



SURFACE VEHICLE STANDARD

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Wrought Copper and Copper Alloys

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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1. Scope—This standard¹ describes the chemical, mechanical, and dimensional requirements for a wide range of wrought copper and copper alloys used in the automotive and related industries.

1.1 Wrought forms covered by this standard include sheet, strip, bar, plate, rod, wire, tube, and shapes; however, form required must be specified by purchaser.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein.

2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B248—Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar

ASTM B249—Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, and Shapes

ASTM B250—Specification for General Requirements for Wrought Copper-Alloy Wire

ASTM B251—Specification for General Requirements for Wrought Copper-Alloy Wire

3. Chemical and Mechanical Properties—The chemical composition of products identified by the UNS designations shall conform to the limits shown in Table 1. Mechanical properties shall conform to limits shown in Table 2A (metric(SI) units) or 2B (customary units).

3.1 Products shall be of uniform quality and free from defects (such as desegregation, pipes, nonmetallic inclusions, cracks, seams, laps, buckles, and die or roll marks) detrimental to their appearance, fabrication and/or performance in service.

3.2 Both inside and outside surfaces of tubing shall be clean and smooth.

1. If none of the alloys listed herein include the characteristics required for a particular application, users are encouraged to consider alloy specifications listed in CDA Publication "Standards Handbook for Copper Alloy Wrought Mill Products," published by the Copper Development Association, 405 Lexington Avenue, New York, NY 10017, before creating specifications of their own.

- 3.3** Forgings shall not be brazed, soldered, welded, or ground to hide defects or to salvage defective products, unless specifically approved by the purchaser.
- 3.4** Necessary brazes in soft annealed copper wire shall be in accordance with best commercial practice.
- 4. *Testing***—Unless otherwise specified all properties stated herein are based on latest methods of test published in the ASTM Standards.
- 5. *Dimensional Tolerances***—Standard forms of products identified by the UNS designations shall conform to the dimensions specified by the purchaser, within the tolerance limits shown in Tables 4 - 11, the “key” for which is Table 3, “Index to Standard Product Tolerance Tables.” Specified dimensions not covered by these tables shall be within the tolerance limits shown in ASTM B248 (plate, sheet, strip, and rolled bar), ATM B249 (rod, bar, and shapes), ASTM B250 (wire), and ASTM B251 (pipe and tube). (Note: the terms “refractory” and “nonrefractory” used in Table 3 are common in the copper industry, the first applying to alloys which, because of their hardness on abrasiveness, require dimensional tolerances greater than those established for nonrefractory alloys.)

