 3 Al 10		✓		B150			
624	165	Cu 86 Fe 3 Al 11		✓		✓			
625	167	Cu 82.7 Fe 4.3 Al 13		✓		✓			
630	169	Cu 82 Fe 3 Al 10 Ni 5		B124, B150		B124, B150	B150		
632	171	Cu 82 Fe 4 Al 9 Ni 5		✓		✓	✓		
638	173	Cu 95 Al 2.8 Si 1.8 Co .40		✓					

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COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					Wire (except Flat)
				Indicated by (✓) or by reference to nearest applicable A S T M Specifications					
				Flat Products	Pipe	Rod	Shapes	Tube	
642	175	Cu Al Si	91.2 7.0 1.8	B124, B150		B124, B150	B124, B150, B283		
651	177	Cu Si	98.5 1.5	B97, B98, B432	B315	B98	B98	B315	B99, B105
655	179	Cu Si	97 3	B96, B97, B98, B100, B124, B432	B315	B98, B124	B98, B124, B283	B315	B99
667	181	Cu Zn Mn	70 28.8 1.2	B291					✓
674	183	Cu Zn Al Mn Si	58.5 36.5 1.2 2.8 1.0	✓		✓	✓		
675	185	Cu Fe Sn Zn Mn	58.5 1.4 1 39.0 .1	B124, B138		B124, B138	B124, B138, B283		
687	187							B111, B359, B395	
688	189	Cu Zn Al Co	73.5 22.7 3.4 .40	✓					
694	191	Cu Zn Si	81.5 14.5 4.0			B371			
706	193	Cu Fe Ni	88.6 1.4 10	B122, B151, B171, B402, B432	B466, B467	B151		B111, B359, B395, B466, B467, B543, B552	
710	195	Cu Ni	79 21	B122	B466, B467			B111, B359, B395, B466, B467	B206
715	197	Cu Ni	70 30	B122, B151, B171, B402, B432	B466, B467	B151		B111, B359, B395, B466, B467, B543, B552	
725	199	Cu Ni Sn	88.2 9.5 2.3	✓					✓
745	201	Cu Zn Ni	65 25 10	B122, B151		B151			B206
752	203	Cu Zn Ni	65 17 18	B122, B151, B206		B151			B206
754	205	Cu Zn Ni	65 20 15	✓					

COPPER OR COPPER ALLOY NO.	PAGE NO.	NOMINAL COMPOSITION PERCENT		FORMS MOST COMMONLY ORDERED					
				Indicated by (✓) or by reference to nearest applicable A S T N Specifications					
				Flat Products	Pipe	Rod	Shapes	Tube	Wire (except Flat)
757	207	Cu 65 Pb 2 Zn 25 Ni 8		✓					✓
770	209	Cu 55 Zn 27 Ni 18		B122, B151, B206		B151			B206
782	211	Cu 65 Pb 2 Zn 25 Ni 8		✓					

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COPPER No. 101 (OXYGEN FREE ELECTRONIC)

Composition — percent

	Nominal	Minimum	Maximum
Copper		99.99	....
Residual Deoxidants		None	
Phosphorus			.0003
Tellurium			.0010
Other Named Elements**			

* Hg, max., 1 ppm, (.0001%); Zn, max., 1 ppm, (.0001%); Cd, max., 1 ppm, (.0001%); S, max., 18 ppm, (.0018%); Pb, max., 10 ppm, (.0010%); Se, max., 10 ppm (.0010%); Bi, max., 10 ppm (.0010%); Oxygen max., 10 ppm, (.0010%).

** The total of the seven following elements, Se, Te, Bi, As, Sb, Sn and Mn not to exceed 40 ppm, (.0040%).

Nearest Applicable A S T M Specifications

Flat Products	B48, B133, B152, B187 B272, B432, F68
Pipe	B42, B188, F68
Rod	B12, B49, B133 B187, F68
Shapes	B133, B187, F68
Tube	B68, B75, B188, B280 B372, F68
Wire	B1, B2, B3, F68

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1981 F	1083 C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	226 Btu/sq ft /ft /hr °F @ 68 F	.934 cal/sq cm /cm /sec °C @ 20 C
Electrical Resistivity (Annealed)	10.3 Ohms (circ mil /ft) @ 68 F	1.71 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101 % IACS @ 68 F	.586 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume and weight basis, minimum value

Typical Uses

ELECTRICAL AND ELECTRONIC:

bus bars, bus conductors and other conductors, wave guides, hollow conductors, lead-in wires and anodes for vacuum tubes, vacuum seals, transistor components, glass to metal seals, coaxial cables and coaxial tubes, klystrons, micro-wave tubes, automotive rectifiers

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	65
Hot Working Temperature	1400-1600 F or 750-875 C
Annealing Temperature	700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Fair
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Not Recommended

Resistance Welding

Spot	Not Recommended
Seam	Not Recommended
Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

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COPPER No. 101 (Continued)

Forms and Tempers
Most Commonly Used

		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers	
		Nominal Grain Size mm																As Hot Rolled	As Extruded
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)
																		Light Drawn - Bending (3)	
FLAT PRODUCTS	Strip, Rolled																		
	Strip, Drawn																		
	Flat Wire, Rolled																		
	Flat Wire, Drawn																		
	Bar, Rolled																		
	Bar, Drawn																		
	Sheet																		
	Plate																		
	ROD																		
	WIRE																		
	TUBE																		
	PIPE																		
	SHAPES																		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	32.0	10.0		45	40	-	-	22.0		
		.025 mm	34.0	11.0		45	45	-	-	23.0		
		Eighth Hard	36.0	28.0		30	60	10	25	25.0		
		Quarter Hard	38.0	30.0		25	70	25	36	25.0		
		Half Hard	42.0	36.0		14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0		6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0		4	94	60	63	29.0	14.0	100
		Extra Spring	57.0	53.0		4	95	62	64	29.0		
		As Hot Rolled	34.0	10.0		45	45	-	-	23.0		
	.250 in.	.050 mm	32.0	10.0		50	40	-	-	22.0		
		Eighth Hard	36.0	28.0		40	60	10	-	25.0		
		Quarter Hard	38.0	30.0		35	70	25	-	25.0		
		Hard	50.0	45.0		12	90	50	-	28.0		
		As Hot Rolled	32.0	10.0		50	40	-	-	22.0		
	1.0 in.	Hard	45.0	40.0		20	85	45	-	26.0		
	ROD	1.0 in. .050 mm	32.0	10.0		55	40	-	-	22.0		
		.250 in. Hard (40%)	55.0	50.0		10	94	60	-	29.0		
		1.0 in. Hard (35%)	48.0	44.0		16	87	47	-	27.0	17.0	100
		2.0 in. Hard (16%)	45.0	40.0		20	85	45	-	26.0		
		1.0 in. As Hot Rolled	32.0	10.0		55	40	-	-	22.0		
WIRE	.080 in.	.050 mm	35.0			35*	-	-	-	24.0		
		Hard	55.0			1.5**	-	-	-	29.0		
		Spring	66.0			1.5**	-	-	-	33.0		
TUBE	1.0 in. OD X .065 in.	.050 mm	32.0	10.0		45	40	-	-	22.0		
		.025 mm	34.0	11.0		45	45	-	-	23.0		
		Light Drawn (15%)	40.0	32.0		25	77	35	45	26.0		
		Hard Drawn (40%)	55.0	50.0		8	95	60	63	29.0		
SHAPES	.500 in.	.050 mm	32.0	10.0		50	40	-	-	22.0		
		Hard (15%)	40.0	32.0		30	-	35	-	26.0		
		As Hot Rolled	32.0	10.0		50	40	-	-	22.0		
		As Extruded	32.0	10.0		50	40	-	-	22.0		

* Elongation in 10 inches.

** Elongation in 60 inches.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 102 (OXYGEN FREE)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)		99.95	....
Residual Deoxidants		None	

Nearest Applicable A S T M Specifications

Flat Products	B48, B133, B152, B187, B272, B370, B432
Pipe	B42, B188
Rod	B12, B49, B124, B133, B187
Shapes	B124, B133, B187
Tube	B68, B75, B88, B111, B188, B280, B359, B372, B395, B447
Wire	B1, B2, B3, B33, B47, B116, B189, B246, B286, B298, B355

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1981 F	1083 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 212 F	.0000170 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	226 Btu /sq ft /ft /hr /°F @ 68 F	.934 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.3 Ohms (circ mil /ft) @ 68 F	1.71 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101 % IACS @ 68 F	.586 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis.

Typical Uses

ELECTRICAL: bus bars and bus conductors, and other electrical conductors, wave guides, copper to glass seals in electronic appliances

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed..... Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 700-1200 F or 375-650 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing Excellent
 Oxyacetylene Welding..... Fair
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Not Recommended

Resistance Welding

Spot Not Recommended
 Seam..... Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 102 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
		.100	.070	.050	.035	.025	.015																
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
	TUBE																						
	PIPE																						
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	32.0	10.0		45	40	-	-	22.0		
		.025 mm	34.0	11.0		45	45	-	-	23.0	11.0	100
		Eighth Hard	36.0	28.0		30	60	10	25	25.0		
		Quarter Hard	38.0	30.0		25	70	25	36	25.0		
		Half Hard	42.0	36.0		14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0		6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0		4	94	60	63	29.0	14.0	100
		Extra Spring	57.0	53.0		4	95	62	64	29.0		
		As Hot Rolled	34.0	10.0		45	45	-	-	23.0		
	.250 in.	.050 mm	32.0	10.0		50	40	-	-	22.0		
		Eighth Hard	36.0	28.0		40	60	10	-	25.0		
		Quarter Hard	38.0	30.0		35	70	25	-	25.0		
		Hard	50.0	45.0		12	90	50	-	28.0		
		As Hot Rolled	32.0	10.0		50	40	-	-	22.0		
	1.0 in.	Hard	45.0	40.0		20	85	45	-	26.0		
ROD	1.0 in.	.050 mm	32.0	10.0		55	40	-	-	22.0		
	.250 in.	Hard (40%)	55.0	50.0		10	94	60	-	29.0		
	1.0 in.	Hard (35%)	48.0	44.0		16	87	47	-	27.0	17.0	100
	2.0 in.	Hard (16%)	45.0	40.0		20	85	45	-	26.0		
	1.0 in.	As Hot Rolled	32.0	10.0		55	40	-	-	22.0		
WIRE	.080 in.	.050 mm	35.0			35*	-	-	-	24.0		
		Hard	55.0			1.5**	-	-	-	29.0		
		Spring	66.0			1.5**	-	-	-	33.0		
TUBE	1.0 in. OD	.050 mm	32.0	10.0		45	40	-	-	22.0		
	X .065 in.	.025 mm	34.0	11.0		45	45	-	-	23.0		
		Light Drawn (15%)	40.0	32.0		25	77	35	45	26.0		
		Hard Drawn (40%)	55.0	50.0		8	95	60	63	29.0		
SHAPES	.500 in.	.050 mm	32.0	10.0		50	40	-	-	22.0		
		Hard (15%)	40.0	32.0		30	-	35	-	26.0		
		As Hot Rolled	32.0	10.0		50	40	-	-	22.0		
		As Extruded	32.0	10.0		50	40	-	-	22.0		

* Elongation in 10 inches.

** Elongation in 60 inches.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER Nos. 104, 105 and 107 (OXYGEN FREE WITH SILVER)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver) Silver*		9995	....
Copper No. 104		.027(8)	....
Copper No. 105		.034(10)	....
Copper No. 107		.085(25)	....

* Figures in parentheses are troy ounces per avoirdupois ton.

Nearest Applicable A S T M Specifications

Flat Products	B48, B133, B152, B187, B272
Pipe	B42, B188
Rod	B12, B49, B133, B187
Shapes	B133, B187
Tube	B68, B75, B188, B280, B372
Wire	B1, B2, B3

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1981 F	1083 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 212 F	.0000170 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	224 Btu /sq ft /ft /hr /°F @ 68 F	.927 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.4 Ohms (circ mil /ft) @ 68 F	1.72 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	100 % IACS @ 68 F	.580 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume and weight basis

Typical Uses

AUTOMOTIVE:	gaskets, radiators
ELECTRICAL:	bus bars, conductivity wire, contacts, radio parts, windings, switches, terminals, commutator segments
MISCELLANEOUS:	chemical process equipment, printing rolls, clad metals, printed circuit foil; also where brazing in a hydrogen atmosphere

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	65
Hot Working Temperature... 1400 - 1600... F or 750-875 C	
Annealing Temperature..... 900 - 1400... F or 475-750 C	
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Fair
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Not Recommended
Resistance Welding { Spot	Not Recommended
Seam	Not Recommended
Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

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COPPER Nos. 104, 105 and 107 (Continued)

Forms and Tempers
Most Commonly Used

		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers	
		Nominal Grain Size mm																As Hot Rolled	As Extruded
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Strip, Drawn	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Flat Wire, Rolled	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Flat Wire, Drawn	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Bar, Rolled	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Bar, Drawn	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Sheet	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Plate	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	ROD	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	WIRE	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
PIPE	TUBE	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	SHAPES	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section In.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm.....	34.0	11.0	.....	45	45	-	-	23.0	.....	.....
		Eighth Hard	36.0	28.0	.....	30	60	10	25	25.0	.....	.....
		Quarter Hard	38.0	30.0	.....	25	70	25	36	25.0	.....	.....
		Half Hard	42.0	36.0	.....	14	84	40	50	26.0	.....	.....
		Hard	50.0	45.0	.....	6	90	50	57	28.0	.....	.....
		Spring	55.0	50.0	.....	4	94	60	63	29.0	.....	.....
		Extra Spring	57.0	53.0	.....	4	95	62	64	29.0	.....	.....
	.250 in.	As Hot Rolled	34.0	10.0	.....	45	45	-	-	23.0	.....	.....
		.050 mm.....	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		Eighth Hard	36.0	28.0	.....	40	60	10	-	25.0	.....	.....
		Quarter Hard	38.0	30.0	.....	35	70	25	-	25.0	.....	.....
		Hard	50.0	45.0	.....	12	90	50	-	28.0	.....	.....
		As Hot Rolled	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		Hard	45.0	40.0	.....	20	85	45	-	26.0	.....	.....
ROD	1.0 in.	.050 mm.....	32.0	10.0	.....	55	40	-	-	22.0	.....	.....
	.250 in.	Hard (40%)	55.0	50.0	.....	10	94	60	-	29.0	.....	.....
	1.0 in.	Hard (35%)	48.0	44.0	.....	16	87	47	-	27.0	.....	.....
	2.0 in.	Hard (16%)	45.0	40.0	.....	20	85	45	-	26.0	.....	.....
	1.0 in.	As Hot Rolled	32.0	10.0	.....	55	40	-	-	22.0	.....	.....
WIRE	.080 in.	.050 mm.....	35.0	.....	.....	35*	-	-	-	24.0	.....	.....
		Hard	55.0	.....	.....	1.5**	-	-	-	29.0	.....	.....
		Spring	66.0	.....	.....	1.5**	-	-	-	33.0	.....	.....
SHAPES	.500 in.	.050 mm.....	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		Hard (15%)	40.0	32.0	.....	30	-	35	-	26.0	.....	.....
		As Hot Rolled	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		As Extruded	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
TUBE	1.0 in. O.D. x .065 in.	.050 mm.....	32.0	10.0	.....	45	40	-	-	22.0	.....	.....
		.025 mm.....	34.0	11.0	.....	45	45	-	-	23.0	.....	.....
		Light Drawn (15%) ..	40.0	32.0	.....	25	77	35	45	26.0	.....	.....
		Hard Drawn (40%) ..	55.0	50.0	.....	8	95	60	62	29.0	.....	.....

* Elongation in 10 inches

** Elongation in 60 inches

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 109 (BORON DEOXIDIZED HIGH CONDUCTIVITY)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)			
+ Boron	.....	99.99	.....
Boron	.010	.005	.015
Phosphorus	.....	.....	.0005

The total of the seven following elements, Se, Te, Bi, As, Sb, Sn and Mn not to exceed 40 ppm, (.0040%).

S, max., 15 ppm, (.0015%); Cd, max., 3 ppm, (.0003%); Zn, max., 5 ppm, (.0005%); Hg, max., 1 ppm, (.0001%); Pb, max., 10 ppm, (.0010%); B, (.005-.015%).

Nearest Applicable A S T M Specifications

Flat Products	B48, B133, B152, B187, B272, B432
Pipe	B42, B188
Rod	B12, B49, B133, B187
Shapes	B133, B187
Tube	B68, B75, B188, B280, B372
Wire	B1, B2, B3

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1981 F	1083 C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	226 Btu/sq ft /ft /hr /°F @ 68 F	.934 cal/sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.3 Ohms (circ mil /ft) @ 68 F	1.71 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101 % IACS @ 68 F	.586 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume and weight basis

Typical Uses

ELECTRICAL: bus bars and bus conductors, communications cable shielding, electronic devices, waveguides, vacuum and conventional switchgear, microwave components, heatsinks, copper to glass sealing, pinch off tubes, clad metal

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100) 65
Hot Working Temperature..... 1400-1600F or 750-875 C
Annealing Temperature 575-1300F or 300-700 C
Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering..... Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Good
Coated Metal Arc Welding..... Not Recommended
Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 109 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	....	....
		.025 mm.	34.0	11.0	....	45	45	-	-	23.0	11.0	100
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100
	.250 in.	Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
		As Hot Rolled	34.0	10.0	....	45	45	-	-	23.0	....	....
		.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	-	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	-	25.0	....	....
		Hard	50.0	45.0	....	12	90	50	-	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
	1.0 in.	Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
ROD	1.0 in.	.050 mm.	32.0	10.0	....	55	40	-	-	22.0	....	....
	.250 in.	Hard (40%)	55.0	50.0	....	10	94	60	-	29.0	....	....
	1.0 in.	Hard (35%)	48.0	44.0	....	16	87	47	-	27.0	17.0	100
	2.0 in.	Hard (16%)	45.0	40.0	....	20	85	45	-	26.0	....	....
WIRE	.080 in.	.050 mm.	35.0	....	....	35*	-	-	-	24.0	....	....
		Hard	55.0	....	....	15**	-	-	-	29.0	....	....
		Spring	66.0	....	....	15**	-	-	-	33.0	....	....
TUBE	1.0 in. O.D.	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	....	....
	x .065 in.	.025 mm.	34.0	11.0	....	45	40	-	-	23.0	....	....
		Light Drawn (15%)	40.0	32.0	....	25	77	35	45	26.0	....	....
		Hard Drawn (40%)	55.0	50.0	....	8	95	60	63	29.0	....	....
SHAPES	.500 in.	.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
		Hard (15%)	40.0	32.0	....	30	-	35	-	26.0	....	....
		As Extruded	32.0	10.0	....	50	40	-	-	22.0	....	....

* Elongation in 10 inches

** Elongation in 60 inches

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 110 (ELECTROLYTIC TOUGH PITCH)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	....	99.90	....
Oxygen	.04	....	....

Nearest Applicable A S T M Specifications

Flat Products	B11, B48, B101, B124, B133, B152, B187, B272, B370
Pipe	B188
Rod	B12, B49, B124, B133, B187
Shapes	B124, B133, B187, B283
Tube	B111, B188, B447
Wire	B1, B2, B3, B8, B33, B47, B49, B116, B189, B246, B286, B298, B355

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1949 F	1065 C
Density	.321 - .323 lb/cu in @ 68 F	8.89 - 8.94 gm/cu cm @ 20 C.
Specific Gravity	8.89 - 8.94	8.89 - 8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	226 Btu/sq ft/ft/hr/°F @ 68 F	.934 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	10.3 Ohms (circ mil/ft) @ 68 F	1.71 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	101 % IACS @ 68 F	.586 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume and Weight Basis

Typical Uses

- ARCHITECTURAL: building fronts, downspouts, flashing, gutters, roofing, screening, spouting
 AUTOMOTIVE: gaskets, radiators
 ELECTRICAL: bus bars, conductivity wire, contacts, radio parts, switches, terminals
 HARDWARE: ball floats, butts, cotter pins, nails, rivets, soldering copper, tacks
 MISCELLANEOUS: anodes, chemical process equipment, kettles, pans, printing rolls, rotating bands, road bed expansion plates, vats

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 700-1200 F or 375-650 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 110 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)		Light Drawn – Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties			Yield Strength			Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength			
Form	Size Section	Temper	Tensile Strength	(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	ksi	Million Cycles	
	in.		ksi	ksi	ksi	%								
FLAT PRODUCTS	.040 in.	.050 mm	32.0	10.0	....	45	40	-	-	22.0	....	....		
		.025 mm	34.0	11.0	....	45	45	-	-	23.0	11.0	100		
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....		
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....		
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100		
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100		
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100		
		Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....		
		As Hot Rolled	34.0	10.0	....	45	45	-	-	23.0	....	....		
	.025 in.	.050 mm	32.0	10.0	....	50	40	-	-	22.0	....	....		
		Eighth Hard	36.0	28.0	....	40	60	10	-	25.0	....	....		
		Quarter Hard	38.0	30.0	....	35	70	25	-	25.0	....	....		
		Hard	50.0	45.0	....	12	90	50	-	28.0	....	....		
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....		
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....		
	1.0 in	Hard	45.0	40.0	....	20	85	45	-	26.0	....	....		
		ROD	1.0 in.	.050 mm	32.0	10.0		55	40	-	-	22.0		
			.250 in.	Hard (40%)	55.0	50.0		10	94	60	-	29.0		
1.0 in.			Hard (35%)	48.0	44.0		16	87	47	-	27.0	17.0	100	
2.0 in.	Hard (16%)		45.0	40.0	....	20	85	45	-	26.0	....	....		
1.0 in.	As Hot Rolled		32.0	10.0	....	55	40	-	-	22.0	....	....		
WIRE	.080 in.	.050 mm	35.0	....	....	35*	-	-	-	24.0	....	....		
		Hard	55.0	....	....	1.5**	-	-	-	29.0	....	....		
		Spring	66.0	....	....	1.5**	-	-	-	33.0	....	....		
TUBE	1.0 in.OD X.065 in.	.050 mm	32.0	10.0	....	45	40	-	-	22.0	....	....		
		.025 mm	34.0	11.0	....	45	45	-	-	23.0	....	....		
		Light Drawn (15%)	40.0	32.0	....	25	77	35	45	26.0	....	....		
		Hard Drawn (40%)	55.0	50.0	....	8	95	60	63	29.0	....	....		
SHAPES	.500 in.	.050 mm	32.0	10.0	....	50	40	-	-	22.0	....	....		
		Hard (15%)	40.0	32.0	....	30	-	35	-	26.0	....	....		
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....		
		As Extruded	32.0	10.0	....	50	40	-	-	22.0	....	....		

* Elongation in 10 inches. ** Elongation in 60 inches.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 111 (ELECTROLYTIC TOUGH PITCH, ANNEAL RESISTANT)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	....	99.90	....
Oxygen	.04	....	....
Cadmium or other Elements	.01	....	....

Nearest Applicable A S T M Specifications

Flat Products	B272
Pipe	
Rod	
Shapes	
Tube	
Wire	B1

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1949 F	1065 C
Density	.321-.323 lb /cu in @ 68 F	8.89-8.94 gm /cu cm @ 20 C.
Specific Gravity	8.89-8.94	8.89-8.94
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 212 F	.0000170 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	224 Btu /sq ft /ft /hr /° F @ 68 F	.927 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	.10.4 Ohms (circ mil /ft) @ 68 F	1.72 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	100 % IACS @ 68 F	.580 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb ° F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume and weight basis

Typical Uses

Electrical power transmission where resistance to softening under overloads is desired

Common Fabrication Processes

Drawing and stranding, stamping

Fabrication Properties

Capacity for Being Cold WorkedExcellent
 Capacity for Being Hot FormedExcellent
 Hot Forgeability Rating (Forging Brass = 100)65
 Hot Working Temperature..... 1400-1600 F or 750-875 C
 Annealing Temperature..... 900-1400 F or 475-750 C
 Machinability Rating (Free Cutting Brass = 100).....20
 Typical Softening Temperature675° F

Suitability for being joined by:

Soldering..... Excellent
 Brazing..... Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding..... Fair
 Coated Metal Arc Welding..... Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam..... Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 111 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength (.5% Ext. under Load)		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.2% Offset)			F	B	30T		ksi	Million Cycles
WIRE	.080 in.	Hard	66.0	....	....	1.5*	-	-	-	33.0	....	....

* Elongation in 60 inches.

COPPER Nos. 113, 114, 115 and 116 (TOUGH PITCH WITH SILVER)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	....	99.90	....
Silver*			
No. 113	....	.027(8)	....
No. 114	....	.034(10)	....
No. 115	....	.054(16)	....
No. 116	....	.085(25)	....
Oxygen	.04	....	....

* Figures in parentheses are troy ounces per avoirdupois ton

Nearest Applicable A S T M Specifications

Flat Products	B48, B101, B124, B133, B152, B187, B272
Pipe	B188
Rod	B12, B49, B124, B133, B187
Shapes	B124, B133, B187
Tube	B188
Wire	B1, B2, B3, B33, B47, B49, B116, B189, B246, B286, B298, B355

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1980 F	1082 C
Melting Point (Solidus)	F	C
Density	.321 - .323 lb /cu in @ 68 F	8.89 - 8.94 gm /cu cm @ 20 C.
Specific Gravity	8.89 - 8.94	8.89 - 8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	224 Btu /sq ft /ft /hr /°F @ 68 F	.927 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.4 Ohms (circ mil /ft) @ 68 F	1.72 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	100 % IACS @ 68 F	.580 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

AUTOMOTIVE: gaskets, radiators

ELECTRICAL: bus bars, conductivity wire, contacts, radio parts, windings, switches, terminals, commutator segments

MISCELLANEOUS: chemical process equipment, printing rolls, clad metals, printed circuit foil

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)..... 65
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 900-1400 F or 475-750 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing Good
 Oxyacetylene Welding..... Not Recommended
 Gas Shielded Arc Welding..... Fair
 Coated Metal Arc Welding..... Not Recommended

Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER Nos. 113, 114, 115 and 116 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm	34.0	11.0	....	45	45	-	-	23.0	....	....
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	....	....
		Hard	50.0	45.0	....	6	90	50	57	28.0	....	....
		Spring	55.0	50.0	....	4	94	60	63	29.0	....	....
		Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
	.250 in.	As Hot Rolled	34.0	10.0	....	45	45	-	-	23.0	....	....
		.050 mm	32.0	10.0	....	50	40	-	-	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	-	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	-	25.0	....	....
		Hard	50.0	45.0	....	12	90	50	-	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
	1.0 in.	Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
ROD	1.0 in.	.050 mm	32.0	10.0	....	55	40	-	-	22.0	....	....
	.250 in.	Hard (40%)	55.0	50.0	....	10	94	60	-	29.0	....	....
	1.0 in.	Hard (35%)	48.0	44.0	....	16	87	47	-	27.0	....	....
	2.0 in.	Hard (16%)	45.0	40.0	....	20	85	45	-	26.0	....	....
	1.0 in.	As Hot Rolled	32.0	10.0	....	55	40	-	-	22.0	....	....
WIRE	.080 in.	.050 mm	35.0	....	....	35*	-	-	-	24.0	....	....
		Hard	55.0	....	....	1.5**	-	-	-	29.0	....	....
		Spring	66.0	....	....	1.5**	-	-	-	33.0	....	....
SHAPES	.500 in.	.050 mm	32.0	10.0	....	50	40	-	-	22.0	....	....
		Hard (15%)	40.0	32.0	....	30	-	35	-	26.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
		As Extruded	32.0	10.0	....	50	40	-	-	22.0	....	....

* Elongation in 10 inches.

** Elongation in 60 inches.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER Nos. 119, 120 and 121

Phosphorized High Conductivity; Phosphorus Deoxidized, Low Residual Phosphorus (DLP); Phosphorus Deoxidized, Low Residual Phosphorus, Silver Bearing

Composition — percent

	Nominal	Minimum	Maximum
Copper No. 119			
Copper (incl. Silver)	....	99.93	....
Phosphorus	.006	.002	.010
Copper No. 120			
Copper (incl. Silver)	....	99.90	....
Phosphorus	.008	.004	.012
Copper No. 121			
Copper (incl. Silver)	....	99.90	....
Silver*	....	.014(4)	....
Phosphorus	.008	.005	.012

Nearest Applicable A S T M Specifications **

Flat Products	B133, B152, B187, B272
Pipe	B42, B188, B302
Rod	B12, B133, B187
Shapes	B133, B187
Tube	B68, B75, B88, B111, B188, B280, B306, B359, B372, B395, B447
Wire	

* Figure in parentheses is troy ounces per avoirdupois ton
 ** Refer to specific ASTM specifications for alloys covered

Physical Properties

	English Units	C.G.S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	1981 F	1083 C
Density	.323 lb./cu in. @ 68 F	8.94 gm /cu cm @ 20 C
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	Btu /sq ft/ft/hr/°F @ 68 F	cal/sq cm/cm/sec/°C @ 20 C
Copper No. 119	224	.927
Copper Nos. 120-121	223	.910
Electrical Resistivity (Annealed)	Ohms (circ mil/ft) @ 68 F	Microhm-cm @ 20 C
Copper No. 119	10.4	1.72
Copper Nos. 120-121	10.6	1.76
Electrical Conductivity* (Annealed)	% IACS @ 68 F	Megmho-cm @ 20 C
Copper No. 119	100	.580
Copper Nos. 120-121	98	.568
Thermal Capacity (Specific Heat)	.092 Btu/lb/°F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume Basis

Typical Uses

Bus bars, electrical conductors, tubular bus and applications requiring welding or brazing

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature . . . 1400-1600 F or 750-875 C
 Annealing Temperature 700-1200 F or 375-650 C
 Machinability Rating (Free Cutting Brass = 100). 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER Nos. 119, 120 and 121 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)		Light Drawn — Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled	•	•							•	•												
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet	•								•	•												
	Plate	•								•													
	ROD																						
	WIRE																						
TUBE	•				•		•							•				•	•	•			
PIPE							•							•				•					
SHAPES							•							•				•					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm.	32.0	10.0	....	45	40	-	-	32.0	....	....
		.025 mm.	34.0	11.0	....	45	45	-	-	23.0	11.0	100
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100
	.250 in.	Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
		As Hot Rolled	34.0	10.0	....	45	45	-	-	23.0	....	....
		.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	-	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	-	25.0	....	....
		Hard	50.0	45.0	....	12	90	50	-	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
ROD	1.0 in.	Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
	1.0 in.	.050 mm.	32.0	10.0	....	55	40	-	-	22.0	....	....
	.250 in.	Hard (40%)	55.0	50.0	....	20	94	60	-	29.0	....	....
	1.0 in.	Hard (35%)	48.0	44.0	....	16	87	47	-	27.0	17.0	100
	2.0 in.	Hard (16%)	45.0	40.0	....	20	85	45	-	26.0	....	....
PIPE	1.0 in.	As Hot Rolled	32.0	10.0	....	55	40	-	-	22.0	....	....
	¾ in. SPS	Hard (30%)	50.0	45.0	....	10	90	50	-	28.0	....	....
TUBE	1.0 in. OD	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	....	....
	x.065 in.	.025 mm.	34.0	11.0	....	45	45	-	-	23.0	....	....
		Light Drawn (15%) ..	40.0	32.0	....	25	77	35	45	26.0	....	....
		Hard Drawn (40%) ..	55.0	50.0	....	8	95	60	63	29.0	....	....
SHAPES	.500 in.	.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
		Hard (15%)	40.0	32.0	....	30	-	35	-	22.6	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
		As Extruded	32.0	10.0	....	50	40	-	-	22.0	....	....

COPPER No. 122 (PHOSPHORUS DEOXIDIZED, HIGH RESIDUAL PHOSPHORUS)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	.....	99.90	.....
Phosphorus	.02	.015	.040

Nearest Applicable A S T M Specifications

Flat Products	B11, B101, B124, B133, B152, B370, B432
Pipe	B42, B302
Rod	B12, B124, B133
Shapes	B124, B133
Tube	B68, B75, B88, B111, B280, B306, B359, B360, B395, B447, B543
Wire	B260

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	F	C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 212 F	.0000170 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000095 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	196 Btu /sq ft /ft /hr /°F @ 68 F	.81 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	12.2 Ohms (circ mil /ft) @ 68 F	2.03 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	85 % IACS @ 68 F	.493 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume and Weight Basis

Typical Uses

HOUSEHOLD:	air conditioners, gas lines, heater lines and units, oil burner tubes, plumbing pipe and tube, refrigerators
INDUSTRIAL:	air conditioners, brewery tubes, condenser, evaporator and heat exchanger tubes, dairy tubes, distiller tubes, kettles, pulp and paper lines, steam and water lines, tanks
TRANSPORTATION:	(Air, Land and Sea): air, gasoline, hydraulic and oil lines, oil coolers
MISCELLANEOUS:	gage lines, rotating bands

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	65
Hot Working Temperature	1400-1600 F or 750-875 C
Annealing Temperature	700-1200 F or 375-650 C
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Good
Gas Shielded Arc Welding	Excellent
Coated Metal Arc Welding	Not Recommended
Resistance Welding { Spot	Not Recommended
Seam	Not Recommended
Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 122 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled			●																			
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet			●																		●	
	Plate			●																		●	
	ROD			●											●								
	WIRE			●																			
TUBE		●			●													●	●	●			
PIPE														●									
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	....	....
		.025 mm.	34.0	11.0	....	45	45	-	-	23.0	11.0	100
		Eighth Hard	36.0	28.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	38.0	30.0	....	25	70	25	36	25.0	....	....
		Half Hard	42.0	36.0	....	14	84	40	50	26.0	13.0	100
		Hard	50.0	45.0	....	6	90	50	57	28.0	13.0	100
		Spring	55.0	50.0	....	4	94	60	63	29.0	14.0	100
		Extra Spring	57.0	53.0	....	4	95	62	64	29.0	....	....
	.250 in.	As Hot Rolled.	34.0	10.0	....	45	45	-	-	23.0	....	....
		.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
		Eighth Hard	36.0	28.0	....	40	60	10	-	25.0	....	....
		Quarter Hard	38.0	30.0	....	35	70	25	-	25.0	....	....
	1.0 in.	Hard	50.0	45.0	....	12	90	50	-	28.0	....	....
		As Hot Rolled	32.0	10.0	....	50	40	-	-	22.0	....	....
		Hard	45.0	40.0	....	20	85	45	-	26.0	....	....
TUBE	1.0 in. OD X .065 in.	.050 mm	32.0	10.0	....	45	40	-	-	22.0	11.0*	20
		.025 mm	34.0	11.0	....	45	45	-	-	23.0	....	....
		Light Drawn (15%) ..	40.0	32.0	....	25	77	35	45	26.0	14.0*	20
		Hard Drawn (40%) ..	55.0	50.0	....	8	95	60	63	29.0	19.0*	20
PIPE	¾ in. SPS	Hard (30%)	50.0	45.0	....	10	90	50	-	28.0	....	....