TABLE 1—CHEMICAL COMPOSITIONS OF WROUGHT COPPER ALLOYS^a

Copper Alloy UNS No. ^b	% by Weight, Maximum (Except where otherwise noted)											Other Named Elements
	Cu	Fe	Zn	Pb	Sn	Mn	Ni	Al	Si	P	Be	
C10200 ^c	99.9 min	—	—	—	—	—	—	—	—	—	—	—
C11000 ^c	99.9 min	—	—	—	—	—	—	—	—	—	—	—
C11100 ^c	99.9 min	—	—	—	—	—	—	—	—	—	—	See Note d
C11300 ^{c,e}	99.9 min ^f	—	—	—	—	—	—	—	—	—	—	Ag, .027 min (8) ^g
C11400 ^{c,e}	99.9 min ^f	—	—	—	—	—	—	—	—	—	—	Ag, .034 min (10) ^g
C11500 ^{c,e}	99.9 min ^f	—	—	—	—	—	—	—	—	—	—	Ag, .054 min (16) ^g
C11600 ^{c,e}	99.9 min ^f	—	—	—	—	—	—	—	—	—	—	Ag, .085 min (25) ^g
C12000	99.9 min	—	—	—	—	—	—	—	—	.004–.012	—	—
C12200 ^h	99.9 min	—	—	—	—	—	—	—	—	.015–.040	—	—
C14500 ⁱ	99.9 min ^j	—	—	—	—	—	—	—	—	.004–.012 ^k	—	Te, .40–.60
C14700	99.9 min ^j	—	—	—	—	—	—	—	—	—	—	S, 2–.5
C15000	99.8 min	—	—	—	—	—	—	—	—	—	—	Zr, .10–.20
C16200	99.8 min	.02	—	—	—	—	—	—	—	—	—	Cd, .7–1.2
C17000	99.5 min ^m	Note n	—	—	—	—	Note n	—	—	—	1.6–1.8	Co ^o
C17200	99.5 min ^m	Note n	—	—	—	—	Note n	—	—	—	1.8–2.0	Co ^o
C17500	99.5 min ^m	.10	—	—	—	—	—	—	—	—	.40–.70	Co, 2.4–2.7
C17600	99.5 min ^m	—	—	—	—	—	—	—	—	—	.25–.50	Co, 1.4–1.7 Ag, .9–1.1
C18400	99.8 min ^o	.15	.70	—	—	—	—	—	.10	.05	—	As, .005 Cr, .40–1.2 U, .05 Ca, .005
C18700	99.9 min ^o	—	—	.8–1.5	—	—	—	—	—	—	—	—
C19200	98.7 min	.8–1.2	—	—	—	—	—	—	—	.01–.04	—	—
C21000	94.0–96.0	.05	rem	.05	—	—	—	—	—	—	—	—
C22000	89.0–91.0	.05	rem	.05	—	—	—	—	—	—	—	—
C23000	84.0–86.0 ^p	.05	rem	.05 ^p	—	—	—	—	—	—	—	—
C24000	78.5–81.5	.05	rem	.05	—	—	—	—	—	—	—	—
C26000	68.5–71.5	.05	rem	.07	—	—	—	—	—	—	—	—
C26800	64.0–68.5	.05	rem	.15	—	—	—	—	—	—	—	—
C27000	63.0–68.5	.07	rem	.10	—	—	—	—	—	—	—	—
C33000	65.0–68.0	.07	rem	.20–.8 ^q	—	—	—	—	—	—	—	—
C33100	65.0–68.0	.06	rem	.70–1.2	—	—	—	—	—	—	—	—
C34200	62.5–66.5	.10	rem	1.5–2.5	—	—	—	—	—	—	—	—
C34500	62.0–64.0	.10	rem	1.5–2.8	—	—	—	—	—	—	—	—
C35000	59.0–64.0 ^r	.10	rem	.8–1.4	—	—	—	—	—	—	—	—
C36000	60.0–63.0	.35	rem	2.5–3.7	—	—	—	—	—	—	—	—
C37700	58.0–62.0	.30	rem	1.5–2.5	—	—	—	—	—	—	—	—
C46400	59.0–62.0	.10	rem	.20	.50–1.0	—	—	—	—	—	—	—
C46500	59.0–62.0	.10	rem	.20	.50–1.0	—	—	—	—	—	—	As, .02–.10

φ

ed. TABLE 1—CHEMICAL COMPOSITIONS OF WROUGHT COPPER ALLOYS^a (CONTINUED)

Copper Alloy UNS No. ^b	% by Weight, Maximum (Except where otherwise noted)											
	Cu	Fe	Zn	Pb	Sn	Mn	Ni (incl. Co)	Al	Si	P	Be	Other Named Elements
C46600	59.0–62.0	.10	rem	.20	.50–1.0	—	—	—	—	—	—	Sb, .02–.10
C46700	59.0–62.0	.10	rem	.20	.50–1.0	—	—	—	—	0.2–.10	—	—
C51000	99.5 min ^a	.10	.30	.05	4.2–5.8	—	—	—	—	.03–.35	—	—
C51100	99.5 min ^a	.10	.30	.05	3.5–4.9	—	—	—	—	.03–.35	—	—
C52100	99.5 min ^a	.10	.20	.05	7.0–9.0	—	—	—	—	.03–.35	—	—
C52400	99.5 min ^a	.10	.20	.05	9.0–11.0	—	—	—	—	.03–.35	—	—
C54400	99.5 min ^c	.10	1.5–4.5	3.5–4.5	3.5–4.5	—	—	—	—	.01–.50	—	—
C60800	88.8–92.5 ^f	.10	—	.10	—	—	—	5.0–6.5	—	—	—	As, .2–.35
C61300	88.5–91.5 ^f	2.0–3.0	.05	.01	—	.15	—	6.0–7.5	—	.015	—	See Note v
C61400	88.0–92.5 ^f	1.5–3.5	.20	.10	—	1.0	—	6.0–8.0	—	.015	—	—
C61800	86.9–91.0 ^f	.50–1.5	.02	.02	—	—	—	8.5–11.0	.10	—	—	—
C62300	82.2–89.5 ^f	2.0–4.0	—	—	.60	.50	1.0	8.5–11.0	.25	—	—	—
C62400	82.8–88.0 ^f	2.0–4.5	—	—	.20	.30	—	10.0–11.5	.25	—	—	—
C63000	78.0–85.0 ^f	2.0–4.0	.30	—	.20	1.5	4.0–5.5	9.0–11.0	.25	—	—	—
C64200	88.2–92.2 ^f	.30	.50	.05	.20	.10	.25	6.3–7.6	1.5–2.2	—	—	As, .15
C65500	rem ^f	.8	1.5	.05	—	.50–1.3	.60	—	2.8–3.8	—	—	—
C67000	63.0–68.0	2.0–4.0	rem	.20	.50	2.5–5.0	—	3.0–6.0	—	—	—	—
C67300	58.0–63.0	.50	rem	.4–3.0	.30	2.0–3.5	.25	.25	.50–1.5	—	—	—
C67400	57.0–60.0	.35	rem	.50	.30	2.0–3.5	.25	.50–2.0	.50–1.5	—	—	—
C67500	57.0–60.0	.8–2.0	rem	.20	.50–1.5	.05–.50	—	.25	—	—	—	—
C70600	99.5 min ^g	1.0–1.8	1.0 ^h	.05 ^h	—	1.0	9.0–11.0	—	—	—	—	See Note u
C71000	99.5 min ^g	1.0	1.0	.05	—	1.0	19.0–23.0	—	—	—	—	—
C71500	99.5 min ^g	.40–.70	1.0 ^h	.05 ^h	—	1.0	29.0–33.0	—	—	—	—	See Note u
C75200	63.0–68.5	.25	rem	.10	—	.50	16.5–19.5	—	—	—	—	—
C77000	53.5–56.5	.25	rem	.10	—	.50	16.5–19.5	—	—	—	—	—

^a These specification limits do not preclude the possible presence of other unnamed elements. However, analysis shall regularly be made only for the minor elements listed in the table, plus all major elements except one. The major element which is not analyzed shall be determined by difference between the sum of those elements analyzed and 100%. By agreement between manufacturer and purchaser, analysis may be required and limits established for elements not specified.

^b Unified Numbering System. For cross reference to SAE, Former SAE, ASTM, and Former Trade Names, see SAE J461.

^c These are high conductivity coppers which have in the annealed condition a minimum conductivity of 100% IACS.

^d Small amounts of Cd or other elements may be added by agreement to improve resistance to softening at elevated temperatures.

^e This includes Low Resistance Lake Copper and Electrolytic Copper.

^f This includes Cu + Ag.

^g Figures in parentheses are tray ounces per avoirdupois ton.

^h This includes Oxygen-Free Copper which contains P in an amount agreed upon.

ⁱ This includes Oxygen-Free Tellurium Bearing Copper which contains P in an amount agreed upon.

^j This includes Cu + Ag + Te.

^k Other deoxidizers may be used as agreed upon, in which case P need not be present.

^l This includes Cu + Ag + S.

^m The value of Cu is exclusive of Ag.

ⁿ Ni + Co, 0.20% min.

^o Ni + Fe, + Co, 0.6% max.

^p This includes copper plus elements with specified limits. Copper alloy UNS Nos. C70600 ed. (CA706), Cu + Ag, 86.5% min and C71500 (CA715), Cu + Ag, 65% min. Specific limits are defined as any numerical values, whether maximum only, minimum only or ranges.

^q For pipe and tube, the Cu limit may be 83.0% minimum and the Pb 0.06% max.

^r For tube over 5 in O.D., the Pb may be less than 0.20%.

^s Copper 61.0% min for rod.

^t This includes Cu + Sn + P.

^u This includes Cu + Sn + P + Pb + Zn.

^v When the product is for welding applications and so specified by the purchaser, Zn shall be 0.50% max, Pb 0.02% max, P 0.02% max, S 0.02% max, and C 0.05% max.

^w When the product is for welding applications and so specified by the purchaser, Cr, Cd, ed. and Zr shall each be 0.05% max.