* Rotating beam tests on rod

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER Nos. 125, 127, 128, 129 and 130

(FIRE REFINED TOUGH PITCH WITH SILVER)

Composition — percent

Nearest Applicable A S T M Specifications **

	Nominal	Minimum	Maximum
Copper (incl. Silver*)		99.88	....
Arsenic			.012
Antimony			.003
Tellurium + Selenium			.025
Nickel			.050
Bismuth			.003
Lead			.004

* Minimum Silver Content

	percent	oz/ton
Copper No. 127	.027	8
Copper No. 128	.034	10
Copper No. 129	.054	16
Copper No. 130	.085	25

Flat Products
Pipe
Rod
Shapes
Tube
Wire

B11, B124, B133, B152, B272
B12, B124, B133
B124, B133

** Refer to specific
ASTM specifications
for alloys covered

Physical Properties

English Units

C. G. S. Units

Melting Point (Liquidus)	1981 F	1083 C
Melting Point (Solidus)	F	C
Density	.321 lb /cu in @ 68 F	8.9 gm /cu cm @ 20 C.
Specific Gravity	8.9	8.9
Coefficient of Thermal Expansion	.0000093 per ° F from 68 F to 212 F	.0000168 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	218 Btu /sq ft /ft /hr /°F @ 68 F	.86 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.6 Ohms (circ mil /ft) @ 68 F	1.76 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	98 % IACS @ 68 F	.568 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL: building fronts, downspouts, flashing, gutters, roofing, screening, spouting
AUTOMOTIVE: gaskets, radiators
ELECTRICAL: bus bars, contacts, radio parts, commutator segments, switches, terminals
MISCELLANEOUS: anodes, chemical process equipment, kettles, pans, printing rolls, rotating bands, road bed expansion plates, vats

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100).
Hot Working Temperature.1400-1750 F or 750-950 C
Annealing Temperature750-1200 F or 400-650 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
Brazing Good
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER Nos. 125, 127, 128, 129 and 130 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
		.100	.070	.050	.035	.025	.015												Soft Anneal		Light Anneal																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm.	34.0	11.0	.....	45	45	-	-	23.0	11.0	100
		Eighth Hard	36.0	28.0	34.0	30	60	10	25	25.0	.....	.....
		Half Hard	42.0	36.0	39.0	14	84	40	50	26.0	.....	.....
		Hard	50.0	45.0	47.5	6	90	50	57	28.0	.....	.....
		Spring	55.0	50.0	52.0	4	94	60	63	29.0	.....	.....
		Extra Spring	57.0	53.0	54.0	4	95	62	64	29.0	.....	.....
		As Hot Rolled	34.0	10.0	.....	45	45	-	-	23.0	.....	.....
ROD	1.0 in.	.050 mm.	32.0	10.0	.....	55	40	-	-	22.0	.....	.....
		Hard (35%)	48.0	44.0	.....	16	87	47	-	27.0	.....	.....
		As Hot Rolled	32.0	10.0	.....	55	40	-	-	22.0	.....	.....
WIRE	.080 in.	.050 mm	35.0	.....	.....	35*	-	-	-	24.0	.....	.....
		Hard	55.0	.....	.....	1.5**	-	-	-	29.0	.....	.....
		Spring	66.0	.....	.....	1.5**	-	-	-	33.0	.....	.....
SHAPES	.500 in.	.050 mm.	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		Hard (15%)	40.0	32.0	.....	30	-	35	-	26.0	.....	.....
		As Hot Rolled	32.0	10.0	.....	50	40	-	-	22.0	.....	.....
		As Extruded	32.0	10.0	.....	50	40	-	-	22.0	.....	.....

* Elongation in 10 inches

** Elongation in 60 inches

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 142 (PHOSPHORUS DEOXIDIZED, ARSENICAL)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	99.68	99.40	....
Arsenic	.3	.15	.50
Phosphorus	.02	.015	.040

Nearest Applicable A S T M Specifications

Flat Products	B11
Pipe	
Rod	B12
Shapes	
Tube	B75, B111, B359, B395, B447
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1978 F	1080 C
Melting Point (Solidus)	F	C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	0000098 per °F from 68 F to 572 F	0000177 per °C from 20 C to 300 C
Thermal Conductivity	112 Btu/sq ft/ft/hr/°F @ 68 F	.463 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	23 Ohms (circ mil/ft) @ 68 F	3.82 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	45 % IACS @ 68 F	.261 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

*Volume Basis

Typical Uses

Plates for locomotive fireboxes, staybolts, heat exchanger and condenser tubes

Common Fabrication Processes

Drawing, forming and bending, heading and upsetting, piercing and punching, roll threading and knurling, shearing

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100). 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding..... Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam..... Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 142 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn		•																	•			
	Sheet Plate ROD WIRE TUBE PIPE SHAPES																				•		
																					•		
																					•		
			•			•												•	•	•			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	....	....
TUBE	1.0 in. OD x .065 in.	.050 mm.	32.0	10.0	....	45	40	-	-	22.0	11.0*	20
		.025 mm.	34.0	11.0	....	45	45	-	-	23.0	....	....
		Light Drawn (15%)..	40.0	32.0	....	25	77	35	45	26.0	14.0*	20
		Hard Drawn (40%)..	55.0	50.0	....	8	95	60	63	29.0	19.0*	20
PIPE	¾ in. SPS	Hard (30%)	50.0	45.0	....	10	90	50	-	28.0	....	....

*Rotating beam tests on rod.

COPPER No. 143 (CADMIUM COPPER, DEOXIDIZED)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver + Cadmium)	....	99.90*	....
Cadmium	0.07	.05	.15

Nearest Applicable A S T M Specifications

* Deoxidized with small amounts of lithium or other suitable elements as agreed upon.

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1976 F	1080 C
Melting Point (Solidus)	1926 F	1052 C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	218 Btu/sq ft/ft/hr/°F @ 68 F	.93 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	10.8 Ohms (circ mil/ft) @ 68 F	1.80 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	96 % IACS @ 68 F	.557 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

Typical Uses

*Volume Basis

Cooling fins for automotive and heavy duty radiators, air conditioners, small motor commutators and electrical terminals and connectors. Anneal resistant electrical applications.

Common Fabrication Processes

Forming and bending, piercing and punching, blanking and etching

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed..... Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 1000-1400 F or 535-750 C
 Machinability Rating (Free Cutting Brass = 100).....20
 Typical Softening Temperature 675 F or355 C

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot..... Not Recommended
 Seam..... Not Recommended
 Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 143 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers								
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers			
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES	.100																								
		.070																								
		.050																								
		.035																								
		.025																								
		.015																								
		Strip, Rolled																								
		Strip, Drawn																								
		Flat Wire, Rolled																								
		Flat Wire, Drawn																								
Bar, Rolled																										
Bar, Drawn																										
Sheet																										
Plate																										
ROD																										
WIRE																										
TUBE																										
PIPE																										
SHAPES																										

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.005 in.	Special Spring.	65.0	62.0	....	2	-	-	-	.....	....	....
	.040 in.	.050 mm	32.0	10.0	....	45	40	-	-	22.0	....	....
		.025 mm	34.0	11.0	....	45	45	-	-	23.0	....	....
		Eighth Hard	38.0	30.0	....	30	60	10	25	25.0	....	....
		Quarter Hard	40.0	32.0	....	25	70	25	36	25.0	....	....
		Half Hard	44.0	38.0	....	12	86	42	51	26.0	....	....
		Hard	52.0	47.0	....	6	91	51	57	28.0	....	....
		Spring	58.0	54.0	....	4	95	61	63	29.0	....	....
		Extra Spring	60.0	58.0	....	3	96	63	64	30.0	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 145 (PHOSPHORUS DEOXIDIZED, TELLURIUM BEARING)

Composition — percent

	Nominal	Minimum	Maximum
Copper	99.50	.....	....
Tellurium	.50	.40	.60
Phosphorus*	.008	.004	.012
Cu + Ag + Te + P*	....	99.90	....

Nearest Applicable A S T M Specifications

Flat Products	B124, B301
Pipe	
Rod	B124, B301
Shapes	B124, B283
Tube	
Wire	

** This includes oxygen-free tellurium copper which contains phosphorus in an amount agreed upon.

*Other deoxidizers may be used in which case phosphorus need not be present.

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1967 F	1075 C
Melting Point (Solidus)	1924 F	1051 C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000095 per ° F from 68 F to 212 F	.0000171 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000097 per ° F from 68 F to 392 F	.0000174 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per ° F from 68 F to 572 F	.0000178 per ° C from 20 C to 300 C
Thermal Conductivity	205 Btu/sq ft/ft/hr/°F @ 68 F	.85 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	11.2 Ohms (circ mil/ft) @ 68 F	1.86 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	93 % IACS @ 68 F	.538 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume and Weight Basis

Typical Uses

Forgings and screw machine products and parts requiring high conductivity, extensive machining, corrosion resistance, copper color, or a combination of these; electrical connectors, motor and switch parts, plumbing fittings, soldering coppers, welding torch tips, transistor bases and furnace brazed articles

Common Fabrication Processes

Hot forging, machining and moderate cold heading

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature..... 1400-1600 F or 750-875 C
 Annealing Temperature..... 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100)..... 85

Suitability for being joined by:

Soldering..... Excellent
 Brazing Good
 Oxyacetylene Welding..... Fair
 Gas Shielded Arc Welding..... Fair
 Coated Metal Arc Welding..... Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 145 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015															Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled																					
	Strip, Drawn																					
	Flat Wire, Rolled																					
	Flat Wire, Drawn																					
	Bar, Rolled																					
	Bar, Drawn																					
	Sheet																					
	Plate																					
	ROD																					
	WIRE																					
	TUBE																					
	PIPE																					
	SHAPES																					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD	1.000 in.	.050 mm.	32.0	10.0	....	50	40	-	-	22.0	....	....
	.500 in.	.015 mm.	33.0	11.0	....	46	43	-	-	22.0	....	....
		Eighth Hard (6%)	38.0	30.0	....	26	-	36	44	25.0	....	....
	.250 in.	Half Hard (20%)	43.0	40.0	....	18	-	43	-	26.0	....	....
	.500 in.	Half Hard (20%)	43.0	40.0	....	20	-	43	50	26.0	....	....
	1.000 in.	Half Hard (20%)	42.0	40.0	....	25	-	42	-	25.0	....	....
	2.000 in.	Half Hard (15%)	42.0	39.0	....	35	-	42	-	25.0	....	....
	.250 in.	Hard (45%)	53.0	49.0	....	10	-	54	-	29.0	....	....
	.500 in.	Hard (35%)	48.0	44.0	....	15	-	48	-	27.0	....	....
	1.000 in.	Hard (35%)	48.0	44.0	....	20	-	48	-	27.0	....	....
WIRE	.080 in.	.035 mm.	33.0	11.0	....	40	-	-	-	22.0	....	....
		Eighth Hard	38.0	30.0	....	20	-	-	-	25.0	....	....
		Half Hard	51.0	41.0	....	6	-	-	-	27.0	....	....
		Hard	56.0	51.0	....	3	-	-	-	30.0	....	....
TUBE	1.0 in.OD x .065 in.	.050 mm.	32.0	10.0	....	40	40	-	-	22.0	....	....
		Light Drawn (15%)	40.0	32.0	....	20	-	35	-	24.0	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER No. 147 (SULFUR BEARING)

Composition — percent

	Nominal	Minimum	Maximum
Copper	99.6	....	....
Sulfur	.40	.20	.50
Cu + Ag + S*	....	99.90	....

Nearest Applicable A S T M Specifications

Flat Products	B301
Pipe	
Rod	B301
Shapes	
Tube	
Wire	

*Oxygen-free or deoxidized grades with agreed upon deoxidizers (such as phosphorus, boron, lithium or others) are available when so ordered.

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1969 F	1076 C
Melting Point (Solidus)	1953 F	1067 C
Density	.323 lb/cu in @ 68 F	8.94 gm/cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000170 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per °F from 68 F to 392 F	.0000173 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	216 Btu/sq ft/ft/hr/°F @ 68 F	.89 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	10.9 Ohms (circ mil/ft) @ 68 F	1.81 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	95 % IACS @ 68 F	.551 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

*Volume and weight basis

Typical Uses

Screw machine products and parts requiring high conductivity, extensive machining, corrosion resistance, copper color or a combination of these; electrical connectors, motor and switch components, plumbing fittings, cold headed and machined parts, cold forgings, furnace brazed articles, screws, soldering coppers, rivets and welding torch tips

Common Fabrication Processes

Hot: extrusion, rolling, forging
Cold: drawing, rolling, machining and swaging

Fabrication Properties

Capacity for Being Cold Worked..... Good
Capacity for Being Hot Formed..... Excellent
Hot Forgeability Rating (Forging Brass = 100).....
Hot Working Temperature.....1400-1600 F or 750-875 C
Annealing Temperature.....800-1200 F or 425-650 C
Machinability Rating (Free Cutting Brass = 100)..... .85

Suitability for being joined by:

Soldering..... Excellent
Brazing..... Excellent
Oxyacetylene Welding..... Not Recommended
Gas Shielded Arc Welding..... Not Recommended
Coated Metal Arc Welding..... Not Recommended

Resistance Welding

{ Spot..... Not Recommended
Seam..... Not Recommended
Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 147 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers				
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)		Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled																							
	Strip, Drawn																							
	Flat Wire, Rolled																							
	Flat Wire, Drawn																							
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD																							
	WIRE																							
TUBE																								
PIPE																								
SHAPES																								

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	.500 in.	.050 mm	32.0	10.0	....	52	40	-	-	22.0	....	....
		.015 mm	33.0	11.0	....	50	43	-	-	22.0	....	....
		Eighth Hard (6%)	38.0	30.0	....	26	-	36	44	25.0	....	....
		Half Hard (20%)	43.0	40.0	....	20	-	43	50	26.0	....	....
	.250 in.	Hard (36%)	48.0	44.0	....	10	-	45	-	27.0	....	....
		Hard (35%)	48.0	44.0	....	12	-	48	-	27.0	....	....
	.500 in.	Hard (29%)	46.0	43.0	....	11	-	46	-	27.0	....	....
	1.000 in.	Hard (25%)	42.0	38.0	....	20	-	-	-	26.0	....	....
	1.625 in.	Hard (24%)	40.0	36.0	....	15	-	-	-	25.0	....	....
	1.750 in.	Extra Hard (56%)	57.0	55.0	....	8	-	-	-	29.0	....	....
	.375 in.											

COPPER No. 150 (ZIRCONIUM COPPER)

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	.....	99.80	.....
Zirconium	.15	.10	.20

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1976 F	1080 C
Melting Point (Solidus)	1796 F	980 C
Density	.321 lb/cu in @ 68 F	8.89 gm/cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	.0000094 per °F from 68 F to 212 F	.0000163 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000180 per °C from 20 C to 300 C
Coefficient of Thermal Expansion	.0000112 per °F from 68 F to 1200 F	.0000201 per °C from 20 C to 650 C
Thermal Conductivity	212 Btu/sq ft/ft/hr/°F @ 68 F	.876 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	11.2 Ohms (circ mil/ft) @ 68 F	1.86 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	93 % IACS @ 68 F	.538 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	18,700,000 psi	13,000 Kg/sq mm
Modulus of Rigidity	psi	Kg/sq mm

*Solution Annealed, 84% cold worked and aged

**After precipitation heat treatment

***Volume Basis

Typical Uses

Electrical: Switches, circuit breakers where high temperatures exist, commutators, stud bases for power transmitters and rectifiers, soldering-welding tips

Common Fabrication Processes

Machining, swaging, bending, heading, hot forging

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1650-1740 F or 900-950 C
 **** Annealing Temperature F or C
 Machinability Rating (Free Cutting Brass = 100) 20

****Recommended Solution Annealing and Aging Cycles

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

	Solution Treating	Time	Aging	Time
Solution Heat Treated and Aged	900-925 C	5-30 min.	500-550 C	1-4 hrs.
Solution Heat Treated, Cold Worked and Aged	900-925 C	5-30 min.	375-475 C	1-4 hrs.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 150 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers						Hot Finished Tempers			
		Nominal Grain Size mm						Solution Heat Treated	Solution Heat Treated and Cold Worked	Solution Heat Treated, Cold Worked and Aged	Solution Heat Treated, Cold Worked, Aged and Cold Worked	Solution Heat Treated and Aged	Mill Annealed	Mill Annealed and Cold Worked	As Hot Rolled	As Extruded	Special Tempers
		.100	.070	.050	.035	.025	.015											Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled																
	Strip, Drawn																
	Flat Wire, Rolled																
	Flat Wire, Drawn																
	Bar, Rolled																
	Bar, Drawn																
	Sheet																
	Plate																
	ROD																
	WIRE																
	TUBE																
	PIPE																
	SHAPES																

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper		Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
				ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD		After Solution Heat Treatment	After Aging	% Reduction									
		80	44	68.0	64.0	.....	11	-	72	-	.....	.....	.....
		56	47	67.0	63.0	.....	15	-	72	-	.....	.....	.....
		61	31	64.0	62.0	.....	15	-	72	-	.....	.....	.....
		50	34	63.0	61.0	.....	15	-	-	-	.....	.....	.....
		48	52	62.0	60.0	.....	15	-	-	-	.....	.....	.....
		48	47	62.0	60.0	.....	15	-	-	-	.....	.....	.....
		32	17	60.0	58.0	.....	18	-	-	-	.....	.....	.....
		-	76	62.0	56.0	.....	8	-	-	-	.....	.....	.....
WIRE		Mill Annealed and Cold Worked (10%)		41.0	36.0	.....	34	-	-	-	.....	.....	.....
		Solution Heat Treated, Cold Worked 98% and Aged		76.0	72.0	.....	1.5	-	-	-	.....	.....	.....
		Solution Heat Treated, Cold Worked 92% and Aged		72.0	68.0	.....	3	-	-	-	.....	.....	.....
		Solution Heat Treated		29.0	6.0	.....	54	-	-	-	.....	.....	.....
		Solution Heat Treated and Aged		30.0	13.0	.....	49	-	-	-	.....	.....	.....
		Mill Annealed (.025 mm)		37.0	11.0	.....	50	40	-	-	.....	.....	.....
		Mill Annealed and Cold Worked (30%)		53.0	49.0	.....	23	90	-	-	.....	.....	.....

COPPER No. 155

Composition — percent

	Nominal	Minimum	Maximum
Copper (incl. Silver)	.....	99.75	.....
Silver	.....	.027(8)*	.10(30)*
Phosphorus	.06	.040	.080
Magnesium	.11	.10	.12

*Figure in parentheses is troy ounces per avoirdupois ton.

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1980 F	1080 C
Melting Point (Solidus)	1972 F	1078 C
Density	.322 lb /cu in @ 68 F	8.91 gm /cu cm @ 20 C.
Specific Gravity	8.91	8.91
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 212 F	.0000177 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	per ° F from 68 F to 572 F	per ° C from 20 C to 300 C
Thermal Conductivity	200 Btu /sq ft /ft /hr /°F @ 68 F	.83 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	11.5 Ohms (circ mil /ft) @ 68 F	1.92 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	90 % IACS @ 68 F	.522 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis after precipitation heat treatment

Typical Uses

High conductivity light duty springs, electrical contacts, resistance welding electrodes, electrical fittings, clamps, connectors, diaphragms, electronic components

Common Fabrication Processes

Blanking, drawing, etching, forming, bending, shearing, spinning, machining

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed..... Excellent
 Hot Forgeability Rating (Forging Brass = 100)..... .65
 Hot Working Temperature..... 1400-1600 F or 750-875 C
 Annealing Temperature..... 900-1000 F or 485-540 C
 Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing..... Excellent
 Oxyacetylene Welding..... Not Recommended
 Gas Shielded Arc Welding..... Not Recommended
 Coated Metal Arc Welding..... Not Recommended

Resistance Welding

{ Spot..... Good
 { Seam..... Not Recommended
 { Butt..... Not Recommended

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER No. 155 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers								
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers			
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES	.100																								
		.070																								
		.050																								
		.035																								
		.025																								
		.015																								
		Soft Anneal																								
		Light Anneal																								
		Eighth Hard																								
		Quarter Hard																								
Half Hard																										
Three Quarter Hard																										
Hard																										
Extra Hard																										
Spring																										
Extra Spring																										
Drawn — General Purpose (1)																										
Hard Drawn (2)																										
Light Drawn — Bending (3)																										
As Hot Rolled																										
As Extruded																										
Special Tempers																										

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Light Anneal	40.0	18.0	17.8	34	70	-	-	.....	15.0	100
		Quarter Hard	45.0	36.0	35.8	25	89	-	-	.....	.....	.....
		Half Hard	53.0	47.0	47.0	13	92	-	-	.....	.....	.....
		Hard	62.0	57.0	57.2	5	97	-	-	.....	23.5	100
		Spring	67.0	65.0	67.0	4	100	-	-	.....	22.5	100
		Extra Spring	72.0	68.0	71.0	3	-	80	-	.....	.....	.....
		Super Spring	75.0	70.0	73.0	3	-	82	-	.....	.....	.....
		Special Spring	80.0	72.0	75.0	3	-	84	-	.....	.....	.....
	.200 in.	Light Anneal	40.0	18.0	17.7	40	70	-	-	.....	.....	.....
		Quarter Hard	45.0	36.0	35.7	28	89	-	-	.....	.....	.....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 162 (CADMIUM COPPER)

Composition — percent

	Nominal	Minimum	Maximum
Copper	99.0	....	....
Cadmium	1.0	.7	1.2
Iron	....	....	.02
Cu + Ag + Cd + Fe	....	99.8	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	
Wire	B105

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1969 F	1076 C
Melting Point (Solidus)	1886 F	1030 C
Density	.321 lb/cu in @ 68 F	8.89 gm/cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 212 F	.0000170 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 392 F	.0000173 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity	208 Btu/sq ft/ft/hr/°F @ 68 F	.86 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	11.5 Ohms (circ mil/ft) @ 68 F	1.92 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	90 % IACS @ 68 F	.522 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

*Volume Basis

Typical Uses

Electrical: Trolley wire, heating pad, electric blanket elements, spring contacts, railbands, high strength transmission lines, connectors, cable wrap, switch gear components and waveguide cavities

Common Fabrication Processes

Drawing, forming and bending, etching, heading and upsetting, hot forging, piercing, and punching

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
Capacity for Being Hot Formed..... Good
Hot Forgeability Rating (Forging Brass = 100).....
Hot Working Temperature..... 1400-1600 F or 750-875 C
Annealing Temperature..... 800-1400 F or 425-750 C
Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering..... Excellent
Brazing..... Excellent
Oxyacetylene Welding..... Good
Gas Shielded Arc Welding..... Good
Coated Metal Arc Welding..... Not Recommended

Resistance Welding

{ Spot..... Not Recommended
Seam..... Not Recommended
Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 162 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled																								
	Strip, Drawn																								
	Flat Wire, Rolled																								
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD																								
	WIRE																								
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm	35.0	11.0	.....	52	54	-	-	.....	.....	.....
		Hard	60.0	45.0	.....	5	-	64	-	.....	.....	.....
		Spring	64.0	.....	.....	3	-	73	-	.....	.....	.....
		Extra Spring	72.0	59.0	.....	1	-	75	-	.....	.....	.....
ROD	.500 in.	.050 mm	35.0	7.0	6.8	56	46	-	-	27.0	14.5	100
		.025 mm	36.0	12.0	.....	57	46	-	-	.....	.....	.....
		Half Hard (25%)	58.0	45.0	.....	12	-	65	-	.....	.....	.....
		Hard	73.0	68.7	70.0	9	-	73	-	56.0	30.0	100
WIRE	.080 in.	.025 mm	38.0	12.0	.....	50	-	-	-	.....	.....	.....
		Hard	70.0	55.0	.....	6	-	-	-	.....	.....	.....
		Spring	80.0	66.0	.....	2	-	-	-	.....	.....	.....
		Drawn (> 96%)	88.0	.....	.....	1.5*	-	-	-	.....	.....	.....
	.010 in.	Drawn (> 99%)	100.0	.....	.....	1.0*	-	-	-	.....	.....	.....

*Elongation in 60 inches.

COPPER ALLOY No. 165

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.6	....	....
Cadmium	.8	.6	1.0
Iron	....	....	.02
Tin	.6	.50	.7
Cu + Ag + Cd + Sn + Fe	....	99.8	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	
Wire	B105

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1958 F	1070 C
Melting Point (Solidus)	F	C
Density	.321 lb /cu in @ 68 F	8.89 gm /cu cm @ 20-C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity	146 Btu /sq ft /ft /hr /°F @ 68 F	.60 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	17.29 Ohms (circ mil /ft) @ 68 F	2.87 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	60 % IACS @ 68 F	.348 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Electrical springs and contacts, trolley wire, clips, flat cable, resistance welding electrodes

Common Fabrication Processes

Drawing, forming and bending, etching, heading and upsetting, hot forging, piercing and punching

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1425-1600 F or 775-875 C
 Annealing Temperature 800-1450 F or 425-800 C
 Machinability Rating (Free Cutting Brass = 100). 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 165 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Hard	66.0	....	....	5	-	79	-	....	....	....
		Extra Hard	69.0	65.5	....	2	-	-	67	....	....	....
		Spring	73.0	66.0	....	2	-	-	72	....	....	....
		Extra Spring	76.0	69.0	....	1.5	-	-	73	....	....	....
ROD	.500 in.	.050 mm	40.0	14.0	13.0	53	62	-	-	....	20.0	100
		Hard (35%)	65.0	55.0	....	15	-	75	-	....	....	....
		Extra Hard (67%)	77.0	71.3	73.0	9	-	78	-	....	31.0	100
WIRE	.080 in.	.025 mm	42.0	....	....	-	-	-	-	....	....	....
		Hard	95.0	....	....	-	-	-	-	....	....	....
DRAWN BAR	1-1/2 x 3/8	Hard	56.0	52.0	....	23	-	60	-	....	....	....

COPPER ALLOY No. 170 (BERYLLIUM COPPER)

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.3	....	....
Beryllium	1.7	1.60	1.79
Nickel + Cobalt	....	.20	....
Ni + Fe + Co	....	....	.6
Copper (incl. Ag) + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B194, B196
Pipe	
Rod	B196
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1800 F	980 C
Melting Point (Solidus)	1590 F	865 C
Density	.298 lb /cu in @ 68 F	8.26 gm /cu cm @ 20 C.
Specific Gravity	8.26	8.26
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per °F from 68 F to 572 F	.0000178 per °C from 20 C to 300 C
Thermal Conductivity	62 - 75 Btu /sq ft /ft /hr /°F @ 68 F	.26 - .31 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	46.2 Ohms (circ mil /ft) @ 68 F	7.68 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed) **	22 % IACS @ 68 F	.128 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.10 Btu /lb °F @ 68 F	.10 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	18,500,000 psi	13,000 Kg /sq .mm
Modulus of Rigidity	7,300,000 psi	5,000 Kg /sq .mm

* In the precipitation hardened condition

** Volume Basis

Typical Uses

HARDWARE: bellows, bourdon tubing, diaphragms, fuse clips, fasteners, lock washers, springs, switch parts, relay parts, electrical and electronic connectors, retaining rings, roll pins

INDUSTRIAL: valves, pump parts, spline shafts, rolling mill parts, welding equipment

Common Fabrication Processes

Blanking, drawing, forming and bending, turning, drilling, tapping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1200-1500 F or 650-825 C
 Annealing Temperature 1425-1475 F or 775-800 C
 Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering Good
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Good

Resistance Welding { Spot Good
 Seam Fair
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 170 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers							
		Nominal Grain Size mm																							
		.100	.070	.050	.035	.025	.015	Soft Anneal (4)	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Mill Hardened (5)	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled																							
		Strip, Drawn																							
		Flat Wire, Rolled																							
		Flat Wire, Drawn																							
		Bar, Rolled																							
		Bar, Drawn																							
		Sheet																							
		Plate																							
		ROD																							
		WIRE																							
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

4. Solution heat treated.

5. Special mill processing and precipitation treatment.

Mechanical Properties

Form	Size Section	Temper		Tensile Strength		Yield Strength .2% Offset		Elongation in 2"		Rockwell Hardness			Fatigue Strength !!	
		I	II	I	II	I	II	I	II	B	30T	C	ksi	Million Cycles
FLAT PRODUCTS	Under .188 in.	A	AT	70.0	165.0	32.0	145.0	45	7	60	58	35	36.0	100
		1/4H	1/4HT	80.0	172.0	70.0	150.0	25	5	80	70	37	40.0	100
		1/2H	1/2HT	92.0	182.0	82.0	160.0	15	4	92	77	39	42.0	100
		H	HT	110.0	190.0	104.0	170.0	5	3	99	81	40	43.0	100
		AM	....	105.0	....	80.0	....	20	-	-	-	20	....	....
		1/4HM	....	115.0	....	90.0	....	18	-	-	-	23	....	....
		1/2HM	....	128.0	....	105.0	....	15	-	-	-	27	....	....
		HM	....	142.0	....	122.0	....	12	-	-	-	32	....	....
		XHM	....	168.0	....	148.0	....	6	-	-	-	36	....	....
ROD	ALL up to 3/8 in. incl. over 3/8 to 1 in. incl. over 1 in.	A	AT	68.0	165.0	....	....	-	-	62	-	35	....	....
		H	HT	112.0	188.0	....	....	-	-	95	-	38	....	....
		H	HT	105.0	183.0	....	....	-	-	95	-	37	....	....
		H	HT	100.0	178.0	....	....	-	-	95	-	36	....	....

Note: A - Solution heat treated
H - Hard (except for tempers utilizing M designation)

(I) As supplied by producer mill

T - Precipitation heat treated
AM through XHM - Special mill processing and precipitation treatment

(II) Properties after precipitation hardening by customer at 600F

COPPER ALLOY Nos. 172 and 173 (BERYLLIUM COPPER)

Composition — percent

	Copper Alloy No. 172			Copper Alloy No. 173		
	Nominal	Minimum	Maximum	Nominal	Minimum	Maximum
Copper	98.1	....	....	97.7	....	....
Beryllium	1.9	1.80	2.00	1.9	1.80	2.00
Lead	....	....	....	.40	.20	.6
Nickel + Cobalt	....	.20	....	....	.20	....
Ni + Fe + Co	....	....	.6	....	....	.6
Copper (incl. Ag) + Elements with Specific Limits	....	99.5	....	....	99.5	....