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS

Metric (SI) Units														
Copper or Copper Alloy UNS No. ^{1,2}	Form	Temper	Size Section, mm		Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ³	Hardness				Grain Size, mm	
			Over/Thru	Min	Max	0.5% Ext Under Load	In 4 × Dia or Thickness of Specimen	Min	Max	Min	Max	Min	Max	
C10200 C11000 C11100 C11300 C11400 C11500 C11600 C12000 C12200	Plate, Sheet, Strip, and Rolled Bar	Soft Anneal	—	—	—	—	—	RF ^b		R30T ^b		Note a	—	
		Deep-Draw- ing Anneal	—	—	—	—	—	30	75	—	—	Note a	0.050	
		Light Cold Rolled	—	220	275	—	—	40	82	—	49	—	—	
		1/2 Hard ^f Hard ^f	—	225 285	315 360	—	—	77 86	80 93	43 54	57 62	—	—	
		Spring ^g Extra Spring ^g	—	345 360	400 —	—	—	91 92	97 —	60 61	66 —	—	—	
		Hot Rolled Hot Rolled and Annealed	—	205 205	260 260	—	—	—	75 65	—	41 31	—	—	
		—	—	205	260	—	—	—	65	—	31	—	—	
C10200 C11000 C12000 C12200	Rod, Bar and Shapes	Soft Anneal	All Sizes ^m		Type B Mat ^{1a}		—	Type B ⁴	Type A ^{4,5}		—	—	—	—
		—	—	255	—	25	—	65	—	—	—	—		
		Hard	—/6.5 ^w	345	—	—	—	68	95	—	—	—	—	
			6.5/9.5 ^w	310	—	—	10	68	95	—	—	—	—	
			9.5/25 ^w	275	—	—	12	68	95	—	—	—	—	
			25/50 ^w	240	—	—	15	68	95	—	—	—	—	
			50/75 ^w	230	—	—	15	68	95	—	—	—	—	
			4.8/9.5 ^a	290	—	—	12	68	95	—	—	—	—	
			9.5/13 ^a	275	—	—	12	68	95	—	—	—	—	
			13/50 ^a	230	—	—	15	68	95	—	—	—	—	
			50/100 ^a	220	—	—	15	68	95	—	—	—	—	
			All Sizes ^g	220	—	—	15	—	—	—	—	—	—	
C10200 C12000 C12200	Tube	Soft Anneal	OD	Wall	—	—	In 50 mm	—	—	R15T ^d		—	—	
			All Sizes	0.4/0.9	—	—	40 ^e	—	50 ^d	—	60	0.040	—	
		Light Anneal	All Sizes	0.4/0.9	—	—	—	—	55 ^d	—	65	—	0.040	
			All Sizes	0.9/—	—	—	—	—	—	—	—	0.040	0.040	
		Light Drawn Drawn Hard Drawn	All Sizes	All Sizes	250	325	—	—	—	R30T ^d		—	—	
			All Sizes	All Sizes	250	—	—	—	—	30	60	—	—	
			—/25	0.5/3.0	310	—	—	—	—	30	—	—	—	
C10200 C11000	Wire	Annealed	25/50	0.4/4.5	310	—	—	—	—	55	—	—	—	
			50/100	1.5/6.5	310	—	—	—	—	55	—	—	—	
			Size Section, mm Over/Thru		—	—	In 250 mm	RF ^b		R30T ^b		—	—	
			0.08/0.25		—	—	15	—	—	—	—	—	—	
			0.25/0.50		—	—	20	—	—	—	—	—	—	
			0.50/2.5		—	—	25	—	—	—	—	—	—	
C14500	Rod	1/2 Hard ^f	1.6/6.5	260	—	205	8	—	—	—	—	—	—	
			6.5/65	260	—	205	12	—	—	—	—	—	—	
		Hard	1.6/6.5	330	—	275	4	—	—	—	—	—	—	
			6.5/30	305	—	260	8	—	—	—	—	—	—	
C14700	Rod	1/2 Hard ^f	1.6/6.5	—	—	205	8	—	—	—	—	—	—	
			6.5/65	—	—	205	12	—	—	—	—	—	—	
		Hard ^g	1.6/6.5	—	—	275	4	—	—	—	—	—	—	
			6.5/30	—	—	260	8	—	—	—	—	—	—	
C15000	Round Rod	—	30/50	—	—	240	8	—	—	—	—	—	—	
			—	—	—	—	—	—	—	—	—	—	—	

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units																		
Copper or Copper Alloy JNS No. ^a	Form	Temper	Size Section, mm	Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm						
			Over/Thru	Min	Max	0.5% Ext Under Load	In 50 mm	Min	Max	Min	Max	Min	Max					
C16200	Round Rod	Drawn	—/25 25/50 50/75	Type B Mat ^{1a}	— — —	— — —	20 25 25	RB		R30T ^b		— — —	— — —					
				415 380 345				— — —	65 60 55	— — —	— — —							
				—/25 25/—				415 345	— —	— —	20 20			55 50	— —	— —	— —	
	Square, Rectangular and Hex Rod and Bar	Drawn	—/25 25/—	415 345	— —	— —	20 20	55 50	— —	— —	— —	— —						
Forging	As Forged	—/25 25/—	415 345	— —	— —	20 25	55 55	— —	— —	— —	— —							
C17000	Strip	A Soft ¹	All Sizes	415 515 585 690	540 605 690 825	— — — —	In 50 mm ^a 35 10 5 2	RB ^{a,4} 45 68 88 96	78 90 96 102	R30T ^{a,4} 46 62 74 79	67 75 79 83	Elec Cond % IACS Min 17 16 15 15	Heat Treat h at 315°C — — — —					
														—	—	—	—	
														—	—	—	—	
		1/4 Hard ¹ 1/2 Hard ¹ Hard ¹	All Sizes All Sizes All Sizes All Sizes	1035 1100 1170 1240	— — — —	885 930 1000 1070	3 2.5 1 1	RC ^{a,4} 33 35 37 39	— — — —	R30N ^{a,4} 53 55 56 59	— — — —	22 22 22 22	3 2 2 2					
														—	—	—	—	
														—	—	—	—	
														—	—	—	—	
														—	—	—	—	
		AM ²	All Sizes	690	795	485 min 655 max	18	18	23	37	44	23	—					
		1/4 HM ²	All Sizes	760	860	550 min 725 max	15	21	26	42	47	23	—					
		1/2 HM ²	All Sizes	830	930	655 min 795 max	12	25	30	46	50	24	—					
		HM ²	All Sizes	930	1030	760 min 930 max 930 min 1100 max	9	30	35	50	55	25	—					
		XHM ²	All Sizes	1100	1200	— — — —	2	32	36	52	56	24	—					
		C17200	Strip	A (Soft) ¹	All Sizes	415 515 585 690	535 605 690 825	— — — —	35 10 5 2	RB ^{a,4} 45 68 88 96	78 90 96 102	R30T ^{a,4} 46 62 74 79	67 75 79 83	17 16 15 15	— — — —			
—	—															—	—	
—	—															—	—	
1/4 Hard ¹ 1/2 Hard ¹ Hard ¹	All Sizes All Sizes All Sizes All Sizes			1140 1200 1770 1310	1350 1410 1480 1520	— — — —	— — — —	RC ^{a,4} 36 38 39 40	— — — —	R30N ^{a,4} 56 58 59 60	— — — —	22 22 22 22	3 2 2 2					
														—	—	—	—	
														—	—	—	—	
														—	—	—	—	
														—	—	—	—	
A (Soft) ¹	All Sizes			415 655 620 585	585 895 825 795	— — — —	— — — —	— — — —	RB ^{a,4} 45 92 91 88	85 103 102 104	— — — —	— — — —	17 15 15 15	— — — —				
															—	—	—	—
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															—	—	—	—
AT ²	All Sizes	1140	1310	— — — —	— — — —	RC ^{a,4} 36 38 39 37	40 45 44 43	— — — —	— — — —	22 22 22 22	3 2 2 2							