Nearest Applicable A S T M Specifications

	Copper Alloy No. 172	Copper Alloy No. 173
Flat Products	B194, B196	B196
Pipe		
Rod	B196	B196
Shapes		
Tube		
Wire	B197	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1800 F	980 C
Melting Point (Solidus)	1590 F	865 C
Density	.298 lb /cu in @ 68 F	8.26 gm /cu cm @ 20 C.
Specific Gravity	8.26	8.26
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per ° F from 68 F to 572 F	.0000178 per ° C from 20 C to 300 C
Thermal Conductivity	62-75 Btu /sq ft /ft /hr /° F @ 68 F	.26-.31 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	46.2 Ohms (circ mil /ft) @ 68 F	7.68 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	22 % IACS @ 68 F	.128 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.10 Btu /lb ° F @ 68 F	.10 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,500,000 psi	13,000 Kg /sq mm
Modulus of Rigidity	7,300,000 psi	5,000 Kg /sq mm

*In the precipitation hardened condition

**Volume Basis

Typical Uses

HARDWARE: Bellows, bourdon tubing, diaphragms, fuse clips, fasteners, lock washers, springs, switch parts, relay parts, electrical and electronic components, retaining rings, roll pins

INDUSTRIAL: Valves, pump parts, spline shafts, rolling mill parts, welding equipment

Common Fabrication Processes

Blanking, drawing, forming and bending, turning, drilling, tapping

Fabrication Properties

Capacity for Being Cold Worked.....	Excellent
Capacity for Being Hot Formed	Good
Hot Forgeability Rating (Forging Brass = 100)	
Copper Alloy No. 172	40
Copper Alloy No. 173	Not Recommended
Hot Working Temperature.....	1200-1500 F or 650-825 C
Annealing Temperature	1425-1475 F or 775-800 C
Machinability Rating (Free Cutting Brass = 100)	
Copper Alloy No. 172	20
Copper Alloy No. 173	50

Suitability for being joined by:

Soldering	Good
Brazing	Good
Oxyacetylene Welding	Not Recommended
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Good
Resistance Welding {	
Spot	Good
Seam	Fair
Butt	Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 172 and 173 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal (4)	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Mill Hardened (5)	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled							●			●	●	●	●			●						
	Strip, Drawn							●		●	●	●	●				●						
	Flat Wire, Rolled							●															
	Flat Wire, Drawn							●															
	Bar, Rolled							●			●												
	Bar, Drawn							●			●												
	Sheet							●															
	Plate							●															
	ROD							●						●									
	WIRE							●		●	●	●	●	●									
TUBE							●										●						
PIPE																							
SHAPES							●																

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.
4. Solution Heat Treated.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

5. Special Mill Processing and Precipitation Treatment.

Mechanical Properties

Form	Size Section	Temper		Tensile Strength		Yield Strength .2% Offset		Elongation in 2"		Rockwell Hardness			Fatigue Strength	
		I	II	I	II	I	II	I	II	B	30T	C	ksi	Million Cycles
FLAT PRODUCTS	Under .188 in.	A	AT	70.0	175.0	32.0	155.0	45	6	60	58	38	36.0	100
		1/4H	1/4HT	80.0	185.0	70.0	165.0	25	4	80	70	40	40.0	100
		1/2H	1/2HT	92.0	195.0	82.0	175.0	15	3	92	77	41	44.0	100
		H	HT	110.0	200.0	104.0	180.0	5	2	99	81	42	44.5	100
		AM	-	105.0	....	82.0	....	20	-	-	-	20	....	....
		1/4HM	-	115.0	....	92.0	....	17	-	-	-	23	....	....
		1/2HM	-	128.0	....	105.0	....	15	-	-	-	27	....	....
		HM	-	142.0	....	122.0	....	12	-	-	-	32	....	....
		XHM	-	168.0	....	148.0	....	7	-	-	-	37	....	....
		XHMS	-	182.0	....	160.0	....	6	-	-	-	39	....	....
ROD	All	A	AT	68.0	178.0	25.0	160.0	48	6	62	-	38	....	....
	Up to 3/8 in. incl.	H	HT	112.0	200.0	90.0	182.0	15	3	95	-	41	....	....
	Over 3/8 to 1 in. incl.	H	HT	105.0	195.0	90.0	178.0	15	5	95	-	41	....	....
	Over 1 in.	H	HT	100.0	190.0	90.0	175.0	15	3	95	-	41	....	....
WIRE		A	AT	68.0	178.0	28.0	160.0	35	3	-	-	-	....	....
		1/4H	1/4HT	102.0	190.0	82.0	175.0	10	2	-	-	-	....	....
		1/2H	1/2HT	122.0	200.0	100.0	185.0	5	1	-	-	-	....	....
		3/4H	3/4HT	142.0	210.0	120.0	190.0	2	1	-	-	-	....	....
		H	HT	152.0	212.0	125.0	195.0	1	1	-	-	-	....	....

Note: A - Solution Heat Treated
H - Hard (except for tempers using M designations)
(I) - As Supplied by Producer Mill

T - Precipitation Heat Treated
AM through XHMS - Special Mill Processing and Precipitation Treatment
(II) - Properties after Precipitation Hardening by Customer at

COPPER ALLOY No. 175 (BERYLLIUM COPPER)

Composition — percent

	Nominal	Minimum	Maximum
Copper	96.9	....	....
Iron	....	....	.10
Cobalt	2.5	2.4	2.7
Beryllium	.6	.40	.7
Copper (incl. Ag) + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B441, B534
Pipe	
Rod	B441
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1955 F	1068 C
Melting Point (Solidus)	1885 F	1029 C
Density	.316 lb /cu in @ 68 F	8.75 gm /cu cm @ 20 C.
Specific Gravity	8.75	8.75
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 392 F	.0000176 per °C from 20 C to 200 C
Coefficient of Thermal Expansion	per °F from 68 F to 572 F	per °C from 20 C to 300 C
Thermal Conductivity	120 - 150 Btu /sq ft /ft /hr /°F @ 68 F	.49 - .62 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	22.8 Ohms (circ mil /ft) @ 68 F	3.79 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed) **	45 % IACS @ 68 F	.261 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.10 Btu /lb °F @ 68 F	.10 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	19,000,000 psi	13,500 Kg /sq mm
Modulus of Rigidity	7,500,000 psi	5,250 Kg /sq mm

* In the precipitation hardened condition

** Volume Basis

Typical Uses

HARDWARE: fuse clips, fasteners, springs, switch parts, relay parts,
electrical conductors
INDUSTRIAL: welding equipment

Common Fabrication Processes

Blanking, forming and bending, turning, drilling, tapping

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
Capacity for Being Hot Formed..... Good
Hot Forgeability Rating (Forging Brass = 100).....
Hot Working Temperature..... 1200-1625 F or 650-765 C
Machinability Rating (Free Cutting Brass = 100).....
Solution Heat Treating Temperature 1675-1725 F or 900-950 C

Suitability for being joined by:

Soldering..... Good
Brazing..... Good
Oxyacetylene Welding..... Not Recommended
Gas Shielded Arc Welding..... Fair
Coated Metal Arc Welding..... Fair
Resistance Welding { Spot..... Good
Seam..... Fair
Butt..... Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 175 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal (4)	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Precipitation Heat Treated	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Strip, Drawn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Flat Wire, Rolled	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Flat Wire, Drawn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Bar, Rolled	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Bar, Drawn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Sheet	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Plate	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	ROD	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	WIRE	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
TUBE	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
PIPE	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
SHAPES	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

1. DRAWN -- GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN -- BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

4. Solution heat treated.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	Under .188 in.	 A(1)	45.0	25.0	.....	28	-	32	36	.....	.....	.....
		 AT(1)(2)	110.0	90.0	.....	12	-	96	80	.....	.....	.....
		 1/2H(1)	68.0	60.0	.....	8	-	70	64	.....	.....	.....
		 1/2HT(1)(2)	115.0	108.0	.....	8	-	98	81	.....	35.0	100
		 H(1)	78.0	70.0	.....	5	-	83	72	.....	.....	.....
		 HT(1)(2)	115.0	110.0	.....	8	-	98	81	.....	.....	.....
ROD	ALL	 A(1)	45.0	25.0	.....	28	-	35	-	.....	.....	.....
		 H(1)	72.0	65.0	.....	12	-	68	-	.....	.....	.....
		 AT(1)(2)	110.0	90.0	.....	18	-	96	-	.....	.....	.....
		 HT(1)(2)	115.0	110.0	.....	14	-	98	-	.....	.....	.....

Note: A -- Solution heat treated
H -- Hard

T -- Precipitation heat treated

(1) As supplied by producer mill

(2) Properties after precipitation heat treating at 900 F either by the producer or the consumer.

COPPER ALLOY Nos. 182, 184 and 185 (CHROMIUM COPPER)

Composition — percent

	Copper Alloy No. 182			Copper Alloy No. 184			Copper Alloy No. 185		
	Nominal	Minimum	Maximum	Nominal	Minimum	Maximum	Nominal	Minimum	Maximum
Copper	99.1	....	....	99.2	....	....	99.2	....	....
Iron			.10	....	....	.15	....	....	....
Chromium	9	.6	1.2	.8	.40	1.2	.7	.40	1.0
Silicon			.10	....	....	.10	....	....	....
Lead			.05	....	....	....	....	....	.015
Arsenic						.005	....	....	....
Calcium						.005	....	....	....
Lithium						.05	....	....	....
Phosphorus						.05	....	....	.04
Zinc						.7	....	....	....
Silver							.10	.08	.12
er (Incl. Ag)									
ements with									
ific Limits		99.5	....	....	99.8	....	99.8	....	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	
Wire	F9

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1967 F	1075 C
Melting Point (Solidus)	1958 F	1070 C
Density	.321 lb/cu in @ 68 F	8.89 gm/cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 212 F	.0000176 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	per °F from 68 F to 572 F	per °C from 20 C to 300 C
Thermal Conductivity **	187 Btu/sq ft/ft/hr/°F @ 68 F	.77 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed) **	13.0 Ohms (circ mil/ft) @ 68 F	2.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed) **	80 % IACS @ 68 F	.463 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu/lb °F @ 68 F	.092 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	7,200,000 psi	5,100 Kg/sq mm

*Volume Basis

**Solution Heat Treated, Cold Worked (50% minimum) and Aged (Volume Basis)

Typical Uses

Resistance welding machine electrodes, seam welding wheels, electrical switch gear, electrode holder jaws, cable connectors, current carrying arms and shafts, circuit breaker parts, arcing and bridging parts, grid siderods in electron tubes, molds, spot welding tips, flash welding electrodes, electrical and thermal conductors requiring greater strength than copper, switch contacts

Common Fabrication Processes

Hot: Extrusion, rolling, forging
Cold: Drawing, rolling, impacting, heading, bending, swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100) 80
Hot Working Temperature 1500-1700 F or 800-925 C
** Annealing Temperature F or C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Good
Brazing Good
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Fair

** Recommended Solution Heat Treating and Aging Cycles

Condition	Solution Treating		Time	Aging		Time
Solution Heat Treated and Aged or						
Solution Heat Treated, Cold Worked and Aged	1800-1850F	980-1000C	10-30 min.	800-930F	425-500C	2-4 hrs.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 182, 184 and 185 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers				Rolled or Drawn Tempers							Hot Finished Tempers		Special Tempers	
		Nominal Grain Size mm						Solution Heat Treated	Solution Heat Treated and Cold Worked	Solution Heat Treated, Cold Worked and Aged	Solution Heat Treated, Cold Worked, Aged, and Cold Worked	Solution Heat Treated and Aged	Mill Annealed	Mill Annealed and Cold Worked		
		.100	.070	.050	.035	.025	.015									Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled							•		•				•		
	Strip, Drawn															
	Flat Wire, Rolled															
	Flat Wire, Drawn															
	Bar, Rolled															
	Bar, Drawn															
	Sheet															
	Plate							•		•				•		
	ROD							•		•		•			•	
	WIRE							•		•		•			•	
TUBE																
PIPE																
SHAPES																

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Solution Heat Treated	34.0	19.0	....	40	-	16	-	....	....	....
		Solution Heat Treated and Aged (500C - 3hrs)	51.0	36.0	....	22	-	59	-	....	....	....
		Solution Heat Treated and Cold Worked (50%)	53.0	51.0	....	6	-	66	-	....	....	....
		Solution Heat Treated, Cold Worked (50%), and Aged (450C - 3hrs)	67.0	59.0	....	14	-	79	-	....	....	....
PLATE	2.0 in.	Solution Heat Treated and Aged	58.0	42.0	....	25	-	70	-	....	....	....
	3.0 in.	Solution Heat Treated and Aged	56.0	40.0	....	30	-	68	-	....	....	....
ROD	.156 in.	Solution Heat Treated and Cold Worked (91%)	74.0	73.0	....	5	-	-	-	....	....	....
		Solution Heat Treated, Cold Worked (90%), and Aged	86.0	77.0	....	14	-	-	-	....	....	....
	.500 in.	Solution Heat Treated	45.0	14.0	....	40	-	-	-	....	....	....
		Solution Heat Treated and Aged (500C - 3hrs)	70.0	55.0	....	21	-	70	-	....	....	....
		Solution Heat Treated and Cold Worked (60.5%)	57.0	56.0	....	11	-	65	-	....	....	....
		Solution Heat Treated and Cold Worked (60.5%) and Aged (450C - 3hrs)	77.0	65.0	....	16	-	82	-	....	....	....
		Solution Heat Treated, Cold Worked (50%), Aged and Cold Worked (6%)	77.0	67.0	....	19	-	83	-	....	....	....
		Solution Heat Treated and Aged	72.0	65.0	....	18	-	80	-	....	....	....
	2.0 in.	Solution Heat Treated and Aged	70.0	65.0	....	18	-	75	-	....	....	....
	3.0 in.	Solution Heat Treated and Aged	65.0	55.0	....	18	-	70	-	....	....	....
TUBE	4.0 in.	Solution Heat Treated and Aged	55.0	43.0	....	25	-	68	-	....	....	....
	3/8 in. OD X .094 in.	Mill Annealed	40.0	15.0	....	50	59	-	-	....	....	....
	1.250 in. OD X .212 in.	Solution Heat Treated and Cold Worked (76%)	59.0	57.0	....	21	-	67	-	....	....	....
		Solution Heat Treated, Cold Worked (76%), Aged and Cold Worked (28%)	69.0	63.0	....	26	-	84	-	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 187 (LEADED COPPER)

Composition — percent

	Nominal	Minimum	Maximum
Copper	99.0	....	....
Lead	1.0	.8	1.5
Cu + Ag + Pb*	....	99.9	....

Nearest Applicable A S T M Specifications

Flat Products	B301
Pipe	
Rod	B301
Shapes	
Tube	
Wire	

*Oxygen-free or deoxidized grades with agreed upon deoxidizers (such as phosphorus, boron, lithium or others) are available when so ordered.

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1976 F	1080 C
Melting Point (Solidus)	1747 F	953 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000176 per ° C from 20 C to 300 C
Thermal Conductivity	218 Btu /sq ft /ft /hr /°F @ 68 F	.93 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	10.8 Ohms (circ mil /ft) @ 68 F	1.79 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	96 % IACS @ 68 F	.556 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Electrical: connectors, motor and switch parts, screw machine parts requiring high conductivity

Common Fabrication Processes

Machining

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Bräss = 100)
 Hot Working Temperature. 1400-1600 F or 750-875 C
 Annealing Temperature. 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100). 85

Suitability for being joined by:

Soldering. Excellent
 Brazing Good
 Oxyacetylene Welding. Not Recommended
 Gas Shielded Arc Welding. Not Recommended
 Coated Metal Arc Welding. Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam. Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 187 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD	1.0 in.	.050 mm	32.0	10.0	....	45	40	-	-	22.0	....	....
	.250 in.	Half Hard (20%)	43.0	40.0	....	18	-	43	-	26.0	....	....
	1.0 in.	Half Hard (20%)	42.0	38.0	....	25	-	42	-	25.0	....	....
	.125 in.	Hard (50%)	55.0	50.0	....	8	-	-	-	30.0	....	....
	.250 in.	Hard (45%)	53.0	49.0	....	10	-	54	-	29.0	....	....
	.500 in.	Hard (35%)	48.0	44.0	....	12	-	48	-	27.0	....	....
	1.0 in.	Hard (35%)	48.0	42.0	....	15	-	48	-	27.0	....	....

COPPER ALLOY No. 189

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.7	....	....
Tin	.8	.6	.9
Silicon	.3	.15	.40
Lead	....	....	.02
Phosphorus	....	....	.05
Aluminum	....	....	.01
Manganese	.2	.10	.30
Zinc	....	....	.10
Copper (incl. Ag) + Elements with Specific Limits	....	99.9	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1967 F	1075 C
Melting Point (Solidus)	F	C
Density	.322 lb /cu in @ 68 F	8.91 gm /cu cm @ 20 C.
Specific Gravity	8.91	8.91
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	per ° F from 68 F to 572 F	per ° C from 20 C to 300 C
Thermal Conductivity	75 Btu /sq ft /ft /hr /°F @ 68 F	.31 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	34.6 Ohms (circ mil /ft) @ 68 F	5.75 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	30 % IACS @ 68 F	.174 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	psi	Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

*Volume Basis

Typical Uses

Welding rod and wire for inert-gas tungsten-arc and oxyacetylene welding of copper. Also inert-gas metal arc welding

Common Fabrication Processes

Welding

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100).
Hot Working Temperature F or C
Annealing Temperature 925-1100 F or 500-600 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Excellent
Gas Shielded Arc Welding Excellent
Coated Metal Arc Welding Good
Resistance Welding { Spot Fair
Seam Not Recommended
Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 189 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	.125 in.	Soft	38.0	9.0	.....	48	—	—	—	.....	.....	.....
	.125 in.	Hard (35%)	56.0	52.0	.....	14	—	—	—	.....	.....	.....
WIRE	.045 in.	Hard (99%)	95.0	.....	.....	.....	—	—	—	.....	.....	.....
	.062 in.	Hard (96%)	90.0	.....	.....	.....	—	—	—	.....	.....	.....
	.093 in.	Hard (92%)	84.0	.....	.....	.....	—	—	—	.....	.....	.....

COPPER ALLOY No. 190

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.6	....	....
Iron	....	....	.10
Nickel	1.1	.9	1.3
Lead	....	....	.05
Zinc	....	....	.8
Phosphorus	.3	.15	.35
Copper (incl. Ag) + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

English Units

C. G. S. Units

Melting Point (Liquidus)	1980 F	1082 C
Melting Point (Solidus)	1900 F	1038 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per ° F from 68 F to 572 F	.0000177 per ° C from 20 C to 300 C
Thermal Conductivity **	145 Btu /sq ft /hr /°F @ 68 F	.60 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed) **	17.3 Ohms (circ mil /ft) @ 68 F	2.88 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed) **	60 % IACS @ 68 F	.347 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg /sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg /sq mm

*Volume Basis

**Age Hardened Condition

Typical Uses

Springs, clips, electrical connectors, electronic parts such as power tube and electron tube components, high strength electrical conductors, bolts, nails, screws, cotter pins and parts requiring some combination of high strength, high electrical or thermal conductivity, high resistance to fatigue and creep, and good workability

Common Fabrication Processes

Forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, shearing, swaging

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
Capacity for Being Hot Formed..... Excellent
Hot Forgeability Rating (Forging Brass = 100)..... 65
Hot Working Temperature..... 1300-1550 F or 700-850 C
Machinability Rating (Free Cutting Brass = 100)..... 30
Annealing Temperature..... 900-1300 F or 475-700 C
Solution Annealing Temperature 1300-1450 F or 700-800 C
Age Hardening Anneal..... 800- 900 F or 425-475 C

Suitability for being joined by:

Soldering..... Excellent
Brazing..... Excellent
Oxyacetylene Welding..... Good
Gas Shielded Arc Welding..... Good
Coated Metal Arc Welding..... Not Recommended
Resistance Welding { Spot..... Fair
Seam..... Fair
Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 190 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers					
		Nominal Grain Size mm						Soft Anneal	Age Hardened	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)		Light Drawn – Bending (3)	As Hot Rolled	As Extruded		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled																								
	Strip, Drawn																								
	Flat Wire, Rolled																								
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD																								
	WIRE																								
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
WIRE	.080 in.	Age Hardened	65.0	40.0	40.0	25	-	-	-	35.0	....	....
		Quarter Hard - HT . .	80.0	70.0	73.0	13	-	-	-	40.0	....	....
		Half Hard - HT	88.0	73.0	78.0	8	-	-	-	43.0	....	....
		Hard - HT	97.0	77.0	85.0	5	-	-	-	49.0	....	....
		Spring - HT	110.0	80.0	97.0	4	-	-	-	57.0	....	....
		Extra Spring - HT . .	115.0	81.0	101.0	3	-	-	-	60.0	....	....
FLAT WIRE	½ in. X .040 in.	Age Hardened	65.0	40.0	40.0	25	-	72	-	35.0	....	....
		Half Hard - HT	76.0	65.0	70.0	4	-	83	-	38.0	....	....
		Hard - HT	84.0	72.0	77.0	3	-	88	-	42.0	....	....
		Extra Spring - HT . .	100.0	77.0	91.0	2	-	94	-	50.0	....	....
ROD	1.0 in.	Solution Treated	38.0	20.0	20.0	50	-	45	-	25.0	....	....
		Age Hardened	65.0	45.0	45.0	30	-	70	-	35.0	....	....
		Hard (35%) HT	85.0	75.0	80.0	15	-	87	-	42.0	....	....
		HT - Heat Treated										

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 191

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.2	.....	.....
Iron	.....	.....	.20
Nickel	1.1	.9	1.3
Lead	.....	.....	.10
Zinc	.....	.....	.50
Tellurium	.5	.35	.6
Phosphorus	.2	.15	.35
Copper (incl. Ag) + Elements with Specific Limits	.....	99.5	.....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1980 F	1082 C
Melting Point (Solidus)	1900 F	1038 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000098 per °F from 68 F to 572 F	.0000177 per °C from 20 C to 300 C
Thermal Conductivity **	145 Btu /sq ft /ft /hr /°F @ 68 F	.60 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed) **	18.9 Ohms (circ mil /ft) @ 68 F	3.14 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed) **	55 % IACS @ 68 F	.318 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

* Volume Basis

** Precipitation Heat Treated

Typical Uses

Forgings and screw machine parts requiring high strength, hardenability, extensive machining, corrosion resistance, copper color, good conductivity, or a combination of these; bolts, bushings, electrical connectors and components, gears, marine hardware, nuts, pinions, tie rods, turnbuckle barrels, welding torch tips

Common Fabrication Processes

Forming and bending, heading and upsetting, hot forging and pressing, machining, roll threading and knurling, shearing, swaging

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100) 65
Hot Working Temperature, 1400-1600 F or 750-875 C
Machinability Rating (Free Cutting Brass = 100) 75
Annealing Temperature 900-1300 F or 475-700 C
Solution Annealing Temperature 1300-1450 F or 700-800 C
Age Hardening Anneal 800- 900 F or 425-475 C

Suitability for being joined by:

Soldering Excellent
Brazing Good
Oxyacetylene Welding Fair
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Fair
Resistance Welding { Spot Poor
Seam Poor
Butt Poor

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 191 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard — Heat Treated	Extra Hard	Spring — Heat Treated	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled																							
	Strip, Drawn																							
	Flat Wire, Rolled																							
	Flat Wire, Drawn																							
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD																							
	WIRE																							
TUBE																								
PIPE																								
SHAPES																								

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
ROD	.250 in.	Hard (35%) — HT...	84.0	73.0	77.0	10	—	85	—	44.0	.....	.....
	.500 in.	Hard (35%) — HT...	80.0	70.0	73.0	15	—	85	—	43.0	33.0	100
	1.0 in.	Hard (30%) — HT...	78.0	68.0	70.0	27	—	84	—	41.0	33.0	100
	.125 in.	Spring (75%) — HT..	104.0	77.0	92.0	6	—	95	—	56.0	.....	.....
	.375 in.	Spring (60%) — HT..	94.0	75.0	86.0	10	—	90	—	48.0	.....	.....
FORGINGS	.....	As Forged and Quenched*	36.0	10.0	.....	.....	35	—	—	.....	.....	.....
	.....	As Forged and Air Cooled*	45.0 - 55.0	12.0 - 20.0	.....	.....	50 - 80	—	—	.....	.....	.....
	.....	As Age Hardened ...	58.0	38.0	.....	.....	97 70	—	—	.....	.....	.....
	.....	HT = Heat Treated * If quenched immediately in water from forging, the alloy will be quite soft as indicated. If air-cooled from forging, there will be an indeterminate amount of age-hardening so that the properties will be somewhere between those of quenched forgings and age-hardened forgings.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

COPPER ALLOY No. 192

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.97	98.7	....
Iron	1	.8	1.2
Phosphorus	.03	.01	.04
Total Other Elements	....	99.9	....

Nearest Applicable A S T M Specifications

Flat Products

Pipe

Rod

Shapes

Tube

Wire

B111, B359, B395, B469

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1983 F	1084 C
Melting Point (Solidus)	F	C
Density	.320 lb/cu in @ 68 F	8.87 gm/cu cm @ 20 C.
Specific Gravity	8.87	8.87
Coefficient of Thermal Expansion	.0000090 per °F from 68 F to 212 F	.0000162 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	per °F from 68 F to 572 F	per °C from 20 C to 300 C
Thermal Conductivity	125 Btu/sq ft/ft/hr/°F @ 68 F	.517 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	20.8 Ohms (circ mil/ft) @ 68 F	3.45 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	50 % IACS @ 68 F	.291 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

*Volume Basis

Typical Uses

Automotive hydraulic brake lines, flexible hose, electrical terminals, fuseclips, gaskets, gift hollow ware, applications requiring resistance to softening and stress corrosion, air conditioning and heat exchanger tubing

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature..... 1500-1750 F or 825-950 C
 Annealing Temperature..... 1300-1500 F or 700-825 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing Excellent
 Oxyacetylene Welding..... Good
 Gas Shielded Arc Welding..... Excellent
 Coated Metal Arc Welding..... Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 192 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
TUBE								•	•											•	•		
PIPE																							
SHAPES																							

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
TUBE	1.875in.OD X .095in.	Light Anneal	42.0	23.0	22.0	30	—	—	—	....	....	....
		Soft Anneal	37.0	12.0	11.0	40	—	—	—	....	....	....
	1.875in.OD X .095in.	Hard Drawn (40%)	56.0	52.0	52.0	7	—	—	—	....	....	....
	3/16in.OD X .030	Light Drawn	42.0	31.0	30.0	35	—	—	—	....	....	....

COPPER ALLOY No. 194

Composition — percent

	Nominal	Minimum	Maximum
Copper	97.43	97.0	....
Iron	2.4	2.1	2.6
Tin	....	....	.03
Zinc	.13	.05	.20
Lead	....	....	.03
Phosphorus	.04	.015	.15
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Flat Products	B465
Pipe	
Rod	
Shapes	
Tube	B543
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1990 F	1090 C
Melting Point (Solidus)	1980 F	1080 C
Density	.317 lb /cu in @ 68 F	8.78 gm /cu cm @ 20 C.
Specific Gravity	8.78	8.78
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000163 per ° C from 20 C to 300 C
Thermal Conductivity	150 Btu /sq ft /ft /hr /°F @ 68 F	.625 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	15 Ohms (circ mil /ft) @ 68 F	2.54 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	65 % IACS @ 68 F	.377 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.092 Btu /lb °F @ 68 F	.092 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,500,000 psi	12,300 Kg /sq mm
Modulus of Rigidity	6,600,000 psi	4,640 Kg /sq mm

*Volume Basis

Typical Uses

Circuit breaker components, contact springs, electrical clamps, electrical springs, electrical terminals, eyelets, flexible hose, fuse clips, gaskets, gift hollow ware, plug contacts, rivets and welded condenser tubes

Common Fabrication Processes

Blanking, coining, coppersmithing, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 65
 Hot Working Temperature..... 1400-1600 F or 750-875 C
 Annealing Temperature..... 700-1200 F or 375-650 C
 Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 194 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm																				
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled							•	•			•		•	•	•	•					•
	Strip, Drawn																					
	Flat Wire, Rolled																					
	Flat Wire, Drawn																					
	Bar, Rolled																					
	Bar, Drawn																					
	Sheet																					
	Plate																					
	ROD																					
	WIRE																					
TUBE								•	•			•		•	•	•	•		•	•		
PIPE																						
SHAPES																						

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.025 in.	Soft Anneal	45.0	....	24.0	32	-	38	-	....	16.0	100
		Light Anneal	50.0	....	30.0	29	-	45	-	....	....	....
	.040 in.	Half Hard	60.0	50.0	53.0	9	-	68	66	....	....	....
		Hard	67.0	....	63.0	4	-	73	69	....	21.0	100
		Extra Hard	70.0	....	67.5	3	-	74	71	....	....	....
		Spring	73.0	....	70.5	2	-	75	72	....	21.5	100
		Extra Spring	76.0	....	73.0	2	-	77	74	....	20.5	100
		Super Spring	80.0	....	> 73.0	> 1	-	> 73	....	....	....	....
TUBE	1 in. OD X .035 in.	Soft Anneal	45.0	....	24.0	28	-	38	-	....	....	....
		Light Anneal	50.0	....	30.0	16	-	45	-	....	....	....
		AW Half Hard	58.0	....	53.0	9	-	61	60	....	....	....
		AW Hard	65.0	....	63.0	4	-	73	66	....	....	....
		AW Extra Hard	70.0	....	67.5	3	-	74	68	....	....	....
		AW Spring	73.0	....	70.5	2	-	75	69	....	....	....
		AW Extra Spring	76.0	....	73.0	1	-	76	69	....	....	....
		Light Drawn (15%)	58.0	....	55.0	9	-	61	60	....	....	....
		Hard Drawn (35%)	68.0	....	66.0	2	-	73	66	....	....	....

COPPER ALLOY No. 195

Composition — percent

	Nominal	Minimum	Maximum
Copper	97.0	96.0	....
Iron	1.5	1.3	1.7
Tin	.6	.40	.7
Zinc	....	....	.20
Aluminum	....	....	.02
Lead	....	....	.02
Phosphorus	.10	.08	.12
Cobalt	.8	.6	1.0
Total Other Elements	....	....	.10*

* .05 % maximum for any element

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1995 F	1090 C
Melting Point (Solidus)	1985 F	1085 C
Density	.322 lb /cu in @ 68 F	8.92 gm /cu cm @ 20 C.
Specific Gravity	8.92	8.92
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000094 per ° F from 68 F to 572 F	.0000169 per ° C from 20 C to 300 C
Thermal Conductivity	115 Btu /sq ft /ft /hr /°F @ 68 F	.47 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	20.8 Ohms (circ mil /ft) @ 68 F	3.44 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	50 % IACS @ 68 F	.293 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	Btu /lb °F @ 68 F	cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,300,000 psi	12,150 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Electrical springs, sockets, terminals, connectors, clips and other current carrying parts requiring strength

Common Fabrication Processes

Drawing, forming, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature. . . 1200-1800 F or 650-980 C
 Annealing Temperature 750-1100 F or 400-600 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Fair

Resistance Welding

{ Spot Fair
 { Seam Good
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 195 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
																							
																							
																							
																							
	Sheet Plate ROD WIRE TUBE PIPE SHAPES																						
																							
																							
																							
																							

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.
2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.
3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)		ksi	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Precipitation Heat Treated	80.0	....	65.0	15	-	-	-	....	26.0	100
		Precipitation Heat Treated and Cold Rolled Half Hard	86.0	....	80.0	10	-	-	-	....	....	....
		Precipitation Heat Treated and Cold Rolled Spring	93.0	....	90.0	4	-	-	-	....	29.0	100
		Precipitation Heat Treated and Cold Rolled Super Spring	97.0	....	95.0	2	-	-	-	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 210 (GILDING, 95%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	95	94.0	96.0
Lead	....	....	.05
Iron	....	....	.05
Zinc	5	Remainder	
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B36, B134
Pipe	
Rod	
Shapes	
Tube	
Wire	B134

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1950 F	1065 C
Melting Point (Solidus)	1920 F	1050 C
Density	.320 lb /cu in @ 68 F	8.86 gm /cu cm @ 20 C.
Specific Gravity	8.86	8.86
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000100 per ° F from 68 F to 572 F	.0000181 per ° C from 20 C to 300 C
Thermal Conductivity	135 Btu /sq ft /ft /hr /°F @ 68 F	.56 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	18.5 Ohms (circ mil /ft) @ 68 F	3.08 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	56 % IACS @ 68 F	.325 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm °C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

COINAGE: coins, medals and tokens
MUNITIONS: bullet jackets, firing pin support shells, fuse caps, primers
NOVELTIES: emblems, jewelry, plaques
MISCELLANEOUS: base for gold plate, base for vitreous enamel

Common Fabrication Processes

Blanking, coining, drawing, etching, forming and bending, piercing and punching, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1400-1600 F or 750-875 C
Annealing Temperature .. 800-1450 F or 425-800 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Not Recommended
Seam..... Not Recommended
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 210 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	{	Strip, Rolled	•	•			•			•	•		•	•	•								
		Strip, Drawn																					
		Flat Wire, Rolled																					
		Flat Wire, Drawn																					
		Bar, Rolled																					
		Bar, Drawn																					
		Sheet																					
		Plate																					
		ROD																					
		WIRE	•	•	•	•	•																
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROLLED STRIP	.040 in.	.050 mm.	34.0	10.0	....	45	46	-	-	....	....	....
		.035 mm.	35.0	11.0	....	45	52	-	4	28.0	....	....
		.015 mm.	38.0	14.0	....	42	60	-	15	30.0	....	....
		Quarter Hard	42.0	32.0	....	25	-	38	44	32.0	....	....
		Half Hard	48.0	40.0	....	12	-	52	54	34.0	....	....
		Hard	56.0	50.0	....	5	-	64	60	37.0	....	....
		Extra Hard	61.0	55.0	....	4	-	70	64	39.0	....	....
		Spring	64.0	58.0	....	4	-	73	66	40.0	....	....