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units													
Copper or Copper Alloy UNS No. ^a	Form	Temper	Size Section, mm	Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Elec Cond, %IACS Min	Heat Treat h at 315°C
				Over/Thru	Min	Max		0.2% Offset	In 50 mm	Min	Max	Min	Max
C17500	Strip and Plate	A (Soft) ^d	All Sizes	—	380	140 min 205 max	20			RB ^{e,g}		R30T ^{e,g}	
										20	45	29	45
		1/2 Hard ^d	All Sizes	415	515	345 min 485 max	5	65	76	60	67	25	—
		Hard ^d	All Sizes	485	585	415 min 550 max	2	78	88	69	75	25	—
		AT ^h	All Sizes	690	825	550 min 690 max	8	92	100	77	82	45	—
		1/2 HT ^h	All Sizes	760	895	655 min 825 max	5	95	102	79	83	48	—
	Hot Worked Sizes, Forgings	A (Soft) ^d	All Sizes	—	380	140 min 205 max	20	20	45	—	—	20	—
		AT ^h	All Sizes	690	825	550 min 690 max	10	92	100	—	—	45	—
C17500 C17600	Rod, Bar Shapes and Tubing	A (Soft) ^d	All Sizes	240	380	140 min 205 max	20	25	45	—	—	20	—
		1/2 Hard	All Sizes	450	585	380 min 515 max	10	60	75	—	—	20	—
		AT ^h	All Sizes	690	825	550 min 690 max	10	92	100	—	—	45	—
		1/2 HT ^h	All Sizes	760	895	690 min 825 max	8	92	102	—	—	48	—
C18400	Rod (Round Only)	Drawn	—/25 25/50 50/75	450	—	0.5% Ext Under Load	15	RB		R30T ^b		Grain Size, mm	
				415	—							Min	Max
				380	—							—	—
	Rod (Hexagonal) and Bar	Drawn	—/25 25/—	450	—	—	15	75	—	—	—	—	—
				415	—			70	—	—	—	—	—
	Forgings	As Forged	—/25 25/50 50/—	450	—	—	15	72	—	—	—	—	—
C18700	Rod	1/2 Hard ^f	1.6/6.5 6.5/65	260	—	205	8	—	—	—	—	—	—
		Hard	1.6/6.5 6.5/30 30/50	330	—	275	4	—	—	—	—	—	—
C19200	Tube	A (Soft)	All Sizes	260	—	80	—	—	—	—	—	—	—
		Light Drawn	All Sizes	275	—	240	—	—	—	—	—	—	—
C21000	Plate, Sheet, Strip and Rolled Bar ¹	Annealed	—	—	—	—	—	RF ^b		—	4	0.035 0.025 0.015 Note 1	0.090 0.050 0.035 0.025
		1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	255	325	—	—	RB ^b		—	—	—	—

(Table continued on next page)

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units															
Copper or Copper Alloy UNS No. ^a	Form	Temper	Size Section, mm	Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm			
			Over/Thru	Min	Max	0.5% Ext Under Load	In 50 mm	Min	Max	Min	Max	Min	Max		
C21000	Plate, Sheet, Strip and Rolled Bar ^d	1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	290	360	—	—	RB ^b		R30T ^b		—	—		
								40 44 —	56 60 —	— 46 48	— 57 59				
								50 53	61 64	—	—				
		3/4 Hard	0.50/0.90 0.90/—	315	385	—	—	In 4 × Dia or Thickness of Specimen	—	—	52 54	60 62	—	—	
		3/4 Hard	0.30/0.70 0.70/—	315	385	—	—								—
		Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	345	405	—	—	57 60 —	64 67 —	— 57 59	— 62 64	—	—		
		Extra Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	385	440	—	—	64 66 —	70 72 —	— 62 63	— 66 67	—	—		
Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	415	470	—	—	68 70 —	73 75 —	— 64 65	— 68 69	—	—				
Extra Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	420	475	—	—	69 71 —	74 76 —	— 65 66	— 69 70	—	—				
C22000	Plate, Sheet, Strip and Rolled Bar ^d	Annealed 0.050 mm 0.035 mm 0.025 mm 0.015 mm	— — — —	— — — —	— — — —	— — — —	— — — —	— — — —	RF ^b		1 7 13 19	16 21 31 39	0.035 0.025 0.015 Note 1	0.090 0.050 0.035 0.025	
									50 54 58 62	60 64 70 75					
									1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	275	345	—	—	—
		27 31 —	52 56 —												
		1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	325	395	—	—	—	—	50 53 —	63 66 —	— 52 54	— 61 63	— — —	— — —
		3/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	360	425	—	—	—	—	59 62 —	68 71 —	— 58 60	— 64 66	— — —	— — —
		Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	395	455	—	—	—	—	65 68 —	72 75 —	— 62 64	— 66 68	— — —	— — —
		Extra Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	440	495	—	—	—	—	72 74 —	77 79 —	— 67 68	— 71 72	— — —	— — —
		Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	475	530	—	—	—	—	76 78 —	79 81 —	— 70 71	— 72 73	— — —	— — —
		Extra Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	495	550	—	—	—	—	78 80 —	81 83 —	— 71 72	— 73 74	— — —	— — —