COPPER ALLOY No. 220 (COMMERCIAL BRONZE, 90%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	90	89.0	91.0
Lead	....	....	.05
Iron	....	....	.05
Zinc	10	Remainder	
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B36, B130, B131, B134
Pipe	
Rod	
Shapes	B130, B131
Tube	B135, B372
Wire	B134

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1910 F	1045 C
Melting Point (Solidus)	1870 F	1020 C
Density	.318 lb /cu in @ 68 F	8.80 gm /cu cm @ 20 C.
Specific Gravity	8.80	8.80
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000102 per °F from 68 F to 572 F	.0000184 per °C from 20 C to 300 C
Thermal Conductivity	109 Btu /sq ft /ft /hr /°F @ 68 F	.45 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	23.6 Ohms (circ mil /ft) @ 68 F	3.92 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	44 % IACS @ 68 F	.255 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL:	etching bronze, grillwork, screen cloth, weatherstripping
COSMETICS:	compacts, lipstick cases
HARDWARE:	escutcheons, kick plates, line clamps, marine hardware, rivets, screws, screw shells
MUNITIONS:	primer caps, rotating bands
MISCELLANEOUS:	costume jewelry, ornamental trim, screen wire, vitreous enamel base

Common Fabrication Processes

Blanking, coining, drawing, etching, forming and bending, heading and upsetting, hot forging and pressing, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Good
Hot Forgeability Rating (Forging Brass = 100)	
Hot Working Temperature	1400-1600 F or 750-875 C
Annealing Temperature	800-1450 F or 425-800 C
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Good
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Not Recommended
Resistance Welding	Spot Not Recommended
	Seam Not Recommended
	Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 220 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•			•	•		•	•	•									
	Strip, Drawn								•														
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet			•								•									•		
	Plate			•								•									•		
	ROD			•						•											•		
	WIRE			•		•				•	•	•		•	•	•							
TUBE																	•	•					
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	37.0	10.0	....	45	53	-	6	28.0	....	....
		.035 mm	38.0	12.0	....	45	57	-	12	30.0	....	....
		.025 mm	39.0	14.0	....	44	60	-	16	31.0	....	....
		.015 mm	41.0	15.0	....	42	65	-	26	32.0	....	....
		Quarter Hard	45.0	35.0	....	25	-	42	44	33.0	....	....
		Half Hard	52.0	45.0	....	11	-	58	56	35.0	....	....
		Hard	61.0	54.0	....	5	-	70	63	38.0	....	....
		Extra Hard	67.0	58.0	....	4	-	75	67	40.0	....	....
	.250 in.	Spring	72.0	62.0	....	3	-	78	69	42.0	21.0	15
		.035 mm	38.0	12.0	....	50	57	-	-	30.0	....	....
	.040 in.	Half Hard	52.0	45.0	....	15	-	58	-	35.0	....	....
		As Hot Rolled	39.0	14.0	....	44	60	-	-	31.0	....	....
	.250 in.	As Hot Rolled	37.0	10.0	....	45	53	-	-	28.0	....	....
WIRE	.080 in.	.035 mm	40.0	....	....	50	-	-	-	30.0	....	....
		.015 mm	42.0	....	....	48	-	-	-	32.0	....	....
		Eighth Hard	44.0	....	....	27	-	-	-	33.0	....	....
		Quarter Hard	50.0	....	....	13	-	-	-	34.0	....	....
		Half Hard	60.0	....	....	6	-	-	-	37.0	....	....
		Hard	74.0	....	....	4	-	-	-	42.0	23.0	100
		Extra Hard	83.0	....	....	3	-	-	-	....	....	....
		Spring	90.0	....	....	3	-	-	-	....	....	....
TUBE	1.0 in. OD X .065 in.	.035 mm	38.0	12.0	....	50	57	-	12	....	....	....
		Hard Drawn (35%)	60.0	53.0	....	6	-	69	62	....	....	....
ROD	.500 in.	.035 mm	40.0	....	....	50	55	-	-	32.0	....	....
		Eighth Hard	45.0	....	....	25	-	42	-	33.0	....	....

COPPER ALLOY No. 226 (JEWELRY BRONZE, 87½%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	87.5	86.0	89.0
Lead	....	....	.05
Iron	....	....	.05
Zinc	12.5	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1895 F	1035 C
Melting Point (Solidus)	1840 F	1005 C
Density	.317 lb /cu in @ 68 F	8.78 gm /cu cm @ 20 C.
Specific Gravity	8.78	8.78
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000103 per ° F from 68 F to 572 F	.0000186 per ° C from 20 C to 300 C
Thermal Conductivity	100 Btu /sq ft /ft /hr /°F @ 68 F	.41 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	25.9 Ohms (circ mil /ft) @ 68 F	4.31 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	40 % IACS @ 68 F	.232 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

- ARCHITECTURAL: angles, channels
 HARDWARE: chain, eyelets, fasteners, slide fasteners
 NOVELTIES: compacts, costume jewelry, emblems, etched articles, lipstick containers, plaques
 MISCELLANEOUS: base for gold plate

Common Fabrication Processes

Blanking, coining, drawing, etching, forming and bending, heading and upsetting, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked..... Excellent
 Capacity for Being Hot Formed..... Good
 Hot Forgeability Rating (Forging Brass = 100).....
 Hot Working Temperature 1400-1650 F or 750-900 C
 Annealing Temperature..... 800-1400 F or 425-750 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering..... Excellent
 Brazing..... Excellent
 Oxyacetylene Welding..... Good
 Gas Shielded Arc Welding..... Good
 Coated Metal Arc Welding..... Not Recommended
 Resistance Welding { Spot..... Fair
 Seam..... Not Recommended
 Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 226 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•			•	•	•	•	•	•	•	•							
	Strip, Drawn									•	•	•	•	•	•	•	•							
	Flat Wire, Rolled									•	•	•	•	•	•	•	•							
	Flat Wire, Drawn	•	•	•	•	•	•																	
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD																							
	WIRE	•	•	•	•	•	•			•	•	•	•	•	•	•	•							
TUBE																								
PIPE																								
SHAPES																								

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	39.0	11.0	....	46	55	-	-	29.0	....	....
		.035 mm	40.0	13.0	....	45	59	-	-	30.0	....	....
		.025 mm	42.0	15.0	....	44	64	-	-	31.0	....	....
		.015 mm	44.0	16.0	....	42	68	-	-	32.0	....	....
		Eighth Hard	....	....	....	....	-	-	-	....	....	....
		Quarter Hard	47.0	37.0	....	25	-	47	-	34.0	....	....
		Half Hard	54.0	47.0	....	12	-	61	-	36.0	....	....
		Hard	66.0	56.0	....	5	-	73	-	40.0	....	....
		Extra Hard	72.0	60.0	....	4	-	78	-	42.0	....	....
		Spring	79.0	62.0	....	4	-	82	-	44.0	....	....
WIRE	.080 in.	.050 mm	40.0	....	....	44	-	-	-	29.0	....	....
		.035 mm	41.0	18.0	....	42	-	-	-	30.0	....	....
		.025 mm	43.0	....	....	40	-	-	-	31.0	....	....
		.015 mm	45.0	18.0	....	38	-	-	-	32.0	....	....
		Eighth Hard	47.0	....	....	26	-	-	-	34.0	....	....
		Quarter Hard	56.0	....	....	12	-	-	-	36.0	....	....
		Half Hard	68.0	....	....	7	-	70	-	40.0	....	....
		Hard	83.0	....	....	5	-	-	-	....	....	....
		Extra Hard	89.0	....	....	4	-	-	-	....	....	....
		Spring	97.0	....	....	3	-	-	-	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

C 23000 ← UNS

COPPER ALLOY No. 230 (RED BRASS, 85%)

(QQ-B-626 J.W.)

Composition — percent

	Nominal	Minimum	Maximum
Copper	85	84.0*	86.0
Lead	....	....	.05*
Iron	....	....	.05
Zinc	15	Remainder	
Total Other Elements	....	....	.15

* For pipe and tube, the copper limit may be 83.0 percent minimum; and the lead .06 percent maximum

Nearest Applicable A S T M Specifications

Flat Products	B36, B134
Pipe	B43
Rod	
Shapes	
Tube	B111, B135, B359, B395, B543
Wire	B134

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1880 F	1025 C
Melting Point (Solidus)	1810 F	990 C
Density	.316 lb /cu in @ 68 F	8.75 gm /cu cm @ 20 C.
Specific Gravity	8.75	8.75
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000104 per °F from 68 F to 572 F	.0000187 per °C from 20 C to 300 C
Thermal Conductivity	92 Btu /sq ft /ft /hr °F @ 68 F	.38 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	28.0 Ohms (circ mil /ft) @ 68 F	4.66 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	37 % IACS @ 68 F	.215 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL:	etching parts, trim, weatherstrip
ELECTRICAL:	conduit, screw shells, sockets
HARDWARE:	eyelets, fasteners, fire extinguishers
INDUSTRIAL:	condenser and heat exchanger tubes, flexible hose, pickling crates, plumbing pipe, pump lines, radiator cores
PLUMBING:	J-bends, pipe service lines, traps
MISCELLANEOUS:	badges, compacts, costume jewelry, dials, etched articles, lipstick containers, nameplates, rouge boxes, tags

Common Fabrication Processes

Blanking, coining, drawing, etching, forming and bending, heading and upsetting, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked.....	Excellent
Capacity for Being Hot Formed.....	Good
Hot Forgeability Rating (Forging Brass = 100).....	
Hot Working Temperature.....	1450-1650 F or 800-900 C
Annealing Temperature.....	800-1350 F or 425-725 C
Machinability Rating (Free Cutting Brass = 100).....	30

Suitability for being joined by:	
Soldering.....	Excellent
Brazing.....	Excellent
Oxyacetylene Welding.....	Good
Gas Shielded Arc Welding.....	Good
Coated Metal Arc Welding.....	Not Recommended
Resistance Welding	{ Spot..... Fair
	{ Seam..... Not Recommended
	{ Butt..... Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 230 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
		.100	.070	.050	.035	.025	.015																
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•				•	•		•	•	•							
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet			•																			
	Plate																						
	ROD																						
	WIRE				•	•	•			•	•	•		•		•							
	TUBE	•																•	•	•			
	PIPE																						
SHAPES																							

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	39.0	10.0	....	48	56	—	10	31.0	....	....
		.050 mm	40.0	12.0	....	47	59	—	14	31.0	....	....
		.035 mm	41.0	14.0	....	46	63	—	22	31.0	....	....
		.025 mm	43.0	16.0	....	44	66	—	28	32.0	....	....
		.015 mm	45.0	18.0	....	42	71	—	38	33.0	....	....
		Quarter Hard	50.0	39.0	....	25	—	55	54	35.0	....	....
		Half Hard	57.0	49.0	....	12	—	65	60	37.0	....	....
		Hard	70.0	57.0	....	5	—	77	68	42.0	....	....
		Extra Hard	78.0	61.0	....	4	—	83	72	44.0	....	....
		Spring	84.0	63.0	....	3	—	86	74	46.0	....	....
WIRE	.080 in.	.035 mm	41.0	....	....	48	—	—	—	31.0	....	....
		.025 mm	43.0	....	....	....	—	—	—	32.0	....	....
		.015 mm	45.0	....	....	....	—	—	—	33.0	....	....
		Eighth Hard	50.0	....	....	25	—	—	—	35.0	20.0*	100
		Quarter Hard	59.0	....	....	11	—	—	—	38.0	....	....
		Half Hard	72.0	....	....	8	—	—	—	43.0	....	....
		Hard	88.0	....	....	6	—	—	—	48.0	....	....
		Spring	105.0	....	....	....	—	—	—	54.0	....	....
TUBE	1.0 in. OD X .065 in.	.050 mm	40.0	12.0	....	55	60	—	15	....	....	....
		.015 mm	44.0	18.0	....	45	71	—	38	....	....	....
		Light Drawn (15%)	50.0	40.0	....	30	—	55	54	....	....	....
		Hard Drawn (35%)	70.0	58.0	....	8	—	77	68	....	....	....
PIPE	3/4 in. SPS	.015 mm	44.0	18.0	....	45	71	—	—	....	....	....

* Rotating beam tests on rod.

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 240 (LOW BRASS, 80%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	80	78.5	81.5
Lead	....	....	.05
Iron	....	....	.05
Zinc	20	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Flat Products	B36, B134
Pipe	
Rod	
Shapes	
Tube	
Wire	B134

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1830 F	1000 C
Melting Point (Solidus)	1770 F	965 C
Density	.313 lb /cu in @ 68 F	8.67 gm /cu cm @ 20 C.
Specific Gravity	8.67	8.67
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000106 per ° F from 68 F to 572 F	.0000191 per ° C from 20 C to 300 C
Thermal Conductivity	81 Btu /sq ft /ft /hr /°F @ 68 F	.33 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	32.4 Ohms (circ mil /ft) @ 68 F	5.39 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	32 % IACS @ 68 F	.186 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL:	ornamental metal work, medallions, spandrels
ELECTRICAL:	battery caps
INSTRUMENTS:	bellows, musical instruments
HARDWARE:	clock dials, flexible hose, pump lines, tokens

Common Fabrication Processes

Blanking, drawing, etching, forming and bending, heading and upsetting, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Fair
Hot Forgeability Rating (Forging Brass = 100)	.....
Hot Working Temperature	1500-1650 F or 825-900 C
Annealing Temperature	800-1300 F or 425-700 C
Machinability Rating (Free Cutting Brass = 100)	30

Suitability for being joined by:	
Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Good
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Not Recommended
Resistance Welding	{ Spot Fair
	{ Seam Not Recommended
	{ Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 240 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•			•	•		•		•								
	Strip, Drawn																						
	Flat Wire, Rolled		•	•						•					•								
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE		•	•		•				•	•	•		•	•	•							
	TUBE																						
	PIPE																						
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	42.0	12.0	....	52	57	-	8	....	....	....
		.050 mm	44.0	14.0	....	50	61	-	16	32.0	....	....
		.035 mm	46.0	15.0	....	48	66	-	28	....	....	....
		.025 mm	48.0	17.0	....	47	69	-	32	....	....	....
		.015 mm	50.0	20.0	....	46	75	-	42	33.0	....	....
		Quarter Hard	53.0	40.0	....	30	-	55	54	36.0	....	....
		Half Hard	61.0	50.0	....	18	-	70	64	39.0	....	....
		Hard	74.0	59.0	....	7	-	82	71	43.0	....	....
		Spring	91.0	65.0	....	3	-	91	77	48.0	24.0	20
WIRE	.080 in.	.050 mm	44.0	....	....	55	-	-	-	32.0	....	....
		.035 mm	46.0	....	....	50	-	-	-	....	....	....
		.015 mm	50.0	....	....	47	-	-	-	33.0	....	....
		Eighth Hard	56.0	....	....	27	-	-	-	37.0	....	....
		Quarter Hard	68.0	....	....	12	-	-	-	42.0	....	....
		Half Hard	82.0	....	....	8	-	-	-	47.0	....	....
		Hard	107.0	....	....	5	-	-	-	53.0	23.0	100
		Extra Hard	116.0	....	....	4	-	-	-	....	....	....
		Spring	125.0	....	....	3	-	-	-	60.0	26.0	100

COPPER ALLOY No. 260 (CARTRIDGE BRASS, 70%)

Q10-B-613
MIL-5-22493

Composition — percent

	Nominal	Minimum	Maximum
Copper	70	68.5	71.5
Lead	....	....	.07
Iron	....	....	.05
Zinc	30	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Flat Products	B19, B36, B134
Pipe	
Rod	
Shapes	B129
Tube	B135
Wire	B134

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1750 F	955 C
Melting Point (Solidus)	1680 F	915 C
Density	.308 lb/cu in @ 68 F	8.53 gm/cu cm @ 20 C.
Specific Gravity	8.53	8.53
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000111 per ° F from 68 F to 572 F	.0000199 per ° C from 20 C to 300 C
Thermal Conductivity	70 Btu/sq ft/ft/hr/°F @ 68 F	.29 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	37.0 Ohms (circ mil/ft) @ 68 F	6.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	28 % IACS @ 68 F	.162 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL:	grillwork
AUTOMOTIVE:	radiator cores and tanks
ELECTRICAL:	flashlight shells, lamp fixtures, reflectors, screw shells, socket shells
HARDWARE:	bead chain, chain, eyelets, fasteners, grommets, finish hardware articles (hinges, kick plates, locks, push plates, etc.), stencils
INDUSTRIAL:	pump and power cylinders and liners
MUNITIONS:	ammunition components
PLUMBING:	plumbing accessories, plumbing brass goods
WIRE:	pins, rivets, screws, springs

Common Fabrication Processes

Blanking, drawing, etching, forming and bending, heading and upsetting, piercing and punching, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold WorkedExcellent
Capacity for Being Hot FormedFair
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1350-1550 F or 725-850 C
Annealing Temperature 800-1400 F or 425-750 C
Machinability Rating (Free Cutting Brass = 100)30

Suitability for being joined by:
Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Good
Seam Not Recommended
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 260 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	{	Strip, Rolled	•	•	•	•	•	•				•	•		•	•	•	•						
		Strip, Drawn	•	•	•	•	•	•				•	•		•	•								
		Flat Wire, Rolled	•	•	•	•	•	•					•	•										
		Flat Wire, Drawn	•	•	•	•	•	•					•	•										
		Bar, Rolled	•	•	•	•	•	•					•	•										
		Bar, Drawn	•	•	•	•	•	•						•	•									
		Sheet	•	•	•	•	•	•					•	•										
		Plate	•	•	•	•	•	•					•	•										
		ROD	•	•	•	•	•	•				•	•											
		WIRE	•	•	•	•	•	•				•	•		•	•				•	•			
		TUBE	•	•	•	•	•	•																
		PIPE	•	•	•	•	•	•																
		SHAPES	•	•	•	•	•	•																

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.100 mm	44.0	11.0	....	66	54	-	11	....	13.0	100
		.070 mm	46.0	14.0	....	65	58	-	15	32.0	13.0	100
		.050 mm	47.0	15.0	....	62	64	-	26	....	....	....
		.035 mm	49.0	17.0	....	57	68	-	31	34.0	14.0	100
		.025 mm	51.0	19.0	....	55	72	-	36	....	....	....
		.015 mm	53.0	22.0	....	54	78	-	43	35.0	14.0	100
		Quarter Hard	54.0	40.0	....	43	-	55	54	36.0	....	....
		Half Hard	62.0	52.0	....	25	-	70	65	40.0	18.0	100
		Hard	76.0	63.0	....	8	-	82	73	44.0	21.0	100
		Extra Hard	86.0	65.0	....	5	-	88	76	46.0	....	....
		Spring	94.0	65.0	....	3	-	91	77	48.0	23.0	100
		Extra Spring	99.0	65.0	....	3	-	93	78	....	....	....
WIRE	.080 in.	.050 mm	48.0	....	....	64	-	-	-	....	....	....
		.035 mm	50.0	....	....	60	-	-	-	34.0	....	....
		.025 mm	52.0	....	....	58	-	-	-	....	....	....
		.015 mm	54.0	....	....	56	-	-	-	....	....	....
		Eighth Hard	58.0	....	....	35	-	-	-	38.0	....	....
		Quarter Hard	70.0	....	....	20	-	-	-	....	....	....
		Extra Hard	124.0	....	....	4	-	-	-	....	....	....
TUBE	1.0 in. OD X .065 in.	.050 mm	47.0	15.0	....	65	64	-	26	....	....	....
		.025 mm	52.0	20.0	....	55	75	-	40	....	....	....
		Hard Drawn (35%)	78.0	64.0	....	8	-	82	73	....	....	....
ROD	1.0 in.	.050 mm	48.0	16.0	....	65	65	-	-	34.0	....	....
		Eighth Hard (6%)	55.0	40.0	....	48	-	60	-	36.0	....	....
		Half Hard (20%)	70.0	52.0	....	30	-	80	-	42.0	22.0	50

COPPER ALLOY Nos. 268 and 270 (YELLOW BRASS)

Composition — percent

	ALLOY NO. 268 (SHEET)			ALLOY NO. 270 (ROD AND WIRE)			Nearest Applicable A S T M Specifications *	
	Nominal	Minimum	Maximum	Nominal	Minimum	Maximum		
Copper	66	64.0	68.5	65	63.0	68.5	Flat Products	B36, B134
Lead	....	....	.15	....	....	.10	Pipe	
Iron	....	....	.05	....	....	.07	Rod	
Zinc	34	Remainder		35	Remainder		Shapes	
Total Other Elements	....	....	.15	....	....	.20	Tube	B135
							Wire	B134

* Refer to specific ASTM Specification for alloys covered

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1710 F	930 C
Melting Point (Solidus)	1660 F	905 C
Density	.306 lb/cu in @ 68 F	8.47 gm/cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per ° F from 68 F to 572 F	.0000203 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	38.4 Ohms (circ mil/ft) @ 68 F	6.39 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	27 % IACS @ 68 F	.157 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

Typical Uses

- ARCHITECTURAL: grillwork
- AUTOMOTIVE: radiator cores and tanks
- ELECTRICAL: flashlight shells, lamp fixtures, reflectors, screw shells, socket shells
- HARDWARE: bead chain, chain, eyelets, fasteners, grommets, finish hardware articles (hinges, kick plates, locks, push plates, etc.), stencils
- PLUMBING: plumbing accessories, sink strainers
- WIRE: pins, rivets, screws, springs

Common Fabrication Processes

Blanking, drawing, etching, forming and bending, heading and upsetting, piercing and punching, roll threading and knurling, shearing, spinning, squeezing and swaging, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 800-1300 F or 425-700 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Good
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 268 and 270 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•			•	•	•		•	•	•									
	Strip, Drawn								•	•	•		•	•										
	Flat Wire, Rolled			•							•			•		•								
	Flat Wire, Drawn			•							•			•										
	Bar, Rolled										•			•										
	Bar, Drawn										•			•										
	Sheet			•			•				•			•										
	Plate			•							•			•										
	ROD			•						•														
	WIRE	•	•	•	•	•				•	•	•		•	•	•								
	TUBE																							
	PIPE																							
	SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	46.0	14.0	....	65	58	-	15	32.0	12.0	100
		.050 mm	47.0	15.0	....	62	64	-	26	....	....	....
		.035 mm	49.0	17.0	....	57	68	-	31	34.0	....	....
		.025 mm	51.0	19.0	....	55	72	-	36	....	....	....
		.015 mm	53.0	22.0	....	54	78	-	43	....	....	....
		Eighth Hard	50.0	35.0	....	50	-	50	50	....	....	....
		Quarter Hard	54.0	40.0	....	43	-	55	54	36.0	....	....
		Half Hard	61.0	50.0	....	23	-	70	65	40.0	....	....
		Hard	74.0	60.0	....	8	-	80	70	43.0	14.0	100
		Extra Hard	85.0	62.0	....	5	-	87	74	45.0	....	....
ROD	1.0 in.	Spring	91.0	62.0	....	3	-	90	76	47.0	20.0	100
WIRE	.080 in.	.050 mm	48.0	16.0	....	65	65	-	-	34.0	....	....
		Eighth Hard (6%)	55.0	40.0	....	48	-	55	-	36.0	....	....
		.035 mm	50.0	....	....	60	-	-	-	34.0	....	....
		Eighth Hard	58.0	....	....	35	-	-	-	38.0	....	....
		Quarter Hard	70.0	....	....	20	-	-	-	42.0	22.0*	300
		Half Hard	88.0	....	....	15	-	-	-	....	....	....
		Hard	110.0	....	....	8	-	-	-	55.0	....	....
WIRE	.080 in.	Extra Hard	120.0	....	....	4	-	-	-	60.0	....	....
		Spring	128.0	....	....	3	-	-	-	60.0	....	....

* Rotating beam tests on rod

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 280 (MUNTZ METAL, 60%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	59.0	63.0
Lead	....	....	.30
Iron	....	....	.07
Zinc	40	Remainder	
Total Other Elements	....	....	.20

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	B111, B135, B395
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1660 F	905 C
Melting Point (Solidus)	1650 F	900 C
Density	.303 lb /cu in @ 68 F	8.39 gm /cu cm @ 20 C.
Specific Gravity	8.39	8.39
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000116 per ° F from 68 F to 572 F	.0000208 per ° C from 20 C to 300 C
Thermal Conductivity	71 Btu /sq ft /ft /hr /° F @ 68 F	.29 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	37.0 Ohms (circ mil /ft) @ 68 F	6.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	28 % IACS @ 68 F	.162 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

ARCHITECTURAL:	panels and large sheets, trim
HARDWARE:	large nuts and bolts
INDUSTRIAL:	brazing rod, condenser plates; condenser, evaporator and heat exchanger tubes; hot forgings

Common Fabrication Processes

Blanking, forming and bending, hot forging and pressing, hot heading and upsetting, shearing

Fabrication Properties

Capacity for Being Cold Worked	Fair
Capacity for Being Hot Formed	Excellent
Hot Forgeability Rating (Forging Brass = 100)	90
Hot Working Temperature	1150-1450 F or 625-800 C
Annealing Temperature	800-1100 F or 425-600 C
Machineability Rating (Free Cutting Brass = 100)	40

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Good
Gas Shielded Arc Welding	Fair
Coated Metal Arc Welding ...	Not Recommended
Resistance Welding { Spot	Good
Seam	Not Recommended
Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 280 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers		Rolled or Drawn Tempers										Hot Finished Tempers									
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled							•				•									•		
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled							•				•									•		
	Bar, Drawn																						
	Sheet							•		•											•		
	Plate							•		•											•		
	ROD							•		•	•										•	•	
	WIRE																						
TUBE																	•		•				
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Soft Anneal	54.0	21.0	....	45	80	-	46	40.0	....	....
		As Hot Rolled	54.0	21.0	....	45	85	-	49	40.0	....	....
		Eighth Hard	60.0	35.0	....	30	-	55	54	42.0	....	....
		Half Hard	70.0	50.0	....	10	-	75	67	44.0	....	....
ROD	1.0 in.	Soft Anneal	54.0	21.0	....	50	80	-	-	40.0	....	....
		Quarter Hard	72.0	50.0	....	25	-	78	-	45.0	....	....
		As Extruded	52.0	20.0	....	52	78	-	-	39.0	....	....
TUBE	1.0 in. OD	Light Anneal	56.0	23.0	....	50	82	-	47	....	....	....
	X .065 in.	Hard Drawn (30%)	74.0	55.0	....	10	-	80	-	....	....	....

COPPER ALLOY No. 314 (LEADED COMMERCIAL BRONZE)

Composition — percent

	Nominal	Minimum	Maximum
Copper	89	87.5	90.5
Lead	1.9	1.3	2.5
Iron	....	....	.10
Zinc	9.1	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B140
Pipe	
Rod	B140
Shapes	B140
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1900 F	1040 C
Melting Point (Solidus)	1850 F	1010 C
Density	.319 lb/cu in @ 68 F	8.83 gm/cu cm @ 20 C.
Specific Gravity	8.83	8.83
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000102 per ° F from 68 F to 572 F	.0000184 per ° C from 20 C to 300 C
Thermal Conductivity	104 Btu/sq ft/ft/hr/°F @ 68 F	.43 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	24.7 Ohms (circ mil/ft) @ 68 F	4.10 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	42 % IACS @ 68 F	.244 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume Basis

Typical Uses

HARDWARE: screws, screw machine parts
INDUSTRIAL: pickling crates

Common Fabrication Processes

Machining

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Poor
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature F or C
Annealing Temperature 800-1200 F or 425-650 C
Machinability Rating (Free Cutting Brass = 100) 80

Suitability for being joined by:

Soldering Excellent
Brazing Good
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Not Recommended
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 314 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm							Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
DRAWN BAR	.250 in.	Half Hard	55.0	50.0	....	12	-	61	-	31.0	....	....
ROD	1.0 in.	.050 mm	37.0	12.0	....	45	55	-	-	24.0	....	....
	.250 in.	Half Hard (37%)	60.0	55.0	....	10	-	65	-	32.0	....	....
	.500 in.	Half Hard (25%)	55.0	50.0	....	14	-	61	-	31.0	....	....
	1.0 in.	Half Hard (20%)	52.0	45.0	....	18	-	58	-	30.0	....	....

COPPER ALLOY No. 316 (LEADED COMMERCIAL BRONZE, NICKEL BEARING)

Composition — percent

	Nominal	Minimum	Maximum
Copper	89	87.5	90.5
Lead	1.9	1.3	2.5
Iron	....	....	.10
Zinc	8.1	Remainder	
Nickel	1	.7	1.2
Phosphorus	....	....	.10
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B140
Pipe	
Rod	B140
Shapes	B140
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1900 F	1040 C
Melting Point (Solidus)	1850 F	1010 C
Density	.320 lb /cu in @ 68 F	8.86 gm /cu cm @ 20 C.
Specific Gravity	8.86	8.86
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000102 per ° F from 68 F to 572 F	.0000184 per ° C from 20 C to 300 C
Thermal Conductivity	81 Btu /sq ft /ft /hr /°F @ 68 F	.33 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	32.4 Ohms (circ mil /ft) @ 68 F	5.39 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	32 % IACS @ 68 F	.186 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

*Volume Basis

Typical Uses

Electrical connectors, fasteners, hardware, nuts, screws, screw machine parts

Common Fabrication Processes

Machining

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100) 80

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 316 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm							Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
DRAWN BAR	.250 in.	Hard	63.0	56.0	.....	12	—	70	—	.....	.....	.....
ROD	1.0 in.	.050 mm	37.0	12.0	.....	45	55	—	—	24.0	.....	.....
	.500 in.	Hard (38%)	67.0	59.0	.....	13	—	72	—	40.0	.....	.....
	1.0 in.	Hard (38%)	65.0	57.0	.....	15	—	70	—	39.0	.....	.....

COPPER ALLOY No. 330 (LOW-LEADED BRASS TUBE)

(See also Copper Alloy No. 335)

Composition — percent

	Nominal	Minimum	Maximum
Copper	66	65.0	68.0
Lead	.5	.20*	.8
Iron	....	....	.07
Zinc	33.5	Remainder	
Total Other Elements	....	....	.50

* For tube over 5 inches OD, lead may be less than .20 percent.

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	B135
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1720 F	940 C
Melting Point (Solidus)	1660 F	905 C
Density	.307 lb /cu in @ 68 F	8.50 gm /cu cm @ 20 C.
Specific Gravity	8.50	8.50
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000112 per ° F from 68 F to 572 F	.0000202 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

GENERAL PURPOSES: where some degree of machinability is required, together with moderate cold working properties

INDUSTRIAL: pump and power cylinders and liners

MUNITIONS: primers

PLUMBING: plumbing accessories, plumbing brass goods

Common Fabrication Processes

Forming and bending, machining, piercing and punching

Fabrication Properties

Capacity for Being Cold Worked Excellent

Capacity for Being Hot Formed Poor

Hot Forgeability Rating (Forging Brass = 100)

Hot Working Temperature F or C

Annealing Temperature 800-1200 F or 425-650 C

Machinability Rating (Free Cutting Brass = 100)..... 60

Suitability for being joined by:

Soldering Excellent

Brazing Good

Oxyacetylene Welding Fair

Gas Shielded Arc Welding Fair

Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Fair

Seam Not Recommended

Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 330 (Continued)

Forms and Tempers
Most Commonly Used

		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers	
		Nominal Grain Size mm																As Hot Rolled	As Extruded
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)
FLAT PRODUCTS	Strip, Rolled																		
	Strip, Drawn																		
	Flat Wire, Rolled																		
	Flat Wire, Drawn																		
	Bar, Rolled																		
	Bar, Drawn																		
	Sheet																		
	Plate																		
ROD	WIRE																		
	TUBE																		
	PIPE																		
	SHAPES																		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD X .065 in.	.050 mm	47.0	15.0	....	60	64	-	26	....	....	....
		.025 mm	52.0	20.0	....	50	75	-	37	....	....	....
		Hard Drawn (35%)..	75.0	60.0	....	7	-	80	69	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 332 (HIGH-LEADED BRASS TUBE)

(See also Copper Alloy Nos. 342 and 353)

Composition — percent

	Nominal	Minimum	Maximum
Copper	66	65.0	68.0
Lead	1.6	1.3	2.0
Iron	....	....	.07
Zinc	32.4	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	B135
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1710 F	930 C
Melting Point (Solidus)	1650 F	900 C
Density	.308 lb/cu in @ 68 F	8.53 gm/cu cm @ 20 C.
Specific Gravity	8.53	8.53
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per ° F from 68 F to 572 F	.0000203 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil/ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

* Volume Basis

Typical Uses

General purpose screw machine products

Common Fabrication Processes

Machining, piercing and punching

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100) 80

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 332 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finish Tempe						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn																							
		Sheet																						
		Plate																						
		ROD																						
		WIRE																						
	TUBE																							
	PIPE																							
	SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD	.025 mm	52.0	20.0	....	50	75	-	36	....	....	....
	X .065 in.	Hard Drawn (35%)	75.0	60.0	....	7	-	80	69	....	....	....

COPPER ALLOY No. 335 (LOW-LEADED BRASS)

(See also Copper Alloy No. 330)

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	62.5	66.5
Lead	.5	.30	.8
Iron	....	....	.10
Zinc	34.5	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1700 F	925 C
Melting Point (Solidus)	1650 F	900 C
Density	.306 lb/cu in @ 68 F	8.47 gm/cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per °F from 68 F to 572 F	.0000203 per °C from 20 C to 300 C
Thermal Conductivity	67 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil/ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

* Volume Basis

Typical Uses

HARDWARE: butts, hinge brass, watch backs

Common Fabrication Processes

Blanking, drawing, machining, piercing and punching, stamping

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 800-1300 F or 425-700 C
 Machinability Rating (Free Cutting Brass = 100) 60

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Fair
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 335 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finishe Tempers		Special Tempers	
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)			
		.100	.070	.050	.035	.025	.015												Soft Anneal		Light Anneal
FLAT PRODUCTS	{	Strip, Rolled	•	•	•	•				•	•		•								
		Strip, Drawn																			
		Flat Wire, Rolled																			
		Flat Wire, Drawn																			
		Bar, Rolled																			
		Bar, Drawn																			
		Sheet																			
		Plate																			
		ROD						•		•	•										
		WIRE																			
		TUBE																			
		PIPE																			
		SHAPES																			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	46.0	14.0	....	65	58	-	15	32.0	....	....
		.050 mm	47.0	15.0	....	62	64	-	26	....	....	....
		.035 mm	49.0	17.0	....	57	68	-	31	34.0	....	....
		.025 mm	51.0	19.0	....	55	72	-	36	....	....	....
		Quarter Hard	54.0	40.0	....	43	-	55	54	36.0	....	....
		Half Hard	61.0	50.0	....	23	-	70	65	40.0	....	....
		Hard	74.0	60.0	....	8	-	80	69	43.0	....	....

COPPER ALLOY No. 340 (MEDIUM-LEADED BRASS, 64½%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	62.5	66.5
Lead	1	.8	1.4
Iron	....	....	.10
Zinc	34	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1700 F	925 C
Melting Point (Solidus)	1630 F	885 C
Density	.306 lb /cu in @ 68 F	8.47 gm /cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per °F from 68 F to 572 F	.0000203 per °C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: butts, gears, nuts, rivets, screws
MISCELLANEOUS: dials, engravings, instrument plates

Common Fabrication Processes

Blanking, heading and upsetting, machining, piercing
and punching, roll threading and knurling, stamping

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Poor
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature F or C
Annealing Temperature 800-1200 F or 425-650 C
Machinability Rating (Free Cutting Brass = 100) 70

Suitability for being joined by:

Soldering Excellent
Brazing Good
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Not Recommended
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 340 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	{	Strip, Rolled	.	•	•	•				•		•		•									
		Strip, Drawn	.								•												
		Flat Wire, Rolled	.									•											
		Flat Wire, Drawn	.																				
		Bar, Rolled	.								•		•										
		Bar, Drawn	.										•										
		Sheet	.																				
		Plate	.										•										
		ROD	.					•			•		•										
		WIRE	.				•			•		•											
TUBE	.							•		•													
PIPE	.																						
SHAPES	.																				•		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	47.0	15.0	....	60	64	-	26	....	....	....
		.035 mm	49.0	17.0	....	54	68	-	31	34.0	....	....
		.025 mm	51.0	19.0	....	53	72	-	36	....	....	....
		Quarter Hard	54.0	40.0	....	41	-	55	54	36.0	....	....
		Half Hard	61.0	50.0	....	21	-	70	65	40.0	....	....
		Hard	74.0	60.0	....	7	-	80	69	43.0	....	....
ROD	1.0 in.	.025 mm	50.0	19.0	....	60	70	-	-	34.0	....	....
		Quarter Hard (10%)	55.0	42.0	....	40	-	60	-	36.0	....	....
WIRE	.080 in.	.025 mm	50.0	....	....	60	-	-	-	34.0	....	....
		Eighth Hard	58.0	....	....	45	-	-	-	38.0	....	....
		Half Hard	88.0	....	....	15	-	-	-	46.0	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 349

Composition — percent

	Nominal	Minimum	Maximum
Copper	62.2	61.0	64.0
Lead	.3	.10	.50
Iron	....	....	.10
Zinc	37.5	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1670 F	910 C
Melting Point (Solidus)	1640 F	895 C
Density	.305 lb /cu in @ 68 F	8.44 gm /cu cm @ 20 C.
Specific Gravity	8.44	8.44
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per ° F from 68 F to 572 F	.0000203 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

*Volume Basis

Typical Uses

Building hardware, drilled and tapped rivets, plumbing goods, saw nuts, and parts requiring moderate cold working combined with some machining

Common Fabrication Processes

Bending and forming, heading and upsetting, machining, roll threading and knurling

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Fair
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature..... 1250-1450 F or 675-800 C
Annealing Temperature..... 800-1200 F or 425-650 C
Machinability Rating (Free Cutting Brass = 100)..... 50

Suitability for being joined by:

Soldering..... Excellent
Brazing Good
Oxyacetylene Welding Fair
Gas Shielded Arc Welding..... Fair
Coated Metal Arc Welding..... Not Recommended

Resistance Welding

{ Spot Fair
Seam Not Recommended
Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 349 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
FLAT PRODUCTS	Strip, Rolled																								
	Strip, Drawn																								
	Flat Wire, Rolled																								
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD																								
	WIRE																								
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD	.250 in.	.035 mm	53.0	24.0	....	50	75	-	-	34.0	....	....
	1.0 in.	Quarter Hard (10%)	56.0	42.0	....	42	-	70	-	36.0	....	....
WIRE	.750 in.	.050 mm	48.0	16.0	....	72	67	-	-	32.0	....	....
	.250 in.	.015 mm	55.0	22.0	....	48	70	-	-	35.0	....	....
	.250 in.	Quarter Hard (21%)	68.0	55.0	....	18	-	72	-	41.0	....	....

COPPER ALLOY No. 350 (MEDIUM-LEADED BRASS, 62%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	62.5	59.0*	64.0
Lead	1.1	.8	1.4
Iron	....	....	.10
Zinc	36.4	Remainder	
Total Other Elements	....	....	.50

*Copper, 61.0% minimum for rod.

Nearest Applicable A S T M Specifications

Flat Products	B121
Rod	B453
Wire	
Tube	
Pipe	
Shapes	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1680 F	915 C
Melting Point (Solidus)	1640 F	895 C
Density	.306 lb/cu in @ 68 F	8.47 gm/cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per ° F from 68 F to 572 F	.0000203 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil/ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

*Volume Basis

Typical Uses

Bearing cages, book dies, clock plates, engraving plates, gears, hinges, hose couplings, keys, lock parts, lock tumblers, meter parts, sink strainers, strike plates, templates, nuts, type characters, washers, wear plates

Common Fabrication Processes

Blanking, machining, piercing and punching, roll threading and knurling, stamping

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Fair
 Hot Forgeability Rating (Forging Brass = 100) 50
 Hot Working Temperature 1400-1500 F or 760-800 C
 Annealing Temperature 800-1100 F or 425-500 C
 Machinability Rating (Free Cutting Brass = 100) 70

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 350 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled		•	•	•	•				•	•	•	•	•									
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD		•				•				•		•										
	WIRE																						
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
			(.5% Ext. under Load)	(.2% Offset)	F		B	30T	ksi		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	45.0	13.0	13.0	57	61	-	-	....	....	....
		.035 mm	47.0	16.0	16.0	54	67	-	-	....	....	....
		.025 mm	48.0	20.0	20.0	50	70	-	-	....	....	....
		.015 mm	51.0	25.0	25.0	46	74	-	-	....	....	....
		Quarter Hard	54.0	32.0	34.0	43	-	53	52	....	....	....
		Half Hard	60.0	45.0	45.0	29	-	66	60	....	....	....
		Three Quarter Hard ..	67.0	53.0	55.0	17	-	75	68	....	....	....
		Hard	73.0	60.0	60.0	10	-	80	71	....	....	....
ROD	.500 in.	Extra Hard	84.0	65.0	69.0	5	-	86	75	....	....	....
		.050 mm	48.0	16.0	....	56	65	-	25	34.0	....	....
		.015 mm	55.0	25.0	....	46	85	-	50	36.0	....	....
		Quarter Hard (10%) ..	58.0	44.0	....	42	-	60	57	38.0	....	....
		Half Hard (20%)	70.0	52.0	....	22	-	80	70	42.0	....	....

COPPER ALLOY Nos. 342 and 353 (HIGH-LEADED BRASS)

(See also Copper Alloy No. 332)

Composition — percent

	Copper Alloy No. 342			Copper Alloy No. 353		
	Nominal	Minimum	Maximum	Nominal	Minimum	Maximum
Copper	64.5	62.5	66.5	62	59.0*	64.5
Lead	2	1.5	2.5	1.8	1.3	2.3
Iron	....	....	0.1	....	....	.1
Zinc	33.5	Remainder		36.2	Remainder	
Total Other Elements	....	....	.05	....	....	.5

* For rod, the copper content shall be 61.0 percent minimum.

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1670 F	910 C
Melting Point (Solidus)	1630 F	885 C
Density	.306 lb /cu in @ 68 F	8.47 gm /cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000113 per ° F from 68 F to 572 F	.0000203 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE. clock plates and nuts, clock and watch parts, gears, wheels
INDUSTRIAL: channel plate

Common Fabrication Processes

Blanking, machining, piercing and punching, roll threading and knurling, stamping

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 90

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 342 and 353 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	{	Strip, Rolled			•			•			•	•		•	•								
		Strip, Drawn																					
		Flat Wire, Rolled																					
		Flat Wire, Drawn																					
		Bar, Rolled										•		•									
		Bar, Drawn																					
		Sheet							•														
		Plate											•										
		ROD							•		•	•											
		WIRE																					
		TUBE																					
		PIPE																					
		SHAPES																					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	49.0	17.0	....	52	68	-	31	34.0	....	....
		Quarter Hard	54.0	40.0	....	38	-	55	54	36.0	....	....
		Half Hard	61.0	50.0	....	20	-	70	65	40.0	....	....
		Hard	74.0	60.0	....	7	-	80	69	43.0	....	....
		Extra Hard	85.0	62.0	....	5	-	87	74	45.0	....	....
ROD	1.0 in.	Half Hard (20%)	58.0	45.0	....	25	-	75	-	....	....	....

COPPER ALLOY No. 356 (EXTRA-HIGH LEADED BRASS)

Composition — percent

	Nominal	Minimum	Maximum
Copper	62	59.0*	64.5
Lead	2.5	2.0	3.0
Iron	....	....	.10
Zinc	35.5	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B121
Pipe	
Rod	B453
Shapes	
Tube	
Wire	

*Copper, 60.0% minimum for rod.

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1660 F	905 C
Melting Point (Solidus)	1630 F	885 C
Density	.307 lb /cu in @ 68 F	8.50 gm /cu cm @ 20 C.
Specific Gravity	8.50	8.50
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000114 per ° F from 68 F to 572 F	.0000205 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	14,000,000 psi	9,800 Kg /sq mm
Modulus of Rigidity	5,300,000 psi	3,700 Kg /sq mm

*Volume Basis

Typical Uses

HARDWARE: Clock plates and nuts, clock and watch backs, clock gears and wheels

INDUSTRIAL: Channel plate

Common Fabrication Processes

Blanking, machining, piercing and punching, stamping

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Fair
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1300-1450 F or 700-800 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100)..... 100

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 { Seam Not Recommended
 { Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 356 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled				•						•	•	•										
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled										•		•										
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD							•		•	•												
	WIRE																						
	TUBE																						
	PIPE																						
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	47.0	16.0	17.0	60	62	12	-	....	....	....
		.035 mm	49.0	17.0	....	50	68	-	31	....	....	....
		.015 mm	54.0	32.0	33.0	42	86	52	-	....	....	....
		Quarter Hard	54.0	40.0	....	35	-	55	54	....	....	....
		Half Hard	61.0	50.0	52.0	20	-	70	65	....	....	....
		Hard	74.0	65.0	68.0	8	-	81	-	....	....	....
		Extra Hard	88.0	66.0	77.0	5	-	85	-	....	....	....
		Spring	92.0	67.0	83.0	4	-	87	-	....	....	....
		Extra Spring	97.0	68.0	87.0	3	-	89	-	....	....	....

COPPER ALLOY No. 360 (FREE CUTTING BRASS)

Composition — percent

	Nominal	Minimum	Maximum
Copper	61.5	60.0	63.0
Lead	3	2.5	3.7
Iron	....	....	.35
Zinc	35.5	Remainder	
Total Other Elements	....	....	.50.

Nearest Applicable A S T M Specifications

Flat Products	B16
Pipe	
Rod	B16
Shapes	B16
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.307 lb /cu in @ 68 F	8.50 gm /cu cm @ 20 C.
Specific Gravity	8.50	8.50
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000114 per ° F from 68 F to 572 F	.0000205 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	14,000,000 psi	9,800 Kg /sq mm
Modulus of Rigidity	5,300,000 psi	3,700 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: gears, pinions
INDUSTRIAL: automatic high speed screw machine parts

Common Fabrication Processes

Machining, roll threading and knurling

Fabrication Properties

Capacity for Being Cold Worked Poor
Capacity for Being Hot Formed Fair
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature..... 1300-1450 F or 700-800 C
Annealing Temperature 800-1100 F or 425-600 C
Machinability Rating (Free Cutting Brass = 100) 100

Suitability for being joined by:

Soldering Excellent
Brazing Good
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Not Recommended
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Not Recommended
Seam Not Recommended
Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 360 (Continued)Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers												Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.250 in.	Quarter Hard (11%)	56.0	45.0	....	20	-	62	-	33.0	....	....
ROD	1.0 in.	Soft Anneal	49.0	18.0	....	53	68	-	-	30.0	....	....
	.250 in.	Half Hard (25%)	68.0	52.0	....	18	-	80	-	38.0	....	....
	1.0 in.	Half Hard (20%)	58.0	45.0	....	25	-	78	-	34.0	....	....
	2.0 in.	Half Hard (15%)	55.0	44.0	....	32	-	78	-	32.0	20.0*	100
SHAPES	.500 in.	As Extruded	49.0	18.0	....	50	68	-	-	30.0	14.0*	100
		Quarter Hard (11%)	56.0	45.0	....	20	-	62	-	33.0	....	....

* Independent rotating beam tests, diameter of test section: 0.350 in.

COPPER ALLOY Nos. 365, 366, 367 and 368 (LEADED MUNTZ METAL)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	58.0	61.0
Lead	.6	.40	.9
Iron	....	....	.15
Tin	....	....	.25
Zinc	39.4	Remainder	
As, Sb or P*	....	.02**	.10**
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B171, B432
Pipe	
Rod	
Shapes	
Tube	
Wire	

* The uninhibited alloy is Copper Alloy No. 365

** Arsenic, Antimony and Phosphorus inhibited alloys are identified respectively by Copper Alloy Nos. 366, 367 and 368

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.304 lb /cu in @ 68 F	8.41 gm /cu cm @ 20 C.
Specific Gravity	8.41	8.41
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000116 per ° F from 68 F to 572 F	.0000208 per ° C from 20 C to 300 C
Thermal Conductivity	71 Btu /sq ft /ft /hr °F @ 68 F	.29 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	37.0 Ohms (circ mil /ft) @ 68 F	6.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	28 % IACS @ 68 F	.162 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: condenser tube plates

Common Fabrication Processes

Machining

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1150-1450 F or 625-800 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 60

Suitability for being joined by:

Soldering..... Excellent
 Brazing Good
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding..... Fair
 Coated Metal Arc Welding..... Not Recommended

Resistance Welding

{ Spot Not Recommended
 { Seam..... Not Recommended
 { Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 365, 366, 367 and 368 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded			
FLAT PRODUCTS	Strip, Rolled	.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal														
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
	TUBE																						
	PIPE																						
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
PLATE	1.0 in.	As Hot Rolled	54.0	20.0		45	80	-	-	40.0		

COPPER ALLOY No. 370 (FREE CUTTING MUNTZ METAL)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	59.0	62.0
Lead	1	.9	1.4
Iron	....	....	.15
Zinc	39	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	B135
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.304 lb/cu in @ 68 F	8.41 gm/cu cm @ 20 C
Specific Gravity	8.41	8.41
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000116 per °F from 68 F to 572 F	.0000208 per °C from 20 C to 300 C
Thermal Conductivity	69 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	38.4 Ohms (circ mil/ft) @ 68 F	6.39 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	27 % IACS @ 68 F	.157 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	15,000 000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: automatic screw machine products

Common Fabrication Processes

Machining

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1150-1450 F or 625-800 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 70

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 370 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)		As Hot Rolled	As Extruded	
FLAT PRODUCTS	Strip, Rolled																							
	Strip, Drawn																							
	Flat Wire, Rolled																							
	Flat Wire, Drawn																							
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD																							
	WIRE																							
TUBE																								
PIPE																								
SHAPES																								

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
			(.5% Ext. under Load)	(.2% Offset)	F		B	30T	ksi		Million Cycles	
TUBE	1.5 in. OD	Light Anneal	54.0	20.0	....	40	80	-	43	....	....	....
	X .125 in.	Hard Drawn (35%) . . .	80.0	60.0	....	6	-	85	74	....	....	....
	2.0 in. OD	Hard Drawn (25%) . . .	70.0	45.0	....	10	-	75	67	....	....	....
	X .250 in.											

COPPER ALLOY No. 377 (FORGING BRASS)

AMS 4614

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	58.0	62.0
Lead	2	1.5	2.5
Iron	.....	.....	.30
Zinc	38	Remainder	
Total Other Elements	.....	.....	.50

Nearest Applicable A S T M Specifications

Flat Products	B124
Pipe	
Rod	B124
Shapes	B124, B283
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1640 F	895 C
Melting Point (Solidus)	1620 F	880 C
Density	.305 lb/cu in @ 68 F	8.44 gm/cu cm @ 20 C.
Specific Gravity	8.44	8.44
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000115 per °F from 68 F to 572 F	.0000207 per °C from 20 C to 300 C
Thermal Conductivity	69 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	38.4 Ohms (circ mil/ft) @ 68 F	6.39 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	27 % IACS @ 68 F	.157 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

* Volume Basis

Typical Uses

Forgings and pressings of all kinds

Common Fabrication Processes

Heading and upsetting, hot forging and pressing, hot heading and upsetting, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 100
 Hot Working Temperature 1200-1500 F or 650-825 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 80

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A S T M. specification references.

(Continued on other side)

COPPER ALLOY No. 377 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
ROD AND SHAPES	1.0 in.	As Extruded	52.0	20.0	.....	45	78	-	-	.....	.....	.....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 385 (ARCHITECTURAL BRONZE)

Composition — percent

	Nominal	Minimum	Maximum
Copper	57	55.0	60.0
Lead	3	2.0	3.8
Iron	....	....	.35
Zinc	40	Remainder	
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B455
Pipe	
Rod	
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1630 F	890 C
Melting Point (Solidus)	1610 F	875 C
Density	.306 lb /cu in @ 68 F	8.47 gm /cu cm @ 20 C.
Specific Gravity	8.47	8.47
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000116 per ° F from 68 F to 572 F	.0000209 per ° C from 20 C to 300 C
Thermal Conductivity	71 Btu /sq ft /ft /hr /°F @ 68 F	.29 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	37.0 Ohms (circ mil /ft) @ 68 F	6.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	28 % IACS @ 68 F	.162 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	14,000,000 psi	9,800 Kg /sq mm
Modulus of Rigidity	5,300,000 psi	3,700 Kg /sq mm

*Volume Basis

Typical Uses

ARCHITECTURAL: architectural extrusions, store fronts, thresholds, trim
 HARDWARE: butts, hinges, lock bodies
 INDUSTRIAL: forgings

Common Fabrication Processes

Hot forging and pressing, hot forming and bending, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1150-1350 F or 625-725 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 90

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 385 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eight Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD											●											
	WIRE																						
	TUBE																						
	PIPE																						
SHAPES										●	●										●		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties											
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi Million Cycles
SHAPES	1.0 in.	As Extruded	60.0	20.0	....	30	-	65	-	35.0	....

122 The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 411

Composition — percent

	Nominal	Minimum	Maximum
Copper	90	89.0	92.0
Lead	....	....	.10
Iron	....	....	.05
Tin	.5	.30	.7
Zinc	9.5	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Flat Products	B508
Pipe	
Rod	
Shapes	
Tube	
Wire	B105

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1920 F	1050 C
Melting Point (Solidus)	1860 F	1015 C
Density	.318 lb /cu in @ 68 F	8.80 gm /cu cm @ 20 C.
Specific Gravity	8.80	8.80
Coefficient of Thermal Expansion	.0000102 per ° F from 68 F to 212 F	.000018 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	per ° F from 68 F to 572 F	per ° C from 20 C to 300 C
Thermal Conductivity	95 Btu /sq ft /ft /hr ° F @ 68 F	.388 cal /sq cm /cm /sec ° C @ 20 C
Electrical Resistivity (Annealed)	32 Ohms (circ mil /ft) @ 68 F	.533 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	32 % IACS @ 68 F	.188 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm ° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,600 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Bearings, bushings, flexible hose, thrust washers

Common Fabrication Processes

Blanking, drawing, forming and bending, piercing
and punching, shearing, spinning, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1500-1650 F or 825-900 C
Annealing Temperature 800-1400 F or 425-750 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Fair
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Not Recommended
Resistance Welding { Spot Fair
Seam Not Recommended
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 411 (Continued)

Forms and Tempers Most Commonly Used

[illegible]

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. **HARD DRAWN** temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)		ksi	F	B		30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	41.0	10.0	11.0	44	58	-	18	32.0	....	....
		.035 mm	42.0	12.0	13.0	43	60	-	20	33.0	....	....
		.015 mm	44.0	16.0	17.0	40	65	-	-	34.0	....	....
		Half Hard	55.0	48.0	51.0	12	-	67	64	36.0	....	....
		Hard	68.0	58.0	63.0	4	-	76	65	40.0	....	....
		Extra Hard	72.0	64.0	69.0	3	-	78	69	....	....	....
		Spring	80.0	67.0	72.0	2	-	81	74	....	....	....
		Extra Spring	82.5	70.0	77.0	1	-	83	76	....	....	....
WIRE	.250 in.	Hard	81.0	....	....	2.0*	-	-	-	....	....	....
	.100 in.	Hard	102.0	....	....	1.0**	-	-	-	....	....	....
	.050 in.	Hard	106.0	....	....	0.9**	-	-	-	....	....	....

* Elongation in 10 inches

** Elongation in 60 inches

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 413

Composition — percent

	Nominal	Minimum	Maximum
Copper	90	89.0	93.0
Lead	....	....	.10
Iron	....	....	.05
Tin	1	.7	1.3
Zinc	9	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1900 F	1038 C
Melting Point (Solidus)	1850 F	1010 C
Density	.318 lb/cu in @ 68 F	8.80 gm/cu cm @ 20 C.
Specific Gravity	8.80	8.80
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000103 per °F from 68 F to 572 F	.0000186 per °C from 20 C to 300 C
Thermal Conductivity	77 Btu/sq ft/ft/hr/°F @ 68 F	.32 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	34.3 Ohms (circ mil/ft) @ 68 F	.570 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	30 % IACS @ 68 F	.174 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm °C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

*Volume Basis

Typical Uses

Plater bar for jewelry products, flat springs for electrical switchgear

Common Fabrication Processes

Bending, blanking, coining, drawing, forming, spinning, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 50
 Hot Working Temperature 415- 460 F or 780-860 C
 Annealing Temperature 900-1400 F or 480-750 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding

{ Spot Fair
 { Seam Not Recommended
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 413 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES	•	•	•	•	•	•																	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.100 mm	41.0	12.0	....	44	58	-	18	32.0	....	....
		.070 mm	42.0	13.0	....	43	59	-	19	32.0	....	....
		.050 mm	43.0	15.0	....	43	60	-	20	33.0	....	....
		.035 mm	44.0	16.0	....	42	61	-	21	34.0	....	....
		.025 mm	45.0	16.0	....	41	62	-	22	34.0	....	....
		.015 mm	46.0	17.0	....	40	63	-	25	35.0	....	....
		Quarter Hard	49.0	40.0	....	29	-	53	54	36.0	....	....
		Half Hard	56.0	50.0	....	17	-	68	64	39.0	....	....
		Three Quarter Hard	64.0	55.0	....	6	-	76	70	42.0	....	....
		Hard	71.0	62.0	....	4	-	79	72	44.0	....	....
		Extra Hard	74.0	65.0	....	4	-	82	74	46.0	....	....
		Spring	79.0	70.0	....	3	-	86	76	48.0	....	....
		Extra Spring	84.0	75.0	....	2	-	88	77	49.0	....	....
WIRE	.080 in.	.070 mm	43.0	16.0	....	45	-	-	-	33.0	....	....
		.050 mm	44.0	17.0	....	44	-	-	-	34.0	....	....
		.035 mm	45.0	18.0	....	43	-	-	-	35.0	....	....
		.025 mm	46.0	20.0	....	42	-	-	-	36.0	....	....
		.015 mm	47.0	21.0	....	41	-	-	-	36.0	....	....
		Eighth Hard	47.0	37.0	....	30	-	-	-	38.0	....	....
		Quarter Hard	55.0	44.0	....	18	-	-	-	39.0	....	....
		Half Hard	67.0	58.0	....	10	-	-	-	42.0	....	....
		Three Quarter Hard	76.0	72.0	....	6	-	-	-	46.0	....	....
		Hard	86.0	77.0	....	5	-	-	-	51.0	....	....
		Extra Hard	96.0	80.0	....	4	-	-	-	56.0	....	....
		Spring	105.0	82.0	....	3	-	-	-	58.0	....	....
ROD	.500 in.	.050 mm	44.0	18.0	....	45	60	-	20	34.0	....	....
		.015 mm	48.0	22.0	....	42	64	-	24	39.0	....	....
		Eighth Hard (6%)	50.0	41.0	....	28	-	53	54	40.0	....	....
		Half Hard (20%)	65.0	56.0	....	12	-	76	70	42.0	....	....
		Hard (35%)	74.0	65.0	....	6	-	82	74	44.0	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 425

Composition — percent

	Nominal	Minimum	Maximum
Copper	88.5	87.0	90.0
Lead	....	....	.05
Iron	....	....	.05
Tin	2	1.5	3.0
Zinc	9.3	Remainder	
Phosphorus	.20	....	.35
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1875 F	1025 C
Melting Point (Solidus)	1850 F	1010 C
Density	.316 lb /cu in @ 68 F	8.75 gm /cu cm @ 20 C.
Specific Gravity	8.75	8.75
Coefficient of Thermal Expansion	.0000102 per ° F from 68 F to 212 F	.0000184 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	per ° F from 68 F to 572 F	per ° C from 20 C to 300 C
Thermal Conductivity	52 Btu /sq ft /ft /hr /° F @ 68 F	.215 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	51.85 Ohms (circ mil /ft) @ 68 F	8.62 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	20.0 % IACS @ 68 F	.116 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,600 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

*Volume Basis — With a .05% maximum phosphorus content, electrical conductivity is 28% IACS.

Typical Uses

Electrical switches and springs, fuse and pen clips, weather stripping

Common Fabrication Processes

Blanking, coining, drawing, forming, bending, heading and upsetting

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1455-1545 F or 790-840 C
 Annealing Temperature 800-1300 F or 425-700 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Fair
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 425 (Continued)

Forms and Tempers Most Commonly Used

Forms and Temper Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)				
		.100	.070	.050	.035	.025	.015												Soft Anneal		Light Anneal	
FLAT PRODUCTS	Strip, Rolled																					
	Strip, Drawn																					
	Flat Wire, Rolled																					
	Flat Wire, Drawn																					
	Bar, Rolled																					
	Bar, Drawn																					
	Sheet																					
	Plate																					
	ROD																					
	WIRE																					
	TUBE																					
	PIPE																					
	SHAPES																					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	44.0	18.0	....	50	67	15	-	....	....	....
		Eighth Hard	52.0	40.0	....	38	-	50	-	....	....	....
		Quarter Hard	57.0	47.0	....	22	-	60	-	....	....	....
		Half Hard	62.0	51.0	....	18	-	70	56	....	....	....
		Hard	73.0	60.0	....	8	-	83	-	....	....	....
		Extra Hard	80.0	63.0	....	5	-	88	-	....	....	....
		Spring	90.0	65.0	....	3	-	90	-	....	....	....
		Extra Spring	97.0	68.0	....	2	-	92	-	....	....	....

COPPER ALLOY No. 435

Composition — percent

	Nominal	Minimum	Maximum
Copper	81	79.0	83.0
Lead	....	....	.10
Iron	....	....	.05
Tin	.9	.6	1.2
Zinc	18.1	Remainder	
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1840 F	1005 C
Melting Point (Solidus)	1770 F	965 C
Density	.313 lb /cu in @ 68 F	8.66 gm /cu cm @ 20 C.
Specific Gravity	8.66	8.66
Coefficient of Thermal Expansion	.0000108 per ° F from 68 F to 212 F	.0000194 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	per ° F from 68 F to 572 F	per ° C from 20 C to 300 C
Thermal Conductivity	Btu /sq ft /ft /hr /°F @ 68 F	cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	37 Ohms (circ mil /ft) @ 68 F	6.16 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	28 % IACS @ 68 F	.163 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

*Volume Basis

Typical Uses

Bourdon tubing and musical instruments

Common Fabrication Processes

Forming and bending

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Fair
 Hot Forgeability Rating (Forging Brass = 100).....
 Hot Working Temperature F or C
 Annealing Temperature F or C
 Machinability Rating (Free Cutting Brass = 100)..... 30

Suitability for being joined by:

Soldering..... Excellent
 Brazing Excellent
 Oxyacetylene Welding..... Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Good
 Seam Not Recommended
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 435 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers							
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
FLAT PRODUCTS	Strip, Rolled																								
	Strip, Drawn																								
	Flat Wire, Rolled																								
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD																								
	WIRE																								
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm	49.0	18.0	....	46	70	-	31	36.0	....	....
		Half Hard	65.0	54.0	....	16	-	72	-	41.5	....	....
		Hard	80.0	68.0	....	7	-	85	-	45.0	....	....
TUBE	1 in. OD X .065 in.	.035 mm	46.0	16.0	....	46	69	-	40	....	....	....
		Hard (35%)	75.0	60.0	....	10	-	-	-	....	....	....

COPPER ALLOY Nos. 443, 444 and 445 (INHIBITED ADMIRALTY)

Composition — percent

	Nominal	Minimum	Maximum
Copper	71	70 0	73.0
Lead	....	....	.07
Iron	....	....	.06
Tin	1	.9*	1.2
Zinc	28	Remainder	
As, Sb or P	....	.02**	.10**
Total Other Elements	....	....	.15

Nearest Applicable A S T M Specifications

Flat Products	B171, B432
Pipe	
Rod	
Shapes	
Tube	B111, B359, B395
Wire	

* For flat products, the minimum tin may be .8%

** Arsenic, Antimony and Phosphorus inhibited alloys are identified respectively by Copper Alloy Nos. 443, 444 and 445

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1720 F	935 C
Melting Point (Solidus)	1650 F	900 C
Density	.308 lb /cu in @ 68 F	8.53 gm /cu cm @ 20 C.
Specific Gravity	8.53	8.53
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000112 per ° F from 68 F to 572 F	.0000202 per ° C from 20 C to 300 C
Thermal Conductivity	64 Btu /sq ft /ft /hr /° F @ 68 F	.26 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	41.5 Ohms (circ mil /ft) @ 68 F	6.90 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	25 % IACS @ 68 F	.145 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: condenser, evaporator and heat exchanger tubes, condenser tube plates, distiller tubes, ferrules

Common Fabrication Processes

Forming and bending, machining

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Fair
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1200-1450 F or 650-800 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding

{ Spot Good
 { Seam Not Recommended
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 443, 444 and 445 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
		.100	.070	.050	.035	.025	.015												Soft Anneal		Light Anneal																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD X .065 in.	.025 mm	53.0	22.0	....	65	75	-	37	....	....	....
PLATE	1.0 in.	As Hot Rolled	48.0	18.0	....	65	70	-	-	....	....	....
WIRE	.080 in.	.015 mm	55.0	....	....	60	-	-	-	....	....	....

COPPER ALLOY Nos. 464, 465, 466 and 467 (NAVAL BRASS)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	59.0	62.0
Lead	....	....	.20
Iron	....	....	.10
Tin	.8	.50	1.0
Zinc	39.7	Remainder	
As, Sb or P*	....	.02**	.10**
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B21, B124, B171, B432
Pipe	
Rod	B21, B124
Shapes	B21, B124, B283
Tube	
Wire	

* The uninhibited alloy is Copper Alloy No. 464

** Arsenic, Antimony and Phosphorus inhibited alloys are identified respectively as Copper Alloy Nos. 465, 466 and 467

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.304 lb /cu in @ 68 F	8.41 gm /cu cm @ 20 C.
Specific Gravity	8.41	8.41
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000118 per ° F from 68 F to 572 F	.0000212 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, structural uses, valve stems

INDUSTRIAL: condenser plates, welding rod

Common Fabrication Processes

Blanking, drawing, forming and bending, heading and upsetting, hot forging and pressing, hot heading and upsetting, shearing

Fabrication Properties

Capacity for Being Cold Worked Fair
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100) 90
Hot Working Temperature 1200-1500 F or 650-825 C
Annealing Temperature 800-1100 F or 425-600 C
Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Not Recommended

Resistance Welding

{ Spot Good
Seam Fair
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY Nos. 464, 465, 466 and 467 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
		.100	.070	.050	.035	.025	.015																
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Light Anneal	62.0	30.0	....	40	- 60	57		41.0	....	....
		Quarter Hard	70.0	58.0	....	17	- 75	68		43.0	....	....
	.250 in.	Soft Anneal	58.0	25.0	....	49	- 56	55		40.0	....	....
		Light Anneal	60.0	28.0	....	45	- 58	56		41.0	....	....
	1.0 in.	As Hot Rolled	55.0	25.0	....	50	- 55	55		40.0	....	....
ROD	.250 in.	Soft Anneal	58.0	27.0	....	45	- 56	-		40.0	....	....
		Light Anneal	63.0	30.0	....	40	- 60	-		42.0	....	....
		Quarter Hard (10%)	70.0	48.0	....	25	- 80	-		43.0	....	....
		Half Hard (20%)	80.0	57.0	....	20	- 85	-		45.0	....	....
	1.0 in.	Soft Anneal	57.0	25.0	....	47	- 55	-		40.0	....	....
		Light Anneal	63.0	30.0	....	40	- 60	-		42.0	....	....
		Quarter Hard (8%)	69.0	46.0	....	27	- 78	-		43.0	....	....
		Half Hard (20%)	75.0	53.0	....	20	- 82	-		44.0	....	....
	2.0 in.	Soft Anneal	56.0	25.0	....	47	- 55	-		40.0	....	....
		Light Anneal	62.0	28.0	....	43	- 60	-		42.0	....	....
		Quarter Hard (8%)	67.0	40.0	....	35	- 75	-		43.0	....	....
TUBE	.375 in. OD X.097 in.	Hard Drawn (35%)	88.0	66.0	....	18	- 95	-		....	....	....

COPPER ALLOY No. 482 (NAVAL BRASS, MEDIUM LEADED)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60.5	59.0	62.0
Lead	.7	.40	1.0
Iron	....	....	.10
Tin	.8	.50	1.0
Zinc	38	Remainder	
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products

Pipe

Rod

B21

Shapes

B21

Tube

Wire

B21

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.305 lb/cu in @ 68 F	8.44 gm/cu cm @ 20 C.
Specific Gravity	8.44	8.44
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000118 per ° F from 68 F to 572 F	.0000212 per ° C from 20 C to 300 C
Thermal Conductivity	67 Btu/sq ft/ft/hr/°F @ 68 F	.28 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil/ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg/sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg/sq mm

*Volume Basis

Typical Uses

Marine hardware, screw machine products, valve stems

Common Fabrication Processes

Hot forging and pressing, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 90
 Hot Working Temperature 1200-1400 F or 650-760 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 50

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended

Resistance Welding

{ Spot Not Recommended
 { Seam Not Recommended
 { Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 482 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers				Rolled or Drawn Tempers											Hot Finished Tempers						
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30°	ksi	ksi	Million Cycles
ROD	1.0 in.	Soft Anneal.....	57.0	25.0	....	40	-	55	-	38.0	....	....
		Light Anneal.....	63.0	30.0	....	35	-	60	-	39.0	....	....
		Quarter Hard (8%) ..	69.0	46.0	....	20	-	78	-	40.0	....	....
		Half Hard (20%)	75.0	53.0	....	15	-	82	-	41.0	....	....
	2.0 in.	Soft Anneal.....	56.0	25.0	....	40	-	55	-	38.0	....	....
		Light Anneal.....	62.0	28.0	....	37	-	60	-	39.0	....	....
		Quarter Hard (8%) ..	67.0	40.0	....	30	-	75	-	40.0	....	....
		Half Hard (15%)	70.0	52.0	....	17	-	78	-	41.0	....	....
	3.0 in.	Quarter Hard (4%) ..	63.0	33.0	....	43	-	78	-	40.0	....	....
BAR	.375 in.	As Extruded	63.0	33.0	....	34	-	60	-	39.0	....	....
	1.5 in.	Quarter Hard (4%) ..	66.0	40.0	....	32	-	75	-	40.0	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 485 (NAVAL BRASS, HIGH LEADED)

Composition — percent

	Nominal	Minimum	Maximum
Copper	60	59.0	62.0
Lead	1.8	1.3	2.2
Iron	....	....	.10
Tin	.7	.50	1.0
Zinc	37.5	Remainder	
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B21, B124
Pipe	
Rod	B21, B124
Shapes	B21, B124, B283
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1650 F	900 C
Melting Point (Solidus)	1630 F	885 C
Density	.305 lb /cu in @ 68 F	8.44 gm /cu cm @ 20 C.
Specific Gravity	8.44	8.44
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000118 per °F from 68 F to 572 F	.0000212 per °C from 20 C to 300 C
Thermal Conductivity	67 Btu /sq ft /ft /hr /°F @ 68 F	.28 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	39.9 Ohms (circ mil /ft) @ 68 F	6.63 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	26 % IACS @ 68 F	.151 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

*Volume Basis

Typical Uses

HARDWARE: marine hardware, screw machine products, valve stems

Common Fabrication Processes

Hot forging and pressing, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 90
 Hot Working Temperature..... 1200-1400 F or 650-750 C
 Annealing Temperature..... 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 70

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 485 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
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	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD	1.0 in.	Soft Anneal	57.0	25.0	.....	40	—	55	—	36.0	.....	.....
		Quarter Hard (8%)..	69.0	46.0	.....	20	—	78	—	39.0	.....	.....
		Half Hard (20%) ...	75.0	53.0	.....	15	—	82	—	40.0	.....	.....

COPPER ALLOY No. 505 (PHOSPHOR BRONZE, 1.25%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.7	....	....
Lead	....	....	.05
Iron	....	....	.10
Tin	1.3	1.0	1.7
Zinc	....	....	.30
Phosphorus	....	.03	.35
Cu + Sn + P	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B508
Pipe	
Rod	
Shapes	
Tube	
Wire	B105

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1970 F	1075 C
Melting Point (Solidus)	1900 F	1035 C
Density	.321 lb/cu in @ 68 F	8.89 gm/cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per °F from 68 F to 572 F	.0000178 per °C from 20 C to 300 C
Thermal Conductivity	120 Btu/sq ft/ft/hr/°F @ 68 F	.49 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	21.6 Ohms (circ mil/ft) @ 68 F	3.59 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	48 % IACS @ 68 F	.278 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: electrical contacts, flexible hose, pole-line hardware

Common Fabrication Processes

Blanking, forming and bending, heading and upsetting, shearing, squeezing and swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1450-1600 F or 800-875 C
 Annealing Temperature 900-1200 F or 475-650 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Fair
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 505 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015																	
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
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	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.025 mm	40.0	14.0	.....	48	68	—	—	.....	.....	.....
		Half Hard	55.0	.....	.....	16	—	64	60	.....	.....	.....
		Hard	65.0	50.0	.....	8	—	75	67	.....	.....	.....
		Spring	75.0	.....	.....	4	—	79	70	.....	.....	.....
WIRE	.080 in.	Hard (80%)	79.0	.....	.....	1*	—	—	—	.....	32.0	100
	.460 in.	Hard (70%)	72.0	.....	.....	4*	—	—	—	.....	.....	.....
* Elongation in 10 inches												

COPPER ALLOY No. 510 (PHOSPHOR BRONZE, 5% A)

Composition — percent

	Nominal	Minimum	Maximum
Copper	94.8	....	....
Lead	....	....	.05
Iron	....	....	.10
Tin	5	4.2	5.8
Zinc	....	....	.30
Phosphorus	.2	.03	.35
Cu + Sn + P	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B100, B103, B139
Pipe	
Rod	B139
Shapes	B139
Tube	
Wire	B159

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1920 F	1050 C
Melting Point (Solidus)	1750 F	950 C
Density	.320 lb /cu in @ 68 F	8.86 gm /cu cm @ 20 C.
Specific Gravity	8.86	8.86
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per ° F from 68 F to 572 F	.0000178 per ° C from 20 C to 300 C
Thermal Conductivity	40 Btu /sq ft /ft /hr /° F @ 68 F	.17 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	69.1 Ohms (circ mil /ft) @ 68 F	11.5 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	15 % IACS @ 68 F	.0870 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

* Volume Basis, determined on an alloy containing 5% Tin and .2% Phosphorus. This value will vary with the composition.

Typical Uses

ARCHITECTURAL: bridge bearing plates
 HARDWARE: beater bars, bellows, Bourdon tubing, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes
 INDUSTRIAL: chemical hardware, perforated sheets, textile machinery, welding rods

Common Fabrication Processes

Blanking drawing, forming and bending, heading and upsetting, roll threading and knurling, shearing, stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 900-1250 F or 745-675 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Fair
 Resistance Welding { Spot Good
 Seam Fair
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 510 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers							
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
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	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	47.0	19.0	....	64	73	26	—	....	....	....
		.035 mm	49.0	20.0	....	58	75	28	—	....	....	....
		.025 mm	50.0	21.0	....	52	77	30	—	....	....	....
		.015 mm	53.0	22.0	....	50	79	34	—	....	....	....
		Half Hard	68.0	55.0	....	28	—	78	69	....	....	....
		Hard	81.0	75.0	....	10	—	87	75	....	25.0	100
		Extra Hard	92.0	80.0	....	6	—	93	78	....	....	....
		Spring	100.0	80.0	....	4	—	95	79	....	22.0	100
		Extra Spring	107.0	80.0	....	3	—	97	80	....	....	....
ROD	.500 in.	Half Hard (20%)	75.0	65.0	....	25	—	80	—	....	....	....
	1.0 in.	Half Hard (20%)	70.0	58.0	....	25	—	78	—	....	....	....
WIRE	.080 in.	.035 mm	50.0	20.0	....	58	—	—	—	....	....	....
		Quarter Hard	68.0	60.0	....	24	—	—	—	....	....	....
		Half Hard	85.0	80.0	....	8	—	—	—	....	....	....
		Hard	110.0	....	....	5	—	—	—	....	27.0	100
		Extra Hard (75%)	130.0	....	....	3	—	—	—	....	30.0	100
		Spring (84%)	140.0	....	....	2	—	—	—	....	....	....

COPPER ALLOY No. 511

Composition — percent

	Nominal	Minimum	Maximum
Copper	95.6	....	....
Lead	....	....	.05
Iron	....	....	.10
Tin	4.2	3.5	4.9
Zinc	....	....	.30
Phosphorus	.2	.03	.35
Cu + Sn + P	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B103
Pipe	
Rod	
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1945 F	1060 C
Melting Point (Solidus)	1785 F	975 C
Density	.320 lb/cu in @ 68 F	8.86 gm/cu cm @ 20 C.
Specific Gravity	8.86	8.86
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per °F from 68 F to 572 F	.0000178 per °C from 20 C to 300 C
Thermal Conductivity	48.4 Btu/sq ft/ft/hr/°F @ 68 F	.20 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	52 Ohms (circ mil/ft) @ 68 F	8.7 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	20 % IACS @ 68 F	.116 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

Typical Uses

ARCHITECTURAL:	bridge bearing plates
HARDWARE:	beater bars, bellows, clutch disks, connectors, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, terminals
INDUSTRIAL:	chemical hardware, perforated sheets, textile machinery

Common Fabrication Processes

Blanking, drawing, forming and bending, roll threading and knurling, shearing, stamping

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Poor
Hot Forgeability Rating (Forging Brass = 100)	.....
Hot Working Temperature	F or C
Annealing Temperature	900-1250 F or 475-675 C
Machinability Rating (Free Cutting Brass = 100)	 20

Suitability for being joined by:

Soldering	 Excellent						
Brazing	 Excellent						
Oxyacetylene Welding	 Fair						
Gas Shielded Arc Welding	 Good						
Coated Metal Arc Welding	 Fair						
Resistance Welding	<table> <tr> <td>Spot</td><td>..... Good</td></tr> <tr> <td>Seam</td><td>..... Fair</td></tr> <tr> <td>Butt</td><td>..... Excellent</td></tr> </table>	Spot	 Good	Seam	 Fair	Butt	 Excellent
Spot	 Good						
Seam	 Fair						
Butt	 Excellent						

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 511 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)		Light Drawn – Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	{	Strip, Rolled	•	•	•	•	•			•	•	•	•	•	•	•	•	•					
		Strip, Drawn																					
		Flat Wire, Rolled																					
		Flat Wire, Drawn																					
		Bar, Rolled																					
		Bar, Drawn																					
		Sheet																					
		Plate																					
		ROD																					
		WIRE																					
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	46.0	....	16.0	48	70	-	-	....	....	....
		.035 mm	48.0	....	19.0	47	73	-	-	....	....	....
		.025 mm	50.0	....	21.0	46	75	-	-	....	....	....
		.015 mm	51.0	....	23.0	46	76	-	-	....	....	....
		Quarter Hard	55.0	50.0	43.0	36	-	48	45	....	....	....
		Half Hard	62.0	54.0	56.0	19	-	70	65	....	....	....
		Three Quarter Hard	74.0	....	72.0	11	-	84	72	....	....	....
		Hard	80.0	74.0	77.0	7	-	86	74	....	....	....
		Extra Hard	92.0	....	89.0	4	-	91	78	....	....	....
		Spring	98.0	80.0	95.0	3	-	93	79	....	....	....
		Extra Spring	103.0	80.0	98.0	2	-	95	80	....	....	....

COPPER ALLOY No. 521 (PHOSPHOR BRONZE, 8% C)

Composition — percent

	Nominal	Minimum	Maximum
Copper	92	....	....
Lead	....	....	.05
Iron	....	....	.10
Tin	8	7.0	9.0
Zinc	....	....	.20
Phosphorus	....	.03	.35
Cu + Sn + P	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B103, B139
Pipe	
Rod	B139
Shapes	B139
Tube	
Wire	B159

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1880 F	1020 C
Melting Point (Solidus)	1620 F	880 C
Density	.318 lb/cu in @ 68 F	8.80 gm/cu cm @ 20 C.
Specific Gravity	8.80	8.80
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000101 per °F from 68 F to 572 F	.0000182 per °C from 20 C to 300 C
Thermal Conductivity	36 Btu/sq ft/ft/hr/°F @ 68 F	.15 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	79.8 Ohms (circ mil/ft) @ 68 F	13.3 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	13 % IACS @ 68 F	.0754 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

* Volume Basis

Typical Uses

(Same as for Phosphor Bronze, 5% (A), but for more severe service conditions)

ARCHITECTURAL: bridge bearing plates

HARDWARE: beater bars, bellows, Bourdon tubing, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes

INDUSTRIAL: chemical hardware, perforated sheets, textile machinery, welding rods

Common Fabrication Processes

Blanking, drawing, forming and bending, shearing, stamping

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 900-1250 F or 475-675 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Fair
 Resistance Welding { Spot Good
 Seam Fair
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 521 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers								Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	55.0	....	....	70	75	-	-	....	....	....
		.035 mm	58.0	....	....	65	80	-	-	....	....	....
		.025 mm	60.0	24.0	....	63	82	50	-	....	....	....
		.015 mm	62.0	....	....	60	85	-	-	....	....	....
		Half Hard	76.0	55.0	....	32	-	84	73	....	....	....
		Hard	93.0	72.0	....	10	-	93	78	....	22.0	100
		Extra Hard	106.0	80.0	....	4	-	96	80	....	....	....
		Spring	112.0	....	....	3	-	98	81	....	....	....
		Extra Spring	120.0	....	....	2	-	100	82	....	....	....
ROD	.500 in.	Half Hard (20%)	80.0	65.0	....	33	-	85	-	....	....	....
WIRE	.080 in.	.035 mm	60.0	24.0	....	65	-	-	-	....	....	....
		Quarter Hard	81.0	....	....	....	-	-	-	....	....	....
		Half Hard	105.0	....	....	....	-	-	-	....	....	....
		Hard	130.0	....	....	....	-	-	-	....	....	....
		Extra Hard	140.0	....	....	....	-	-	-	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 524 (PHOSPHOR BRONZE, 10% D)

Composition — percent

	Nominal	Minimum	Maximum
Copper	90	....	....
Lead	....	....	.05
Iron	....	....	.10
Tin	10	9.0	11.00
Zinc	....	....	.20
Phosphorus	....	.03	.35
Cu + Sn + P	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B103, B139
Pipe	
Rod	B139
Shapes	B139
Tube	
Wire	B159

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1830 F	1000 C
Melting Point (Solidus)	1550 F	845 C
Density	.317 lb/cu in @ 68 F	8.78 gm/cu cm @ 20 C.
Specific Gravity	8.78	8.78
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000102 per °F from 68 F to 572 F	.0000184 per °C from 20 C to 300 C
Thermal Conductivity	29 Btu/sq ft/ft/hr/°F @ 68 F	.12 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	94.3 Ohms (circ mil/ft) @ 68 F	15.7 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	11 % IACS @ 68 F	.0638 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

* Volume Basis

Typical Uses

Heavy bars and plates for severe compression, good wear and corrosion resistance; bridge and expansion plates and fittings; and articles requiring extra spring qualities, greatest resiliency, particularly in fatigue

Common Fabrication Processes

Blanking, forming and bending, shearing

Fabrication Properties

Capacity for Being Cold Worked	Good
Capacity for Being Hot Formed	Poor
Hot Forgeability Rating (Forging Brass = 100)	
Hot Working Temperature	F or C
Annealing Temperature	900-1250 F or 475-675 C
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent
Brazing	Excellent
Oxyacetylene Welding	Fair
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Fair
Resistance Welding { Spot	Good
Resistance Welding { Seam	Fair
Resistance Welding { Butt	Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 524 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	66.0	28.0	....	68	-	55	-	....	....	....
		Half Hard	83.0	....	....	32	-	92	-	....	....	....
		Hard	100.0	....	....	13	-	97	-	....	....	....
		Extra Hard	115.0	....	....	7	-	100	-	....	....	....
		Spring	122.0	....	....	4	-	101	-	....	....	....
		Extra Spring	128.0	....	....	3	-	103	-	....	....	....
WIRE	.080 in.	.035 mm	66.0	....	....	70	-	-	-	....	....	....
		Quarter Hard	93.0	....	....	....	-	-	-	....	....	....
		Half Hard	118.0	....	....	....	-	-	-	....	....	....
		Hard	147.0	....	....	....	-	-	-	....	....	....

COPPER ALLOY No. 544 (PHOSPHOR BRONZE B-2)

Composition — percent

	Nominal	Minimum	Maximum
Copper	88	....	....
Pb = Lead	4	3.5	4.5
Iron	....	....	.10
Tin	4	3.5	4.5
Zinc	4	1.5	4.5
Phosphorus	....	.01	.50
Cu + Sn + P + Pb + Zn	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B103, B139
Pipe	
Rod	B139
Shapes	B139
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1830 F	1000 C
Melting Point (Solidus)	1700 F	930 C
Density	.321 lb /cu in @ 68 F	8.89 gm /cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000096 per ° F from 68 F to 572 F	.0000173 per ° C from 20 C to 300 C
Thermal Conductivity	50 Btu /sq ft /ft /hr /°F @ 68 F	.21 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	54.6 Ohms (circ mil /ft) @ 68 F	9.07 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	19 % IACS @ 68 F	.110 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: bearings, bushings, gears, pinions, shafts, thrust washers, valve parts

Common Fabrication Processes

Blanking, drawing, forming and bending, machining, shearing, stamping

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 900-1250 F or 475-675 C
 Machinability Rating (Free Cutting Brass = 100) 80

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 { Seam Not Recommended
 { Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 544 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled				●							●											
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD												●										
	WIRE																						
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	44.0	19.0	....	50	65	-	-	....	....	....
		Half Hard	58.0	40.0	....	24	-	68	-	....	....	....
ROD	.500 in.	Hard (35%)	75.0	63.0	....	15	-	83	-	....	....	....
	1.0 in.	Hard (25%)	68.0	57.0	....	20	-	80	-	....	....	....

COPPER ALLOY No. 608 (ALUMINUM BRONZE, 5%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	95	93.0	....
Lead	....	....	.10
Iron	....	....	.10
Aluminum	5	5.0	6.5
Arsenic	....	.02	.35
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	
Shapes	
Tube	B111, B359, B395

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1945 F	1063 C
Melting Point (Solidus)	1920 F	1050 C
Density	.295 lb /cu in @ 68 F	8.17 gm /cu cm @ 20 C.
Specific Gravity	8.17	8.17
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000100 per ° F from 68 F to 572 F	.0000181 per ° C from 20 C to 300 C
Thermal Conductivity	46 Btu /sq ft /ft /hr /°F @ 68 F	.19 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	60 Ohms (circ mil /ft) @ 68 F	10 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	17 % IACS @ 68 F	.099 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,500,000 psi	12,300 Kg /sq mm
Modulus of Rigidity	6,600,000 psi	4,640 Kg /sq mm

*Volume Basis

Typical Uses

Industrial: condenser, evaporator and heat exchanger
tubes, distiller tubes, ferrules

Common Fabrication Processes

Forming and bending

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Fair
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1450-1600 F or 800-875 C
Annealing Temperature 1000-1200 F or 550-650 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Not Recommended
Brazing Fair
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Good
Resistance Welding { Spot Good
Seam Good
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 608 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)		Light Drawn — Bending (3)	As Hot Rolled	As Extruded		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled																								
	Strip, Drawn																								
	Flat Wire, Rolled																								
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD																								
	WIRE																								
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD X .065 in.	.025 mm	60.0	27.0	.....	55	77	—	—	.....	.....	.....

COPPER ALLOY No. 610

Composition — percent

	Nominal	Minimum	Maximum
Copper	92	....	....
Lead	....	....	.02
Iron	....	....	.50
Zinc	....	....	.20
Aluminum	8	6.0	8.5
Silicon	....	....	.10
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1905 F	1040 C
Melting Point (Solidus)	F	C
Density	.281 lb /cu in @ 68 F	7.78 gm /cu cm @ 20 C.
Specific Gravity	7.78	7.78
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per ° F from 68 F to 572 F	.0000179 per ° C from 20 C to 300 C
Thermal Conductivity	40 Btu /sq ft /ft /hr /°F @ 68 F	.17 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	69.2 Ohms (circ mil /ft) @ 68 F	11.5 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	15 % IACS @ 68 F	.087 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Bolts, pump parts, shafts, tie rods, overlay on steel for wearing surface

Common Fabrication Processes

Blanking, drawing, forming and bending, heading and roll threading

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 70
 Hot Working Temperature..... 1400-1600 F or 760-875 C
 Annealing Temperature..... 1100-1250 F or 600-675 C
 Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering..... Fair
 Brazing Not Recommended
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Good

Resistance Welding

{ Spot Good
 { Seam Fair
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 610 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	1.0 in.	Soft Anneal	70.0	30.0	....	65	-	60	-	....	....	....
		Hard (40%)	80.0	55.0	....	25	-	85	-	....	....	....

COPPER ALLOY No. 614 (ALUMINUM BRONZE D)

Composition — percent

	Nominal	Minimum	Maximum
Copper	91	....	....
Lead	....	....	.01
Iron	2	1.5	3.5
Zinc	....	....	.20
Aluminum	7	6.0	8.0
Manganese	....	....	1.0
Phosphorus	....	....	.015
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B150, B169, B171, B432
Pipe	
Rod	B150
Shapes	B150
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1915 F	1045 C
Melting Point (Solidus)	1905 F	1040 C
Density	.285 lb /cu in @ 68 F	7.89 gm /cu cm @ 20 C.
Specific Gravity	7.89	7.89
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	39 Btu /sq ft /ft /hr /°F @ 68 F	.16 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	74.1 Ohms (circ mil /ft) @ 68 F	12.3 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	14 % IACS @ 68 F	.081 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

HARDWARE:	nuts, bolts, stringers and threaded members
INDUSTRIAL:	corrosion resistant vessels and tanks, structural components, machine parts and members, condenser tubes and piping systems
MARINE:	protective sheathing and fastening
MUNITIONS:	mixing troughs and blending chambers

Common Fabrication Processes

Blanking, drawing, forming and bending, heading and roll threading

Fabrication Properties

Capacity for Being Cold Worked	Good
Capacity for Being Hot Formed	Good
Hot Forgeability Rating (Forging Brass = 100).....	
Hot Working Temperature	1450-1700 F or 800-925 C
Annealing Temperature	1125-1650 F or 600-900 C
Machinability Rating (Free Cutting Brass = 100).....	20

Suitability for being joined by:

Soldering.....	Not Recommended
Brazing	Fair
Oxyacetylene Welding	Not Recommended
Gas Shielded Arc Welding	Good
Coated Metal Arc Welding	Good
Resistance Welding { Spot	Good
{ Seam	Good
{ Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 614 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	●	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.125 in.	Soft	82.0	45.0	....	40	-	84	-	45.0	30.0	100
		Hard	89.0	60.0	....	32	-	87	-	....	....	....
	.312 in.	Soft	80.0	40.0	....	40	-	83	-	42.0	28.0	100
		Hard	85.0	58.0	....	35	-	86	-	....	....	....
	.500 in.	Soft	78.0	35.0	....	42	-	82	-	40.0	26.0	100
		Hard	80.0	54.0	....	38	-	85	-	....	....	....
	1.0 in.	Soft	76.0	33.0	....	45	-	81	-	40.0	25.0	100
		Hard	78.0	45.0	....	40	-	84	-	....	....	....
ROD	.500 in.	Hard	85.0	45.0	....	35	-	91	-	48.0	....	....
	1.0 in.	Hard	82.0	40.0	....	35	-	90	-	45.0	....	....
	2.0 in.	Hard	80.0	35.0	....	35	-	88	-	40.0	....	....

COPPER ALLOY No. 613

Composition — percent

	Nominal	Minimum	Maximum
Copper	92.7	.....	.....
Iron	....	....	3.5
Tin	.3	.20	.50
Aluminum	7.0	6.0	8.0
Manganese	....	....	.50
Nickel	....	....	.50
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B169, B171
Pipe	
Rod	B150
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1915 F	1045 C
Melting Point (Solidus)	1905 F	1040 C
Density	.287 lb /cu in @ 68 F	7.95 gm /cu cm @ 20 C.
Specific Gravity	7.95	7.95
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	32 Btu /sq ft /ft /hr /°F @ 68 F	.13 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	86.8 Ohms (circ mil /ft) @ 68 F	14.4 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	12 % IACS @ 68 F	.070 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

HARDWARE:	Nuts, bolts
INDUSTRIAL:	Corrosion resistant vessels, tanks, components, machine parts, piping systems, heat exchanger tube
MARINE:	Protective sheathing and fasteners
MUNITIONS:	Blending chambers, mixing troughs

Common Fabrication Processes

Blanking, drawing, forming and bending, cold heading, roll threading, welding

Fabrication Properties

Capacity for Being Cold Worked	Good
Capacity for Being Hot Formed	Good
Hot Forgeability Rating (Forging Brass = 100)	50
Hot Working Temperature	1450-1700 F or 800-925 C
Annealing Temperature	1125-1600 F or 600-875 C
Machinability Rating (Free Cutting Brass = 100)	30

Suitability for being joined by:

Soldering	Not Recommended
Brazing	Fair
Oxyacetylene Welding	Not Recommended
Gas Shielded Arc Welding	Excellent
Coated Metal Arc Welding	Good
Resistance Welding { Spot	Good
Seam	Good
Butt	Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 613 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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		Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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		TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.125 in.	Soft Anneal.....	80.0	40.0	....	40	-	82	-	52.0	28.0	100
	.500 in.	Soft Anneal.....	78.0	35.0	....	42	-	81	-	50.0	26.0	100
	1.0 in.	Soft Anneal.....	76.0	33.0	....	42	-	79	-	45.0	25.0	100
	3.0 in.	Soft Anneal.....	70.0	30.0	....	40	-	78	-	42.0	21.0	100
ROD	.500 in.	Hard (25%).....	85.0	58.0	....	35	-	91	-	48.0	....	....
	1.0 in.	Hard (25%).....	82.0	55.0	....	35	-	90	-	45.0	....	....
	2.0 in.	Hard (25%).....	80.0	48.0	....	35	-	88	-	40.0	....	....

COPPER ALLOY No. 618

Composition — percent

	Nominal	Minimum	Maximum
Copper	89	....	....
Lead	....	....	.02
Iron	1	.50	1.5
Zinc	....	....	.02
Aluminum	10	8.5	11.0
Silicon	....	....	.10
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1913 F	1045 C
Melting Point (Solidus)	1904 F	1040 C
Density	.272 lb /cu in @ 68 F	7.53 gm /cu cm @ 20 C.
Specific Gravity	7.53	7.53
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	37 Btu /sq ft /ft /hr /°F @ 68 F	.15 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	79.8 Ohms (circ mil /ft) @ 68 F	13.3 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	13 % IACS @ 68 F	.075 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Bushings, bearings, corrosion applications, welding rod

Common Fabrication Processes

Hot forging, hot pressing

Fabrication Properties

Capacity for Being Cold Worked Fair
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100) 50
 Hot Working Temperature 1400-1625 F or 750-885 C
 Annealing Temperature 1100-1200 F or 600-650 C
 Machinability Rating (Free Cutting Brass = 100) 40

Suitability for being joined by:

Soldering..... Fair
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Good
 Resistance Welding { Spot Good
 Seam Good
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 618 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finishe Tempers								
		Nominal Grain Size mm																								
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES	.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Binding (3)	As Hot Rolled	As Extruded	Special Tempers			

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	1.0 in.	Half Hard (15%)	85.0	42.5	....	23	-	89	-	47.0	28.0	100
	2.0 in.	Half Hard (15%)	82.5	39.0	....	25	-	88	-	45.0	28.0	100
	3.0 in.	Half Hard (15%)	80.0	39.0	....	28	-	88	-	43.0	26.0	100

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 619

Composition — percent

	Nominal	Minimum	Maximum
Copper	86.5	....	....
Lead	....	....	.02
Iron	4	3.0	4.5
Tin	....	....	.6
Zinc	....	....	.8
Aluminum	9.5	8.5	10.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1920 F	1050 C
Melting Point (Solidus)	1905 F	1040 C
Density	.270 lb /cu in @ 68 F	7.5 gm /cu cm @ 20 C.
Specific Gravity	7.5	7.5
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	45.9 Btu /sq ft /ft /hr /°F @ 68 F	19 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	99 Ohms (circ mil /ft) @ 68 F	16.4 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	10.5 % IACS @ 68 F	.061 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.10 Btu /lb °F @ 68 F	.10 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

*Volume Basis

Typical Uses

Springs, contacts and switch components

Common Fabrication Processes

Blanking, forming, bending, shearing and stamping

Fabrication Properties

Capacity for Being Cold WorkedFair
 Capacity for Being Hot FormedExcellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature..... 1020-1520 F or 580-825 C
 Annealing Temperature..... 1000-1450 F or 550-790 C
 Machinability Rating (Free Cutting Brass = 100).....

Suitability for being joined by:

Soldering.....Fair
 BrazingFair
 Oxyacetylene Welding..... Not Recommended
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Good
 Resistance Welding { Spot Good
 { Seam Good
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 619 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers								Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																							
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
FLAT PRODUCTS	Strip, Rolled Strip, Drawn Flat Wire, Rolled Flat Wire, Drawn Bar, Rolled Bar, Drawn Sheet Plate ROD WIRE TUBE PIPE SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
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1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	Million Cycles	
FLAT PRODUCTS	.040 in.	Annealed	92.0	49.0	60.0	30	-	-	72	....	....	....
		Half Hard	104.0	**	80.0	21	-	93	78	....	....	....
		Hard	121.0	**	102.0	8	-	98	83	....	....	....
		Hard*	135.0	**	120.0	2	-	-	-	....	....	....
		Spring	130.0	**	108.0	4	-	100	83	....	33.5	100
		Spring*	145.0	**	135.0	1.5	-	-	-	....	38.5	100
		Extra Spring	137.0	**	117.0	3	-	100	84	....	....	....
		Extra Spring*	152.0	**	145.0	1	-	-	-	....	....	....
*After heat treatment for 1 hour at 450F.												
**Not applicable because the ½% extension under load yield strength is below the elastic limit.												

COPPER ALLOY No. 623

Composition — percent

	Nominal	Minimum	Maximum
Copper	87	....	....
Iron	3	2.0	4.0
Tin	....	....	.6
Aluminum	10	8.5	11.0
Manganese	....	....	.50
Silicon	....	....	.25
Nickel	....	....	1.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	B150
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1915 F	1045 C
Melting Point (Solidus)	1905 F	1040 C
Density	.276 lb /cu in @ 68 F	7.66 gm /cu cm @ 20 C.
Specific Gravity	7.66	7.66
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	31 Btu /sq ft /ft /hr /°F @ 68 F	.13 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	86.4 Ohms (circ mil /ft) @ 68 F	14.4 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	12 % IACS @ 68 F	.070 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	0.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Bearings, bushings, valve guides, gears, valve seats,
nuts, bolts, pump rods, worm gears, cams

Common Fabrication Processes

Bending, hot forging, hot pressing, forming, welding

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100) 75
Hot Working Temperature 1300-1600 F or 700-875 C
Annealing Temperature 1100-1200 F or 600-650 C
Machinability Rating (Free Cutting Brass = 100) 50

Suitability for being joined by:

Soldering Not Recommended
Brazing Fair
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Good
Resistance Welding { Spot Good
Seam Good
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 623 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finish Tempers				
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015															Soft Anneal
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	Bar, Extruded	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

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3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
BAR	3.0 in.	As Extruded	75.0	35.0	....	35	- 80	-	....	....	....	....
	1.0 in.	Half Hard (15%)	90.0	45.0	....	30	- 85	-	....	....	....	....
	2.0 in.	Half Hard (15%)	85.0	40.0	....	30	- 82	-	....	....	....	....
ROD	4.0 in.	As Extruded	75.0	35.0	....	35	- 80	-	35.0	25.0	100	....
	.5 in.	Half Hard (15%)	98.0	52.0	....	22	- 89	-	52.0	31.0	100	....
	1.0 in.	Half Hard (15%)	95.0	50.0	....	25	- 88	-	50.0	30.0	100	....
	2.0 in.	Half Hard (15%)	92.0	48.0	....	28	- 87	-	48.0	30.0	100	....
	3.0 in.	Half Hard (15%)	87.0	45.0	....	35	- 85	-	46.0	29.0	100	....

COPPER ALLOY No. 624

Composition — percent

	Nominal	Minimum	Maximum
Copper	86	....	....
Iron	3	2.0	4.5
Tin	....	....	.20
Aluminum	11	10.0	11.5
Manganese	....	....	.30
Silicon	....	....	.25
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1900 F	1040 C
Melting Point (Solidus)	1880 F	1025 C
Density	.269 lb /cu in @ 68 F	7.45 gm /cu cm @ 20 C.
Specific Gravity	7.45	7.45
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000192 per ° C from 20 C to 300 C
Thermal Conductivity	34 Btu /sq ft /ft /hr /°F @ 68 F	.14 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	86.4 Ohms (circ mil /ft) @ 68 F	14.4 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	12 % IACS @ 68 F	.070 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Bushings, gears, cams, wear plates, nuts, drift pins, tie rods

Common Fabrication Processes

Hot forging, hot bending

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 80
 Hot Working Temperature 1400-1625 F or 750-885 C
 Annealing Temperature 1100-1200 F or 600-650 C
 Machinability Rating (Free Cutting Brass = 100) 50

Suitability for being joined by:

Soldering Not Recommended
 Brazing Fair
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Good
 Coated Metal Arc Welding Good

Resistance Welding { Spot Good
 Seam Good
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 624 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)		Light Drawn – Bending (3)	As Hot Rolled	As Extruded																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			(ksi)	(.5% Ext. under Load)	(.2% Offset)	(%)				(ksi)	(ksi)	(Million Cycles)
							F	B	30T			
BAR	1.0 in.	Light Anneal	100.0	50.0	....	14	-	92	-	....	....	....
	2.0 in.	Light Anneal	93.0	45.0	....	14	-	91	-	....	....	....
	3.0 in.	As Extruded	90.0	40.0	....	18	-	87	-	....	....	....
ROD	1.0 in.	Half Hard (10%)	105.0	52.0	....	14	-	92	-	65	36.0	100
	2.0 in.	Half Hard (10%)	95.0	48.0	....	14	-	92	-	62	35.0	100
	3.0 in.	Half Hard (10%)	95.0	47.0	....	14	-	91	-	60	34.0	100
	4.0 in.	As Extruded	90.0	40.0	....	18	-	87	-	58	32.0	100

COPPER ALLOY No. 625

Composition — percent

	Nominal	Minimum	Maximum
Copper	82.7	....	....
Iron	4.3	3.5	5.0
Aluminum	13	12.5	13.5
Manganese	....	....	2.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1925 F	1052 C
Melting Point (Solidus)	1917 F	1047 C
Density	.260 lb /cu in @ 68 F	7.21 gm /cu cm @ 20 C.
Specific Gravity	7.21	7.21
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	27 Btu /sq ft /ft /hr /°F @ 68 F	.11 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	104 Ohms (circ mil /ft) @ 68 F	17.2 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	10 % IACS @ 68 F	.058 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Guide bushings, wear strips, cams, dies, forming rolls

Common Fabrication Processes

Hot forging, machining

Fabrication Properties

Capacity for Being Cold WorkedNot Recommended
Capacity for Being Hot FormedExcellent
Hot Forgeability Rating (Forging Brass = 100)80
Hot Working Temperature..... 1375-1550 F or 745-850 C
Annealing Temperature..... 1100-1200 F or 600-650 C
Machinability Rating (Free Cutting Brass = 100)20

Suitability for being joined by:

Soldering..... Not Recommended
Brazing..... Fair
Oxyacetylene Welding..... Not Recommended
Gas Shielded Arc Welding..... Good
Coated Metal Arc Welding..... Good

Resistance Welding { Spot..... Fair
Seam..... Fair
Butt..... Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 625 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015															Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Extruded	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
ROD & BAR	All	As Extruded	100.0	55.0	....	1	-	29	-	60.0	67.0	100

COPPER ALLOY No. 630

Composition — percent

	Nominal	Minimum	Maximum
Copper	82	....	....
Iron	3	2.0	4.0
Tin	....	....	.20
Zinc	....	....	.30
Aluminum	10	9.0	11.0
Manganese	....	....	1.5
Silicon	....	....	.25
Nickel	5	4.0	5.5
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B124, B150
Pipe	
Rod	B124, B150
Shapes	B150
Tube	
Wire	

AMS 4640
Q9-C-465

Cond M → { Cond M20 AS hot rolled
Cond M30 AS hot EXTRUDED

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1930 F	1054 C
Melting Point (Solidus)	1895 F	1035 C
Density	.274 lb/cu in @ 68 F	7.58 gm/cu cm @ 20 C.
Specific Gravity	7.58	7.58
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per °F from 68 F to 572 F	.0000162 per °C from 20 C to 300 C
Thermal Conductivity	22.6 Btu/sq ft/ft/hr/°F @ 68 F	.09 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	116 Ohms (circ mil/ft) @ 68 F	19.2 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	7 % IACS @ 68 F	.041 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,500,000 psi	12,250 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

*Volume Basis

Typical Uses

Nuts, bolts, valve seats, plunger tips, marine shafts,
valve guides, aircraft parts, pump shafts, structural
members

Common Fabrication Processes

Hot forming and forging

Fabrication Properties

Capacity for Being Cold Worked..... Poor
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100)..... 75
Hot Working Temperature..... 1450-1700 F or 800-925 C
Annealing Temperature 1100-1300 F or 600-700 C
Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering..... Not Recommended
Brazing Fair
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Good
Coated Metal Arc Welding..... Good

Resistance Welding

{ Spot Good
Seam Good
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 630 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finishes Tempers							
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
		.100	.070	.050	.035	.025	.015																		
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Extruded	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elonga- tion in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
BAR	1.0 in.	Half Hard (10%)	110.0	62.0	.....	15	-	97	-	.....	.....	.....
	2.0 in.	Half Hard (10%)	100.0	60.0	.....	15	-	96	-	.....	.....	.....
	3.0 in.	As Extruded	90.0	50.0	.....	15	-	96	-	.....	.....	.....
ROD	1.0 in.	Half Hard (10%)	118.0	75.0	.....	15	-	98	-	70.0	38.0	100
	2.0 in.	Half Hard (10%)	115.0	65.0	.....	18	-	96	-	69.0	37.0	100
	3.0 in.	Half Hard (10%)	112.0	62.0	.....	20	-	96	-	65.0	37.0	100
	4.0 in.	As Extruded	100.0	60.0	.....	15	-	96	-	62.0	36.0	100

Al Bronze

Hard

10

$\frac{1}{2}$ Hard

S68 Cubes

Al 63a → 63a $\frac{1}{2}$ H

⇒ Cond H → $\sqrt{11}$

674 → $\frac{1}{2}$ H

AS EXTR → $\sqrt{11}$

دی

15 January
2003

چهارشنبه

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۱۳۸۱

۱۱ ذی‌عده
۱۴۲۳

ولادت

حضرت امام رضا (ع)

در دعای وتر:

بار الها، ارتشیان و لشکریان اهل ایمان، پیروز فرما.

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اصفهان	اذان صبح ۵:۴۰	طلوع آفتاب ۷:۰۶	اذان ظهر ۱۲:۱۳	غروب ۱۷:۲۰	خفتاب ۱۷:۴۰	اذان مغرب ۱۷:۴۰
تهران	اذان صبح ۵:۴۵	طلوع آفتاب ۷:۱۵	اذان ظهر ۱۲:۱۴	غروب ۱۷:۲۵	خفتاب ۱۷:۴۵	اذان مغرب ۱۷:۴۵

COPPER ALLOY No. 632

Composition — percent

	Nominal	Minimum	Maximum
Copper	82	....	....
Lead	....	....	.02
Iron*	4	3.0	5.0
Aluminum	9	8.5	9.5
Manganese	....	....	3.5
Silicon	....	....	.10
Nickel*	5	4.0	5.5
Copper + Elements with Specific Limits	....	99.5	....

*Iron content shall not exceed
nickel content

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1940 F	1060 C
Melting Point (Solidus)	1905 F	1040 C
Density	.276 lb/cu in @ 68 F	7.64 gm/cu cm @ 20 C.
Specific Gravity	7.64	7.64
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	20 Btu/sq ft/ft/hr/°F @ 68 F	.086 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	148 Ohms (circ mil/ft) @ 68 F	24.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	7 % IACS @ 68 F	.041 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.105 Btu/lb °F @ 68 F	.105 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg/sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg/sq mm

* Volume Basis

Typical Uses

MARINE: Nuts, bolts, structural pump parts, shafting

INDUSTRIAL: Corrosion resistant articles

Common Fabrication Processes

Hot forming, welding

Fabrication Properties

Capacity for Being Cold WorkedFair
Capacity for Being Hot FormedGood
Hot Forgeability Rating (Forging Brass = 100) 70
Hot Working Temperature1500-1650 F or 825-900 C
Annealing Temperature.....1150-1300 F or 600-700 C
Machinability Rating (Free Cutting Brass = 100)..... 30

Suitability for being joined by:

Soldering.....Fair
BrazingFair
Oxyacetylene Welding..... Not Recommended
Gas Shielded Arc Welding : Excellent
Coated Metal Arc Welding..... Good
Resistance Welding { Spot Good
Seam..... Fair
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 632 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers		Rolled or Drawn Tempers													Hot Finished Tempers						
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS												
PLATE	.250 in.	Light Anneal	100.0	50.0	.....	20	—	92	—	.....	.....	.....
	.500 in.	Light Anneal	95.0	47.0	.....	22	—	89	—	.....	.....	.....
	1.0 in.	Light Anneal	90.0	45.0	.....	25	—	85	—	.....	.....	.....
ROD	1.0 in.	Light Anneal	105.0	53.0	.....	22	—	96	—	.....	.....	.....
	2.0 in.	Light Anneal	103.0	52.0	.....	24	—	94	—	.....	.....	.....
	3.0 in.	Light Anneal	102.0	51.0	.....	24	—	93	—	.....	.....	.....
FORGING	5.0 in.	Light Anneal	100.0	45.0	.....	22	—	92	—	.....	.....	.....

COPPER ALLOY No. 638

Composition — percent

	Nominal	Minimum	Maximum
Copper	95	....	....
Lead	....	....	.05
Iron	....	....	.05
Zinc	....	....	.50
Aluminum	2.8	2.5	3.1
Manganese	....	....	.10
Silicon	1.8	1.5	2.1
Nickel	....	....	.10
Cobalt	.40	.25	.55
Copper + Elements with Specific Limits		99.5	

Nearest Applicable A S T M Specifications

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Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1885 F	1030 C
Melting Point (Solidus)	1830 F	1000 C
Density	.299 lb /cu in @ 68 F	8.28 gm /cu cm @ 20 C.
Specific Gravity	8.28	8.28
Coefficient of Thermal Expansion	.0000083 per ° F from 68 F to 212 F	.0000150 per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	.0000087 per ° F from 68 F to 392 F	.0000157 per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000095 per ° F from 68 F to 572 F	.0000171 per ° C from 20 C to 300 C
Thermal Conductivity	23 Btu /sq ft /ft /hr /°F @ 68 F	.097 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	104 Ohms (circ mil /ft) @ 68 F	17.3 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	10 % IACS @ 68 F	.058 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,700,000 psi	11,700 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Springs, switch parts, contacts, relay springs, glass
sealing and porcelain enameling

Common Fabrication Processes

Blanking, drawing, forming and bending, shearing and stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature F orC
Annealing Temperature 750-1100 F or 400-600 C
Machinability Rating (Free Cutting Brass = 100)

Suitability for being joined by:

Soldering Fair
Brazing Fair
Oxyacetylene Welding Fair
Gas Shielded Arc Welding Excellent
Coated Metal Arc Welding Excellent
Resistance Welding { Spot Excellent
Seam Excellent
Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 638 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled		As Extruded	
		.100	.070	.050	.035	.025	.015															Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled							●														
	Strip, Drawn								●	●												
	Flat Wire, Rolled																					
	Flat Wire, Drawn																					
	Bar, Rolled																					
	Bar, Drawn																					
	Sheet																					
	Plate																					
	ROD																					
	WIRE																					
	TUBE																					
	PIPE																					
	SHAPES																					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	Soft Anneal	82.0	53.0	54.0	36	-	86	73	.....	.....	.....
		Quarter Hard	96.0	.....	77.0	23	-	93	78	.....	.....	.....
		Half Hard	106.0	.....	88.0	15	-	96	79	.....	.....	.....
		Hard	120.0	.....	101.0	7	-	99	82	.....	.....	.....
		Extra Hard	124.0	.....	107.0	5	-	100	82	.....	.....	.....
		Spring	128.0	.....	110.0	4	-	101	82	.....	35.0	100
		Extra Spring	130.0	.....	114.0	4	-	101	83	.....	.....	.....

COPPER ALLOY No. 642

Composition — percent

	Nominal	Minimum	Maximum
Copper	91.2	....	....
Lead	....	....	.05
Iron	....	....	.30
Tin	....	....	.20
Zinc	....	....	.50
Aluminum	7.0	6.3	7.6
Arsenic	....	....	.15
Manganese	....	....	.10
Silicon	1.8	1.5	2.2
Nickel	....	....	.25
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B124, B150
Pipe	
Rod	B124, B150
Shapes	B124, B150, B283
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1840 F	1005 C
Melting Point (Solidus)	1800 F	985 C
Density	.278 lb/cu in @ 68 F	7.69 gm/cu cm @ 20 C.
Specific Gravity	7.69	7.69
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000100 per °F from 68 F to 572 F	.0000181 per °C from 20 C to 300 C
Thermal Conductivity	26 Btu/sq ft/ft/hr/°F @ 68 F	108 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	113 Ohms (circ mil/ft) @ 68 F	18.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	8 % IACS @ 68 F	.0464 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

*Volume Basis

Typical Uses

Valve stems, gears, marine hardware, pole line hardware, bolts, nuts, valve bodies and components

Common Fabrication Processes

Hot forming, forging, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100) 80
Hot Working Temperature 1300-1600 F or 700-870 C
Annealing Temperature 1100-1300 F or 600-700 C
Machinability Rating (Free Cutting Brass = 100) 60

Suitability for being joined by:

Soldering Not Recommended
Brazing Fair
Oxyacetylene Welding Not Recommended
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Fair
Resistance Welding { Spot Fair
Seam Fair
Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 642 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)		Light Drawn — Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Extruded	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size	Temper	Tensile	Yield Strength		Elonga-	Rockwell			Shear	Fatigue	
	Section		Strength	(.5% Ext.	(.2% Offset)	tion	Hardness			Strength	Strength	
	in.		ksi	ksi	ksi	in 2 in.	F	B	30T	ksi	ksi	Million
						%						Cycles
BAR	.750 in.	As Extruded	75.0	35.0	....	32	-	77	-	....	....	....
ROD	.750 in.	As Extruded	75.0	35.0	....	32	-	77	-	....	....	....
	.500 in.	Light Anneal	92.0	58.0	....	22	-	98	-	....	....	....
	.750 in.	Light Anneal	90.0	55.0	....	28	-	89	-	....	....	....
	.750 in.	Hard (15%)	102.0	68.0	....	22	-	94	-	59.0	50.0	100
	1.500 in.	Hard (10%)	93.0	60.0	....	26	-	90	-	....	....	....
FORGING	2.0 in.	As Forged	79.0	38.0	....	30	-	78	-	....	....	....

COPPER ALLOY No. 651 (LOW SILICON BRONZE B)

Composition — percent

	Nominal	Minimum	Maximum
Copper	98.5	....	....
Lead	....	....	.05
Iron	....	....	.8
Zinc	....	....	1.5
Manganese	....	....	.7
Silicon	1.5	.8	2.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B97, B98, B432
Pipe	B315
Rod	B98
Shapes	B98
Tube	B315
Wire	B99, B105

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1940 F	1060 C
Melting Point (Solidus)	1890 F	1030 C
Density	.316 lb /cu in @ 68 F	8.75 gm /cu cm @ 20 C.
Specific Gravity	8.75	8.75
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000099 per ° F from 68 F to 572 F	.0000179 per ° C from 20 C to 300 C
Thermal Conductivity	33 Btu /sq ft /ft /hr /°F @ 68 F	.14 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	86.4 Ohms (circ mil /ft) @ 68 F	14.4 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	12 % IACS @ 68 F	.0696 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

* Volume Basis

Typical Uses

AIRCRAFT: hydraulic pressure lines
 HARDWARE: anchor screws, bolts, cable clamps, cap screws, machine screws,
 marine hardware, nuts, pole line hardware, rivets, U-bolts
 INDUSTRIAL: electrical conduits, heat exchanger tubes, welding rod

Common Fabrication Processes

Forming and bending, heading and upsetting, hot forging and
 pressing, roll threading and knurling, squeezing and swaging

Fabrication Properties

Capacity for Being Cold WorkedExcellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1300-1600 F or 700-875 C
 Annealing Temperature 900-1250 F or 475-675 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Fair
 Resistance Welding { Spot Excellent
 Seam Good
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 651 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	{	Strip, Rolled																						
		Strip, Drawn																						
		Flat Wire, Rolled																						
		Flat Wire, Drawn																						
		Bar, Rolled																						
		Bar, Drawn																						
		Sheet																						
		Plate																						
		ROD				•									•	•								
		WIRE									•	•	•		•	•								
		TUBE																	•	•				
		PIPE																						
		SHAPES																						

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
ROD	1.0 in.	.035 mm	40.0	15.0	....	50	55	-	-	....	....	....
		Hard (36%)	70.0	55.0	....	15	-	80	-	45.0	....	....
		Extra Hard (50%)...	90.0	67.0	....	12	-	90	-	50.0	....	....
WIRE	.080 in.	Eighth Hard	55.0	40.0	....	40	-	-	-	36.0	....	....
		Quarter Hard	65.0	50.0	....	25	-	-	-	40.0	....	....
		Half Hard	80.0	63.0	....	15	-	-	-	45.0	....	....
		Hard	100.0	70.0	....	11	-	-	-	50.0	25.0	100
		Extra Hard	105.0	71.0	....	10	-	-	-	53.0	28.0	100
	.440 in.	Quarter Hard (21%)	63.0	....	....	30	-	-	-	....	....	....
		Half Hard (37%) ...	80.0	....	....	20	-	-	-	....	....	....
		Hard (60%)	95.0	....	....	12	-	-	-	....	....	....
TUBE	1.0 in. OD X .065 in.	.015 mm	45.0	20.0	....	55	68	-	-	....	....	....
		Hard Drawn (35%)..	65.0	40.0	....	20	-	75	67	....	....	....

COPPER ALLOY No. 655 (HIGH SILICON BRONZE A)

Composition — percent

	Nominal	Minimum	Maximum
Copper	97	....	....
Lead	....	....	.05
Iron	....	....	.8
Zinc	....	....	1.5
Manganese	....	....	1.5
Silicon	3	2.8	3.8*
Nickel	....	....	.6
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B96, B97, B98, B100, B124, B432
Pipe	B315
Rod	B98, B124
Shapes	B98, B124, B283
Tube	B315
Wire	B99

* In the case of wire, maximum silicon content is 3.6

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1880 F	1025 C
Melting Point (Solidus)	1780 F	970 C
Density	.308 lb /cu in @ 68 F	8.53 gm /cu cm @ 20 C.
Specific Gravity	8.53	8.53
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000100 per °F from 68 F to 572 F	.0000180 per °C from 20 C to 300 C
Thermal Conductivity	21 Btu /sq ft /ft /hr /°F @ 68 F	.09 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	148 Ohms (circ mil /ft) @ 68 F	24.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	7.0 % IACS @ 68 F	.0406 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

AIRCRAFT: hydraulic pressure lines
HARDWARE: bolts, burrs, butts, clamps, cotter pins, hinges, marine hardware, nails, nuts, pole line hardware, screws
INDUSTRIAL: bearing plates, bushings, cable, channels, chemical equipment, heat exchanger tubes, kettles, piston rings, tanks, rivets, screen cloth and wire, screen plates, shafting
MARINE: propeller shafts

Common Fabrication Processes

Blanking, drawing, forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, shearing, squeezing and swaging

Fabrication Properties

Capacity for Being Cold WorkedExcellent
 Capacity for Being Hot FormedExcellent
 Hot Forgeability Rating (Forging Brass = 100)40
 Hot Working Temperature..... 1300-1600 F or 700-875 C
 Annealing Temperature..... 900-1300 F or 475-700 C
 Machinability Rating (Free Cutting Brass = 100)30

Suitability for being joined by:

Soldering Good
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Fair

Resistance Welding { Spot Excellent
 Seam Excellent
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 655 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled	•		•			•				•	•		•	•	•								
	Strip, Drawn																							
	Flat Wire, Rolled										•			•										
	Flat Wire, Drawn																							
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																				•			
	Plate																				•			
	ROD		•									•		•	•	•						•		
	WIRE			•			•			•	•	•		•		•								
	TUBE			•															•	•				
	PIPE																							
	SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	56.0	21.0	....	63	76	40	-	42.0	....	....
		.035 mm	60.0	25.0	....	60	85	62	-	43.0	....	....
		.015 mm	63.0	30.0	....	55	90	66	-	45.0	....	....
		Quarter Hard	68.0	35.0	....	30	-	75	67	47.0	....	....
		Half Hard	78.0	45.0	....	17	-	87	75	50.0	....	....
		Hard	94.0	58.0	....	8	-	93	78	57.0	....	....
		Extra Hard	104.0	60.0	....	6	-	96	80	60.0	....	....
		Spring	110.0	62.0	....	4	-	97	81	63.0	....	....
ROD	1.0 in.	.050 mm	58.0	22.0	....	60	-	60	-	43.0	....	....
		Half Hard (20%)	78.0	45.0	....	35	-	85	-	52.0	....	....
		Hard (36%)	92.0	55.0	....	22	-	90	-	58.0	....	....
		Extra Hard (50%)	108.0	60.0	....	13	-	95	-	62.0	....	....
WIRE	.080 in.	.035 mm	60.0	25.0	....	60	-	-	-	43.0	....	....
		Eighth Hard	70.0	40.0	....	35	-	-	-	48.0	....	....
		Quarter Hard	80.0	48.0	....	20	-	-	-	52.0	....	....
		Half Hard	98.0	57.0	....	8	-	-	-	58.0	....	....
		Hard	125.0	65.0	....	5	-	-	-	65.0	29.0	100
		Spring (80)	145.0	70.0	....	3	-	-	-	70.0	30.0	100
TUBE	1.0 in. OD	.050 mm	57.0	....	....	70	-	45	-	....	....	....
	X .065 in.	Hard Drawn (35%)	93.0	....	....	22	-	92	78	....	....	....

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

COPPER ALLOY No. 667 (MANGANESE BRASS)

Composition — percent

	Nominal	Minimum	Maximum
Copper	70	68.5	71.5
Lead	....	....	.07
Iron	....	....	.10
Zinc	28.8	Remainder	
Manganese	1.2	.8	1.5
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	B291
Pipe	
Rod	
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2000 F	1100 C
Melting Point (Solidus)	1920 F	1030 C
Density	.308 lb /cu in @ 68 F	8.53 gm /cu cm @ 20 C.
Specific Gravity	8.53	8.53
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000111 per ° F from 68 F to 572 F	.0000200 per ° C from 20 C to 300 C
Thermal Conductivity	56 Btu /sq ft /ft /hr /°F @ 68 F	.23 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	61 Ohms (circ mil /ft) @ 68 F	10.1 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	17 % IACS @ 68 F	.099 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

* Volume Basis

Typical Uses

Resistance weldable brass products

Common Fabrication Processes

Blanking, bending, forming, stamping, resistance welded components by spot, seam and butt welding

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Good to Fair
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature..... 1340-1560 F or 725-850 C
 Annealing Temperature..... 930-1300 F or 500-700 C
 Machinability Rating (Free Cutting Brass = 100).....30

Suitability for being joined by:

Soldering..... Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Excellent
 Seam Excellent
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 667 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Strip, Drawn	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Flat Wire, Rolled	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Flat Wire, Drawn	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Bar, Rolled	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Bar, Drawn	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Sheet	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	Plate	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	ROD	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
	WIRE	•	•	•	•	•	•			•	•	•	•	•	•	•	•						
TUBE	•	•	•	•	•	•			•	•	•	•	•	•	•	•							
PIPE	•	•	•	•	•	•			•	•	•	•	•	•	•	•							
SHAPES	•	•	•	•	•	•			•	•	•	•	•	•	•	•							

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.100 mm	45.8	12.0	11.8	60	60	—	18	•	•	•
		.070 mm	47.0	16.0	13.5	58	64	—	22	•	•	•
		.050 mm	49.0	•	14.9	55	70	—	30	•	•	•
		.035 mm	50.0	18.0	17.4	53	74	—	35	•	•	•
		.025 mm	53.0	20.0	20.0	44	77	—	41	•	•	•
		.015 mm	55.0	24.0	24.0	38	83	—	47	•	•	•
		Quarter Hard	56.0	36.2	36.0	20	—	57	55	•	•	•
		Half Hard	64.0	48.0	57.0	13	—	70	64	•	•	•
		Three Quarter Hard	71.0	•	66.0	10	—	78	69	•	•	•
		Hard	77.5	62.0	74.0	4	—	84	72	•	•	•
		Extra Hard	88.0	•	85.0	2.5	—	89	75	•	•	•
		Spring	96.0	•	90.0	2	—	91	77	•	•	•
		Extra Spring	100.0	•	92.5		—	93	78	•	•	•
WIRE	.080 in.	Half Hard	90.0	•	•	5	—	—	—	•	•	•

COPPER ALLOY No. 674

Composition — percent

	Nominal	Minimum	Maximum
Copper	58.5	57.0	60.0
Lead	....	....	.50
Iron	....	....	.35
Tin	....	....	.30
Zinc	36.5	Remainder	
Nickel	....	....	.25
Aluminum	1.2	.50	2.0
Manganese	2.8	2.0	3.5
Silicon	1.0	.50	1.5
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Physical Properties

English Units

C. G. S. Units

Melting Point (Liquidus)	1625 F	885 C
Melting Point (Solidus)	1590 F	865 C
Density	.292 lb /cu in @ 68 F	8.08 gm /cu cm @ 20 C.
Specific Gravity	8.08	8.08
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.000011 per ° F from 68 F to 572 F	.000020 per ° C from 20 C to 300 C
Thermal Conductivity	58 Btu /sq ft /ft /hr /°F @ 68 F	.24 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	45.1 Ohms (circ mil /ft) @ 68 F	7.5 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	23 % IACS @ 68 F	.133 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg /sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg /sq mm

* Volume Basis

Typical Uses

Bushings, gears, connecting rods, shafts, wear plates

Common Fabrication Processes

Hot forging and pressing, machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 100
 Hot Working Temperature 1100-1250 F or 600-675 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 25

Suitability for being joined by:

Soldering Fair
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding

{ Spot Good
 { Seam Good
 { Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 674 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers				Rolled or Drawn Tempers											Hot Finished Tempers						
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties												
Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	ksi	Million Cycles
ROD	.750 in.	Soft Anneal.....	70.0	34.0	....	28	-	78	-	....	....	....
		Half Hard, Stress Relieved*.....	92.0	55.0	....	20	-	87	-	48.0	29.0	100
BAR	2 in. X 3 in.	As Extruded.....	78.0	38.0	....	26	-	78	-	....	....	....
		Half Hard, Stress Relieved*.....	85.0	45.0	....	24	-	83	-	....	....	....
* 1 Hour at 550°F												

COPPER ALLOY No. 675 (MANGANESE BRONZE A)

Composition — percent

	Nominal	Minimum	Maximum
Copper	58.5	57.0	60.0
Lead	....	....	.20
Iron	1.4	.8	2.0
Tin	1	.50	1.5
Zinc	39.0	Remainder	
Aluminum	....	....	.25
Manganese	.1	.05	.50
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Flat Products	B124, B138
Pipe	
Rod	B124, B138
Shapes	B124, B138, B283
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1630 F	890 C
Melting Point (Solidus)	1590 F	865 C
Density	.302 lb /cu in @ 68 F	8.36 gm /cu cm @ 20 C.
Specific Gravity	8.36	8.36
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000118 per ° F from 68 F to 572 F	.0000212 per ° C from 20 C to 300 C
Thermal Conductivity	61 Btu /sq ft /ft /hr /°F @ 68 F	.26 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	43.2 Ohms (circ mil /ft) @ 68 F	7.18 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	24 % IACS @ 68 F	.139 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	15,000,000 psi	10,500 Kg /sq mm
Modulus of Rigidity	5,600,000 psi	3,900 Kg /sq mm

* Volume Basis

Typical Uses

AUTOMOTIVE: clutch disks, pump rods, shafting
HARDWARE: balls, valve stems and bodies

Common Fabrication Processes

Hot forging and pressing, hot heading and upsetting

Fabrication Properties

Capacity for Being Cold Worked Poor
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100) 80
Hot Working Temperature 1150-1450 F or 625-750 C
Annealing Temperature 800-1100 F or 425-600 C
Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Good
Seam Fair
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 675 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm						Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
		.100	.070	.050	.035	.025	.015															Soft Anneal	Light Anneal
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	1.0 in.	Soft Anneal	65.0	30.0	....	33	-	65	-	42.0	....	....
		Quarter Hard (10%) ..	77.0	45.0	....	23	-	83	-	47.0	....	....
		Half Hard (20%)	84.0	60.0	....	19	-	90	-	48.0	....	....
	2.0 in.	Quarter Hard (10%) ..	72.0	42.0	....	27	-	77	-	44.0	....	....

COPPER ALLOY No. 687 (ALUMINUM BRASS, ARSENICAL)

Composition — percent

	Nominal	Minimum	Maximum
Copper	77.5	76.0	79.0
Lead	.....	.....	.07
Iron	.....	.....	.06
Zinc	20.5	Remainder	
Aluminum	2	1.8	2.5
Arsenic	.....	.02	.10
Total Other Elements	.....	.....	.15

Nearest Applicable A S T M Specifications

Flat Products

Pipe

Rod

Shapes

Tube

Wire

B111, B359, B395

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1780 F	970 C
Melting Point (Solidus)	1710 F	935 C
Density	.301 lb/cu in @ 68 F	8.33 gm/cu cm @ 20 C.
Specific Gravity	8.33	8.33
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000103 per °F from 68 F to 572 F	.0000185 per °C from 20 C to 300 C
Thermal Conductivity	58 Btu/sq ft/ft/hr/°F @ 68 F	.24 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	45.1 Ohms (circ mil/ft) @ 68 F	7.50 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	23 % IACS @ 68 F	.133 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	6,000,000 psi	4,200 Kg/sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules

Common Fabrication Processes

Forming and bending

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Fair
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1400-1600 F or 750-875 C
 Annealing Temperature 800-1100 F or 425-600 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering Fair
 Brazing Good
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Good
 Seam Fair
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 687 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers							
		Nominal Grain Size mm																							
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
FLAT PRODUCTS	{	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
		Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
																				</					

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD X .065 in.	.025 mm	60.0	27.0	....	55	77	-	-	....	....	....

COPPER ALLOY No. 688

Composition — percent

	Nominal	Minimum	Maximum
Copper	73.5	72.3	74.7
Lead	....	....	.05
Iron	....	....	.05
Zinc	22.7	Remainder	
Aluminum	3.4	3.0	3.8
Cobalt	.40	.25	.55
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1765 F	965 C
Melting Point (Solidus)	1740 F	950 C
Density	.296 lb /cu in @ 68 F	8.20 gm /cu cm @ 20 C.
Specific Gravity	8.20	8.20
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000101 per ° F from 68 F to 572 F	.0000182 per ° C from 20 C to 300 C
Thermal Conductivity	23 Btu /sq ft /ft /hr /°F @ 68 F	.095 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	58 Ohms (circ mil /ft) @ 68 F	9.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	18 % IACS @ 68 F	.104 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	16,800,000 psi	11,800 Kg /sq mm
Modulus of Rigidity	psi	Kg /sq mm

*Volume Basis

Typical Uses

Springs, switches, contacts, relays, drawn parts

Common Fabrication Processes

Blanking, drawing, forming and bending, shearing and stamping

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 750-1100 F or 400-600 C
 Machinability Rating (Free Cutting Brass = 100)

Suitability for being joined by:

Soldering Fair
 Brazing Fair
 Oxyacetylene Welding
 Gas Shielded Arc Welding
 Coated Metal Arc Welding

Resistance Welding { Spot Good
 Seam Good
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 688 (Continued)

Forms and Tempers
Most Commonly Used

		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers	
		Nominal Grain Size mm																As Hot Rolled	As Extruded
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)
FLAT PRODUCTS	Strip, Rolled																		
	Strip, Drawn																		
	Flat Wire, Rolled																		
	Flat Wire, Drawn																		
	Bar, Rolled																		
	Bar, Drawn																		
	Sheet																		
	Plate																		
	ROD																		
	WIRE																		
TUBE	TUBE																		
	PIPE																		
	SHAPES																		

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.015 mm	82.0	54.0	55.0	36	-	81	71	....	....	....
		Half Hard	93.0	....	75.0	20	-	90	78	....	....	....
		Hard	109.0	....	97.0	6	-	96	82	....	....	....
		Extra Hard	117.0	....	105.0	3	-	97	83	....	....	....
		Spring	122.0	....	110.0	2	-	98	83	....	36.5	100
		Extra Spring	129.0	....	114.0	2	-	99	83	....	....	....

COPPER ALLOY No. 694 (SILICON RED BRASS)

Composition — percent

	Nominal	Minimum	Maximum
Copper	81.5	80.0	83.0
Lead	....	....	.30
Iron	....	....	.20
Zinc	14.5	Remainder	
Silicon	4.0	3.5	4.5
Total Other Elements	....	....	.50

Nearest Applicable A S T M Specifications

Flat Products	
Pipe	
Rod	B371
Shapes	
Tube	
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1685 F	920 C
Melting Point (Solidus)	1510 F	820 C
Density	.296 lb/cu in @ 68 F	8.19 gm/cu cm @ 20 C.
Specific Gravity	8.19	8.19
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000112 per °F from 68 F to 572 F	.0000202 per °C from 20 C to 300 C
Thermal Conductivity	15 Btu/sq ft/ft/hr/°F @ 68 F	45.4 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	167 Ohms (circ mil/ft) @ 68 F	28 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	6.2 % IACS @ 68 F	.036 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	16,000,000 psi	11,200 Kg/sq mm
Modulus of Rigidity	psi	Kg/sq mm

*Volume Basis

Typical Uses

Valve stems where corrosion resistance and high strength are critical

Common Fabrication Processes

Forging, screw machining

Fabrication Properties

Capacity for Being Cold Worked Poor
 Capacity for Being Hot Formed Excellent
 Hot Forgeability Rating (Forging Brass = 100) 80
 Hot Working Temperature..... 1200-1600 F or 650-875 C
 Annealing Temperature..... 800-1200 F or 425-650 C
 Machinability Rating (Free Cutting Brass = 100)..... 30

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding
 Coated Metal Arc Welding
 Resistance Welding { Spot Good
 Seam Good
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 694 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm																						
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled																							
	Strip, Drawn																							
	Flat Wire, Rolled																							
	Flat Wire, Drawn																							
	Bar, Rolled																							
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD								•		•													
	WIRE																							
	TUBE																							
	PIPE																							
	SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
ROD	.500 in.	Soft Anneal	90.0	45.0	.....	20	-	85	-	.....	.....	.....
	1.0 in.	Soft Anneal	85.0	43.0	.....	25	-	85	-	.....	.....	.....
	2.0 in.	Soft Anneal	80.0	40.0	.....	25	-	85	-	.....	.....	.....
	.75 in.	Eighth Hard (7%)....	100.0	57.0	.....	21	-	95	-	.....	.....	.....

COPPER ALLOY No. 706 (COPPER NICKEL, 10%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	88.6	....	....
Lead	....	....	.05
Iron	1.4	1.0	1.8
Zinc	....	....	1.0
Nickel	10	9.0	11.0
Manganese	....	....	1.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B122, B151, B171, B402, B432
Pipe	B466, B467
Rod	B151
Shapes	
Tube	B111, B359, B395, B466, B467, B543, B552
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2100 F	1150 C
Melting Point (Solidus)	2010 F	1100 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000095 per ° F from 68 F to 572 F	.0000171 per ° C from 20 C to 300 C
Thermal Conductivity	26 Btu /sq ft /ft /hr /°F @ 68 F	.11 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	115 Ohms (circ mil /ft) @ 68 F	19.1 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	9.0 % IACS @ 68 F	.0522 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg /sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg /sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: condensers, condenser plates, distiller tubes, evaporator and heat exchanger tubes, ferrules, salt water piping

Common Fabrication Processes

Forming and bending, welding

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1550-1750 F or 850-950 C
Annealing Temperature 1100-1500 F or 600-825 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering..... Excellent
Brazing Excellent
Oxyacetylene Welding Fair
Gas Shielded Arc Welding Excellent
Coated Metal Arc Welding Good

Resistance Welding

{ Spot Good
Seam Good
Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 706 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn – General Purpose (1)	Hard Drawn (2)	Light Drawn – Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
TUBE	1.0 in. OD X .065 in.	.025 mm	44.0	16.0	.....	42	65	15	26	.....	.....	.....
		Light Drawn	60.0	57.0	.....	10	100	72	70	.....	.....	.....

COPPER ALLOY No. 710 (COPPER NICKEL, 20%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	79	....	....
Lead	....	....	.05
Iron	....	....	1.0
Zinc	....	....	1.0
Nickel	21	19.0	23.0
Manganese	....	....	1.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B122
Pipe	B466, B467
Rod	
Shapes	
Tube	B111, B359, B395, B466, B467
Wire	B206

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2190 F	1200 C
Melting Point (Solidus)	2100 F	1150 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000091 per ° F from 68 F to 572 F	.0000164 per ° C from 20 C to 300 C
Thermal Conductivity	21 Btu /sq ft /ft /hr /°F @ 68 F	.09 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	160 Ohms (circ mil /ft) @ 68 F	26.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	6.5 % IACS @ 68 F	.038 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	20,000,000 psi	14,100 Kg /sq mm
Modulus of Rigidity	7,500,000 psi	5,275 Kg /sq mm

*Volume Basis

Typical Uses

Communication relays, condensers, condenser plates, electrical springs, evaporator and heat exchanger tubes, ferrules, resistors

Common Fabrication Processes

Blanking, forming and bending, welding

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Good
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature 1600-1900 F or 875-1050 C
 Annealing Temperature 1200-1500 F or 650-825 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Fair
 Gas Shielded Arc Welding Excellent
 Coated Metal Arc Welding Good

Resistance Welding { Spot Excellent
 Seam Excellent
 Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 710 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	•	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TUBE	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	
PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.050 mm	51.0	13.0	13.0	35	72	25	-	....	....	....
		.035 mm	52.0	14.0	14.0	35	73	27	-	....	....	....
		.025 mm	53.0	16.0	16.0	35	75	30	-	....	....	....
		Quarter Hard	60.0	48.0	49.0	20	92	58	-	....	....	....
		Half Hard	68.0	62.0	63.0	8	100	75	-	....	....	....
		Hard	75.0	71.0	72.0	5	-	80	-	....	....	....
		Extra Hard	78.0	75.0	76.0	4	-	82	-	....	....	....
		Spring	82.0	78.0	79.0	3	-	84	-	....	....	....
		Extra Spring	85.0	78.0	79.0	3	-	86	-	....	....	....
TUBE	1.0 in. OD X .065 in.	.025 mm	49.0	18.0	....	40	72	-	-	....	....	....
		Light Drawn	68.0	62.0	....	14	-	76	-	....	20.0	100
WIRE	.080 in.	Extra Spring	95.0	85.0	....	5	-	-	-	....	....	....

COPPER ALLOY No. 715 (COPPER NICKEL, 30%)

Composition — percent

	Nominal	Minimum	Maximum
Copper	69.5	....	....
Lead	....	....	.05
Iron	.5	.40	.7
Zinc	....	....	1.0
Nickel	30	29.0	33.0
Manganese	....	....	1.0
Copper + Elements with Specific Limits	....	99.5	....

Nearest Applicable A S T M Specifications

Flat Products	B122, B151, B171, B402, B432
Pipe	B466, B467
Rod	B151
Shapes	
Tube	B111, B359, B395, B466, B467, B543, B552
Wire	

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2260 F	1240 C
Melting Point (Solidus)	2140 F	1170 C
Density	.323 lb /cu in @ 68 F	8.94 gm /cu cm @ 20 C.
Specific Gravity	8.94	8.94
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	17 Btu /sq ft /ft /hr /°F @ 68 F	.07 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	225 Ohms (circ mil /ft) @ 68 F	37.5 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	4.6 % IACS @ 68 F	.0267 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	22,000,000 psi	15,500 Kg /sq mm
Modulus of Rigidity	8,300,000 psi	5,800 Kg /sq mm

* Volume Basis

Typical Uses

INDUSTRIAL: condensers, condenser plates, distiller tubes, evaporator and heat exchanger tubes, ferrules, salt water piping

Common Fabrication Processes

Forming and bending, welding

Fabrication Properties

Capacity for Being Cold Worked Good
Capacity for Being Hot Formed Good
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature 1700-1900 F or 925-1050 C
Annealing Temperature 1200-1500 F or 650- 825 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Excellent
Coated Metal Arc Welding Excellent
Resistance Welding { Spot Excellent
Seam Excellent
Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 715 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers											Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
	TUBE																						
	PIPE																						
	SHAPES																						

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	1.0 in.	As Hot Rolled	55.0	20.0		45	-	35	-			
TUBE	1.0 in. OD	.025 mm	50.0	25.0		45	80	45	-			
	X .065 in.											
ROD	4.5 in. OD	.035 mm	54.0			45	77	36	-			
	X .109 in.											
	1.0 in.	Half Hard (20%)	75.0	70.0		15	-	80	-			

COPPER ALLOY No. 725

Composition — percent

	Nominal	Minimum	Maximum
Copper	88.2	....	....
Lead	....	....	.05
Iron	....	....	.6
Zinc	....	....	.50
Nickel	9.5	8.5	10.5
Manganese	....	....	.20
Tin	2.3	1.8	2.8
Copper + Elements with Specific Limits	....	99.8	....

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2065 F	1130 C
Melting Point (Solidus)	1940 F	1060 C
Density	.321 lb /cu in @ 68 F	8.89 gm /cu cm @ 20 C.
Specific Gravity	8.89	8.89
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000092 per ° F from 68 F to 572 F	.0000165 per ° C from 20 C to 300 C
Thermal Conductivity	31 Btu /sq ft /ft /hr /° F @ 68 F	.13 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	94.3 Ohms (circ mil /ft) @ 68 F	15.7 Microhm-cm @ 20 C
Thermal Conductivity* (Annealed)	11 % IACS @ 68 F	.064 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb ° F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	20,000,000 psi	14,000 Kg /sq mm
Modulus of Rigidity	7,500,000 psi	5,250 Kg /sq mm

*Volume Basis

Typical Uses

Relay and switch springs, connectors, brazing
alloy, lead frames, control and sensing bellows

Common Fabrication Processes

Blanking, brazing, coining, drawing, etching, forming and
bending, heading and upsetting, roll threading and knurling,
shearing, spinning, squeezing, stamping and swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Excellent
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature . . . 1550-1750 F or 850-950 C
Annealing Temperature. 1200-1475 F or 650-800 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering. Excellent
Brazing Excellent
Oxyacetylene Welding Fair
Gas Shielded Arc Welding Good
Coated Metal Arc Welding Good

Resistance Welding { Spot Excellent
Seam Good
Butt Excellent

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 725 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers								Rolled or Drawn Tempers										Hot Finished Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn -- General Purpose (1)	Hard Drawn (2)	Light Drawn -- Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Strip, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Flat Wire, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Rolled	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bar, Drawn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sheet	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Plate	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ROD	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WIRE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TUBE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PIPE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SHAPES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load) ksi	(.2% Offset) ksi	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.015 mm	55.0	22.0	22.0	35	-	42	44	....	....	....
		Eighth Hard	58.0	....	43.0	29	-	65	60	....	....	....
		Quarter Hard	55.0	53.0	58.0	18	-	71	-	....	....	....
		Half Hard	71.0	65.0	69.0	6	-	78	-	....	....	....
		Three Quarter Hard	77.0	....	75.0	5	-	81	-	....	....	....
		Hard	83.0	75.0	81.0	3	-	85	-	....	....	....
		Extra Hard	87.0	81.0	86.0	2	-	88	-	....	....	....
		Spring	91.0	83.0	90.0	1	-	90	-	....	....	....
		Super Spring	112.0	92.0	108.0	1	-	99	-	....	....	....
WIRE	.080 in.	.015 mm	60.0	25.0	....	....	-	-	-	....	....	....
		Quarter Hard (20%)	80.0	....	....	....	-	-	-	....	....	....
		Half Hard (45%)	90.0	....	....	....	-	-	-	....	....	....
		Extra Hard (75%)	100.0	....	....	....	-	-	-	....	....	....
		Extra Spring (90%)	110.0	....	....	....	-	-	-	....	....	....
		Super Spring (99%)	120.0	....	....	....	-	-	-	....	....	....

COPPER ALLOY No. 745 (NICKEL SILVER, 65-10)

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	63.5	68.5*
Lead	....	....	.10*
Iron	....	....	.25
Zinc	25	Remainder	
Nickel	10	9.0	11.0
Manganese	....	....	.50
Total Other Elements	....	....	.50

* In the case of rod and wire, maximum copper is 66.5% and maximum lead is .05%.

Nearest Applicable A S T M Specifications

Flat Products	B122, B151
Pipe	
Rod	B151
Shapes	
Tube	
Wire	B206

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1870 F	1020 C
Melting Point (Solidus)	F	C
Density	.314 lb /cu in @ 68 F	8.69 gm /cu cm @ 20 C.
Specific Gravity	8.69	8.69
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000091 per ° F from 68 F to 572 F	.0000164 per ° C from 20 C to 300 C
Thermal Conductivity	26 Btu /sq ft /ft /hr /°F @ 68 F	.11 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	115 Ohms (circ mil /ft) @ 68 F	19.2 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	9.0 % IACS @ 68 F	.0522 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	17,500,000 psi	12,300 Kg /sq mm
Modulus of Rigidity	6 600,000 psi	4,600 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: rivets, screws, slide fasteners
 OPTICAL GOODS: optical parts
 MISCELLANEOUS: etching stock, hollow ware, name plates, platers' bars

Common Fabrication Processes

Blanking, drawing, etching, forming and bending,
 heading and upsetting, roll threading and knurl-
 ing, shearing, spinning, squeezing and swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 1100-1400 F or 600-750 C
 Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
 Brazing Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Good
 Seam Fair
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 745 (Continued)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers		Special Tempers		
		Nominal Grain Size mm																				
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•	•			•	•	•		•	•							
	Strip, Drawn																					
	Flat Wire, Rolled									•	•	•		•								
	Flat Wire, Drawn																					
	Bar, Rolled			•																		
	Bar, Drawn																					
	Sheet																					
	Plate																					
	ROD																					
	WIRE	•	•	•	•	•	•			•	•	•		•	•	•						
TUBE																						
PIPE																						
SHAPES																						

1. DRAWN — GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN — BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties			Yield Strength				Elongation			Rockwell Hardness			Shear Strength		Fatigue Strength	
Form	Size Section in.	Temper	Tensile Strength	(.5% Ext. under Load)	(.2% Offset)	in 2 in.										
			ksi	ksi	ksi	%	F	B	30T	ksi	ksi	Million Cycles				
FLAT PRODUCTS	.040 in.	.070 mm	49.0	18.0	....	49	67	22	30	....	....	....				
		.050 mm	51.0	19.0	....	46	71	28	34	....	....	....				
		.035 mm	53.0	20.0	....	43	76	35	38	41.0	....	....				
		.025 mm	56.0	23.0	....	40	80	42	44	....	....	....				
		.015 mm	60.0	28.0	....	36	85	52	51	....	....	....				
		Eighth Hard	60.0	35.0	....	34	—	60	55	43.0	....	....				
		Quarter Hard	65.0	45.0	....	25	—	70	63	45.0	....	....				
		Half Hard	73.0	60.0	....	12	—	80	70	50.0	....	....				
		Hard	86.0	75.0	....	4	—	89	76	55.0	....	....				
		Extra Hard	95.0	76.0	....	3	—	92	78	59.0	....	....				
WIRE	.080 in.	.070 mm	50.0	....	....	50	—	—	—	....	....	....				
		.050 mm	52.0	....	....	48	—	—	—	....	....	....				
		.035 mm	56.0	....	....	45	—	—	—	....	....	....				
		.025 mm	58.0	....	....	40	—	—	—	....	....	....				
		.015 mm	63.0	....	....	35	—	—	—	....	....	....				
		Eighth Hard (10%) ..	65.0	....	....	25	—	—	—	....	....	....				
		Quarter Hard (20%) ..	72.0	....	....	10	—	—	—	....	....	....				
		Half Hard (37%) ..	85.0	....	....	7	—	—	—	....	....	....				
		Hard (60%)	105.0	....	....	5	—	—	—	....	....	....				
		Extra Hard (75%) ..	120.0	....	....	3	—	—	—	....	....	....				
	Spring (84%)	130.0	....	....	1	—	—	—	....	....	....					

COPPER ALLOY No. 752 (NICKEL SILVER, 65-18)

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	63.0	66.5
Lead	....	....	.10*
Iron	....	....	.25
Zinc	17	Remainder	
Nickel	18	16.5	19.5
Manganese	....	....	.50
Total Other Elements	....	....	.50

* In the case of rod and wire, maximum lead is .05%

Nearest Applicable A S T M Specifications

Flat Products	B122, B151, B206
Pipe	
Rod	B151
Shapes	
Tube	
Wire	B206

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	2030 F	1110 C
Melting Point (Solidus)	1960 F	1070 C
Density	.316 lb/cu in @ 68 F	8.73 gm/cu cm @ 20 C.
Specific Gravity	8.73	8.73
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per ° F from 68 F to 572 F	.0000162 per ° C from 20 C to 300 C
Thermal Conductivity	19 Btu/sq ft /ft /hr /°F @ 68 F	.08 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	173 Ohms (circ mil /ft) @ 68 F	28.7 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	6.0 % IACS @ 68 F	.0348 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg /sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: rivets, screws, table flat ware, truss wire, zippers
OPTICAL GOODS: bows, camera parts, core bars, temples
MISCELLANEOUS: base for silver plate, costume jewelry, etching stock, hollow ware, name plates, radio dials

Common Fabrication Processes

Blanking, drawing, etching, forming and bending, heading and upsetting, roll threading and knurling, shearing, spinning, squeezing and swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100).....
 Hot Working Temperature F or C
 Annealing Temperature 1100-1400 F or 600-750 C
 Machinability Rating (Free Cutting Brass = 100)..... 20

Suitability for being joined by:

Soldering..... Excellent
 Brazing..... Excellent
 Oxyacetylene Welding Good
 Gas Shielded Arc Welding Fair
 Coated Metal Arc Welding Not Recommended

Resistance Welding

Spot Good
 Seam Fair
 Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 752 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers					
		Nominal Grain Size mm																							
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers		
FLAT PRODUCTS	Strip, Rolled				•			•			•	•		•											
	Strip, Drawn									•	•														
	Flat Wire, Rolled					•				•	•			•											
	Flat Wire, Drawn																								
	Bar, Rolled																								
	Bar, Drawn																								
	Sheet																								
	Plate																								
	ROD						•					•													
	WIRE						•		•		•			•											
TUBE																									
PIPE																									
SHAPES																									

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Mechanical Properties			Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
Form	Size Section	Temper		(.5% Ext. under Load)	(.2% Offset)		F	B	30T		ksi	ksi	Million Cycles
	in.		ksi	ksi	ksi	%						
FLAT PRODUCTS	.040 in.	.035 mm	58.0	25.0	....	40	85	40	-	....	....	....
		.015 mm	60.0	30.0	....	32	90	55	-	....	....	....
		Quarter Hard	65.0	50.0	....	20	-	73	65	....	....	....
		Half Hard	74.0	62.0	....	8	-	83	72	....	....	....
		Hard	85.0	74.0	....	3	-	87	75	....	....	....
ROD	.500 in.	.035 mm	56.0	25.0	....	42	-	-	-	....	....	....
		Half Hard (20%)	70.0	60.0	....	20	-	78	-	....	....	....
WIRE	.080 in.	.035 mm	58.0	25.0	....	45	-	-	-	....	....	....
		.015 mm	60.0	30.0	....	35	-	-	-	....	....	....
		Quarter Hard	73.0	65.0	....	16	-	-	-	....	....	....
		Half Hard	86.0	80.0	....	7	-	-	-	....	....	....
		Hard	103.0	90.0	....	3	-	-	-	....	....	....

COPPER ALLOY No. 754 (NICKEL SILVER, 65-15)

Composition — percent

Nearest Applicable A S T M Specifications

	Nominal	Minimum	Maximum
Copper	65	63.5	66.5
Lead	....	....	.10
Iron	....	....	.25
Zinc	20	Remainder	
Nickel	15	14.0	16.0
Manganese	....	....	.50
Total Other Elements	....	....	.50

Physical Properties

English Units

C. G. S. Units

Melting Point (Liquidus)	1970 F	1075 C
Melting Point (Solidus)	1900 F	1040 C
Density	.314 lb /cu in @ 68 F	8.70 gm /cu cm @ 20 C.
Specific Gravity	8.70	8.70
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per °F from 68 F to 572 F	.0000162 per °C from 20 C to 300 C
Thermal Conductivity	21 Btu /sq ft /ft /hr /°F @ 68 F	.09 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	148 Ohms (circ mil /ft) @ 68 F	24.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	7.0 % IACS @ 68 F	.0406 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg /sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg /sq mm

*Volume Basis

Typical Uses

OPTICAL GOODS:	camera parts, optical equipment
MISCELLANEOUS:	etching stock, jewelry

Common Fabrication Processes

Blanking, drawing, etching, forming and bending,
heading and upsetting, roll threading and knurling,
shearing, spinning, squeezing and swaging

Fabrication Properties

Capacity for Being Cold Worked	Excellent
Capacity for Being Hot Formed	Poor
Hot Forgeability Rating (Forging Brass = 100)	....
Hot Working Temperature	 F or C
Annealing Temperature	1100-1500 F or 600-825 C
Machinability Rating (Free Cutting Brass = 100)	20

Suitability for being joined by:

Soldering	Excellent						
Brazing	Excellent						
Oxyacetylene Welding	Good						
Gas Shielded Arc Welding	Fair						
Coated Metal Arc Welding	Not Recommended						
Resistance Welding	<table> <tr> <td>Spot</td><td>Good</td></tr> <tr> <td>Seam</td><td>Fair</td></tr> <tr> <td>Butt</td><td>Good</td></tr> </table>	Spot	Good	Seam	Fair	Butt	Good
Spot	Good						
Seam	Fair						
Butt	Good						

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

Forms and Tempers
Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers					
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•				•	•	•		•	•								
	Strip, Drawn									•	•	•		•	•								
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
	TUBE																						
	PIPE																						
	SHAPES																						

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elonga- tion in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	53.0	18.0	••••	43	69	-	27	••••	••••	••••
		.050 mm	55.0	19.0	••••	42	73	-	33	••••	••••	••••
		.035 mm	57.0	21.0	••••	40	79	-	41	41.0	••••	••••
		.025 mm	59.0	24.0	••••	37	82	-	46	••••	••••	••••
		.015 mm	61.0	28.0	••••	34	89	-	53	••••	••••	••••
		Eighth Hard	62.0	35.0	••••	30	-	60	55	43.0	••••	••••
		Quarter Hard	65.0	49.0	••••	21	-	70	63	44.0	••••	••••
		Half Hard	74.0	62.0	••••	10	-	80	70	47.0	••••	••••
		Hard	85.0	75.0	••••	3	-	87	75	52.0	••••	••••
		Extra Hard	92.0	79.0	••••	2	-	90	77	54.0	••••	••••

COPPER ALLOY No. 757 (NICKEL SILVER, 65-12)

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	63.5	66.5
Lead	.....	.....	.05
Iron	.....	.....	.25
Zinc	23	Remainder	
Nickel	12	11.0	13.0
Manganese	.....	.....	.50
Total Other Elements	.....	.....	.50

Nearest Applicable A S T M Specifications

Flat Products	B151, B206
Pipe	
Rod	B151
Shapes	
Tube	
Wire	B206

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1900 °F	1040 °C
Melting Point (Solidus)	°F	°C
Density	.314 lb /cu in @ 68 F	8.69 gm /cu cm @ 20 C
Specific Gravity	8.69	8.69
Coefficient of Thermal Expansion	per °F from 68 F to 212 F	per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000090 per °F from 68 F to 572 F	.0000162 per °C from 20 C to 300 C
Thermal Conductivity	23 Btu /sq ft /ft /hr /°F @ 68 F	.10 cal /sq cm /cm /sec /° C @ 20 C
Electrical Resistivity (Annealed)	130 Ohms (circ mil /ft) @ 68 F	21.6 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	8.0 % IACS @ 68 F	.0464 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /° C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg /sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg /sq mm

* Volume Basis

Typical Uses

HARDWARE: slide fasteners
OPTICAL GOODS: camera parts, optical parts
MISCELLANEOUS: etching stock, name plates

Common Fabrication Processes

Blanking, drawing, etching, forming and bending,
heading and upsetting, roll threading and knurl-
ing, shearing, spinning, squeezing and swaging

Fabrication Properties

Capacity for Being Cold Worked Excellent
Capacity for Being Hot Formed Poor
Hot Forgeability Rating (Forging Brass = 100)
Hot Working Temperature F or C
Annealing Temperature 1100-1500 F or 600-825 C
Machinability Rating (Free Cutting Brass = 100) 20

Suitability for being joined by:

Soldering Excellent
Brazing Excellent
Oxyacetylene Welding Good
Gas Shielded Arc Welding Fair
Coated Metal Arc Welding Not Recommended

Resistance Welding { Spot Good
Seam Fair
Butt Good

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 757 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers						Rolled or Drawn Tempers										Hot Finished Tempers						
		Nominal Grain Size mm						Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers	
FLAT PRODUCTS	Strip, Rolled	•	•	•	•	•			•	•	•		•	•										
	Strip, Drawn								•	•	•		•											
	Flat Wire, Rolled								•	•	•		•											
	Flat Wire, Drawn																							
	Bar, Rolled		•																					
	Bar, Drawn																							
	Sheet																							
	Plate																							
	ROD																							
	WIRE	•	•	•	•	•	•			•	•	•		•	•									
TUBE																								
PIPE																								
SHAPES																								

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.070 mm	52.0	18.0	....	48	69	22	27	....	....	....
		.050 mm	54.0	19.0	....	45	73	30	33	....	....	....
		.035 mm	56.0	21.0	....	42	78	37	38	41.0	....	....
		.025 mm	59.0	24.0	....	38	82	45	44	....	....	....
		.015 mm	61.0	28.0	....	35	88	55	51	....	....	....
		Eighth Hard	60.0	35.0	....	32	-	60	55	43.0	....	....
		Quarter Hard	65.0	45.0	....	23	-	70	63	44.0	....	....
		Half Hard	73.0	60.0	....	11	-	80	70	47.0	....	....
		Hard	85.0	75.0	....	4	-	89	75	52.0	....	....
		Extra Hard	93.0	79.0	....	2	-	92	77	56.0	....	....

COPPER ALLOY No. 770 (NICKEL SILVER, 55-18)

Composition — percent

	Nominal	Minimum	Maximum
Copper	55	53.5	56.5
Lead	....	....	.10*
Iron	....	....	.25
Zinc	27	Remainder	....
Nickel	18	16.5	19.5
Manganese	....	....	.50
Total Other Elements	....	....	.50

* In the case of rod and wire, maximum lead is .05%

Nearest Applicable A S T M Specifications

Flat Products	B122, B151, B206
Pipe	....
Rod	B151
Shapes	....
Tube	....
Wire	B206

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1930 F	1055 C
Melting Point (Solidus)	F	C
Density	.314 lb/cu in @ 68 F	8.70 gm/cu cm @ 20 C
Specific Gravity	8.70	8.70
Coefficient of Thermal Expansion	per ° F from 68 F to 212 F	per ° C from 20 C to 100 C
Coefficient of Thermal Expansion	per ° F from 68 F to 392 F	per ° C from 20 C to 200 C
Coefficient of Thermal Expansion	.0000093 per ° F from 68 F to 572 F	.0000167 per ° C from 20 C to 300 C
Thermal Conductivity	17 Btu/sq ft/ft/hr/°F @ 68 F	.07 cal/sq cm/cm/sec/°C @ 20 C
Electrical Resistivity (Annealed)	189 Ohms (circ mil/ft) @ 68 F	31.4 Micronm-cm @ 20 C
Electrical Conductivity* (Annealed)	5.5 % IACS @ 68 F	.0319 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu/lb °F @ 68 F	.09 cal/gm/°C @ 20 C
Modulus of Elasticity (Tension)	18,000,000 psi	12,700 Kg/sq mm
Modulus of Rigidity	6,800,000 psi	4,800 Kg/sq mm

* Volume Basis

Typical Uses

Optical goods, springs, resistance wire

Common Fabrication Processes

Blanking, forming and bending, shearing

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forgeability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 1100-1500 F or 600-825 C
 Machinability Rating (Free Cutting Brass = 100) 30

Suitability for being joined by:

Soldering	Excellent						
Brazing	Excellent						
Oxyacetylene Welding	Good						
Gas Shielded Arc Welding	Fair						
Coated Metal Arc Welding	Not Recommended						
Resistance Welding	<table> <tr> <td>Spot</td> <td>Good</td> </tr> <tr> <td>Seam</td> <td>Fair</td> </tr> <tr> <td>Butt</td> <td>Good</td> </tr> </table>	Spot	Good	Seam	Fair	Butt	Good
Spot	Good						
Seam	Fair						
Butt	Good						

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 770 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers										Hot Finished Tempers				
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn — General Purpose (1)	Hard Drawn (2)	Light Drawn — Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
TUBE																							
PIPE																							
SHAPES																							

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength ksi	Yield Strength		Elongation in 2 in. %	Rockwell Hardness			Shear Strength ksi	Fatigue Strength	
				(.5% Ext. under Load) ksi	(.2% Offset) ksi		F	B	30T		ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	60.0	27.0	....	40	90	55	-	....	....	....
		Hard	100.0	85.0	....	3	-	91	77	....	....	....
		Extra Hard	108.0	90.0	....	2.5	-	96	80	....	....	....
		Spring	115.0	....	....	2.5	-	99	81	....	....	....
WIRE	.080 in.	.035 mm	60.0	....	....	40	-	-	-	....	....	....
		Spring (68%)	145.0	....	....	2	-	-	-	....	....	....

COPPER ALLOY No. 782

Composition — percent

	Nominal	Minimum	Maximum
Copper	65	63.0	67.0
Lead	2	1.5	2.5
Iron	....	....	.35
Zinc	25	Remainder	
Nickel	8	7.0	9.0
Manganese	....	....	.50
Total Other Elements	....	....	.10

Nearest Applicable A S T M Specifications

Physical Properties

	English Units	C. G. S. Units
Melting Point (Liquidus)	1830 F	1000 C
Melting Point (Solidus)	1780 F	970 C
Density	.314 lb /cu in @ 68 F	8.69 gm /cu cm @ 20 C
Specific Gravity	8.69	8.69
Coefficient of Thermal Expansion	.0000103 per °F from 68 F to 212 F	.0000185 per °C from 20 C to 100 C
Coefficient of Thermal Expansion	per °F from 68 F to 392 F	per °C from 20 C to 200 C
Coefficient of Thermal Expansion	per °F from 68 F to 572 F	per °C from 20 C to 300 C
Thermal Conductivity	28 Btu /sq ft /ft-hr /°F @ 68 F	.11 cal /sq cm /cm /sec /°C @ 20 C
Electrical Resistivity (Annealed)	103 Ohms (circ mil /ft) @ 68 F	17.2 Microhm-cm @ 20 C
Electrical Conductivity* (Annealed)	10.9 % IACS @ 68 F	.058 Megmho-cm @ 20 C
Thermal Capacity (Specific Heat)	.09 Btu /lb °F @ 68 F	.09 cal /gm /°C @ 20 C
Modulus of Elasticity (Tension)	17,000,000 psi	12,000 Kg /sq mm
Modulus of Rigidity	6,400,000 psi	4,500 Kg /sq mm

*Volume Basis

Typical Uses

Key blanks, watch plates, watch parts

Common Fabrication Processes

Blanking, milling, drilling

Fabrication Properties

Capacity for Being Cold Worked Good
 Capacity for Being Hot Formed Poor
 Hot Forging Ability Rating (Forging Brass = 100)
 Hot Working Temperature F or C
 Annealing Temperature 930-1150 F or 500-620 C
 Machinability Rating (Free Cutting Brass = 100) 60

Suitability for being joined by:

Soldering Excellent
 Brazing Good
 Oxyacetylene Welding Not Recommended
 Gas Shielded Arc Welding Not Recommended
 Coated Metal Arc Welding Not Recommended
 Resistance Welding { Spot Not Recommended
 Seam Not Recommended
 Butt Fair

The values listed above represent reasonable approximations suitable for general engineering use. Due to commercial variations in composition and to manufacturing limitations, they should not be used for specification purposes. See applicable A.S.T.M. specification references.

(Continued on other side)

COPPER ALLOY No. 782 (Continued)

Forms and Tempers Most Commonly Used

Forms and Tempers Most Commonly Used		Annealed Tempers							Rolled or Drawn Tempers											Hot Finished Tempers			
		Nominal Grain Size mm																					
		.100	.070	.050	.035	.025	.015	Soft Anneal	Light Anneal	Eighth Hard	Quarter Hard	Half Hard	Three Quarter Hard	Hard	Extra Hard	Spring	Extra Spring	Drawn - General Purpose (1)	Hard Drawn (2)	Light Drawn - Bending (3)	As Hot Rolled	As Extruded	Special Tempers
FLAT PRODUCTS	Strip, Rolled																						
	Strip, Drawn																						
	Flat Wire, Rolled																						
	Flat Wire, Drawn																						
	Bar, Rolled																						
	Bar, Drawn																						
	Sheet																						
	Plate																						
	ROD																						
	WIRE																						
	TUBE																						
	PIPE																						
	SHAPES																						

1. DRAWN - GENERAL PURPOSE temper is used for general purpose tube only, usually where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.

2. HARD DRAWN temper is used only where there is need for a tube as hard or as strong as is commercially feasible for the size in question.

3. LIGHT DRAWN - BENDING temper is used only where a tube of some stiffness, but yet capable of readily being bent (or otherwise moderately cold worked) is needed.

Mechanical Properties

Form	Size Section in.	Temper	Tensile Strength	Yield Strength		Elongation in 2 in.	Rockwell Hardness			Shear Strength	Fatigue Strength	
			ksi	(.5% Ext. under Load)	(.2% Offset)	%	F	B	30T	ksi	ksi	Million Cycles
FLAT PRODUCTS	.040 in.	.035 mm	53.0	23.0	.....	40	78	-	-	40.0	.....	.....
		.015 mm	59.0	27.0	.....	32	85	-	-	43.0	.....	.....
		Quarter Hard	62.0	42.0	.....	24	-	65	63	44.0	.....	.....
		Half Hard	69.0	58.0	.....	12	-	78	69	47.0	.....	.....
		Three Quarter Hard	78.0	63.0	.....	5	-	84	72	51.0	.....	.....
		Hard	85.0	73.0	.....	4	-	87	74	54.0	.....	.....
		Extra Hard	91.0	76.0	.....	3	-	90	75	58.0	.....	.....