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units																
Copper or Copper Alloy UNS No.**	Form	Temper	Size Section, mm		Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm			
			Over/Thru		Min	Max			0.5% Ext Under Load	In 4 × Dia or Thickness of Specimen	Min	Max	Min	Max	Min	Max
			Wall Thickness				Min	Max								
C22000	Tube	Soft Anneal	—/1.1 1.1/—		—	—			—	—	—	—	70	—	30	—
			—/1.1 1.1/—		—	—	—	—	—	78	—	37	—	Note a Note a	0.035 0.035	
		Drawn (General Purpose)	All Sizes		275	—	—	—	—	—	38	—	—	—		
		Hard Drawn	OD	Wall	360	—	—	—	—	—	55	—	—	—		
			—/100	0.5/6.5												
C23000	Sheet and Strip	Annealed 0.070 mm 0.050 mm 0.035 mm 0.025 mm 0.015 mm	Size Section, mm		—	—	—	—	53 56 58 60 62	60 63 66 72 79	6 10 13 16 19	16 20 24 34 48	0.050 0.035 0.025 0.015 Note a	0.100 0.070 0.050 0.035 0.025		
			Over/Thru													
			—													
			—													
			—													
		1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		305	370	—	—	RB ^b		33 37 —	58 62 —	— — 42 45	— — 57 60	— — — —	
			—													
			—													
		1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		350	420	—	—	56 59 —	68 71 —	— — 56 58	— — 64 66	— — — —	— — — —		
			—													
			—													
		3/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		395	460	—	—	66 69 —	73 76 —	— — 63 65	— — 68 70	— — — —	— — — —		
			—													
			—													
		Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		435	495	—	—	72 74 —	78 80 —	— — 67 68	— — 71 72	— — — —	— — — —		
			—													
			—													
		Extra Hard	0.50/0.90		495	550	—	—	78	83	—	—	—	—		
		Extra Hard	0.90/— 0.30/0.70 0.70/—		495	550	—	—	80 — —	85 — —	— 70 71	— 74 75	— — —	— — —		
			—													
			—													
		Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—		540	595	—	—	82 84 —	85 87 —	— — 74 75	— — 76 77	— — — —	— — — —		
		Extra Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—		565	620	—	—	84 86 —	87 89 —	— — 75 76	— — 77 78	— — — —	— — — —		
			—													
			—													
Tube	Soft Anneal	Wall Thickness		—	—	—	—	RF ^d		R30T ^d		0.025 0.025	0.060 0.060			
		—/1.1 1.1/—						—	75	—	36					
	Light Anneal	—/1.1 1.1/—		—	—	—	—	—	85	—	39	—	Note a Note a	0.035 0.035		
	Light Drawn ^e	All Sizes		305	400	—	—	—	—	43	75	—	—			
	Drawn (General Purpose)	All Sizes		305	—	—	—	—	—	43	—	—	—			

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units															
Copper or Copper Alloy UNS No. ^a	Form	Temper	Size Section, mm		Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm		
			Over/Thru		Min	Max	0.5% Ext Under Load	In 4 × Dia or Thickness of Specimen	Min	Max	Min	Max	Min	Max	
			OD	Wall											
C23000	Tube	Hard Drawn	—/109	0.5/6.5	395	—	—	—	—	—	—	65	—	—	—
C24000	Sheet and Strip	Annealed	Size Section, mm		—	—	—	—	53	64	2	21	0.050	0.120	
			Over/Thru												
			—												
			—												
			—												
		1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		330	400	—	—	RB ^b		—	—	—	—	
			38 42						61 65						
			—						—						
			—						42 45						
			—						57 60						
		1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		380	450	—	—	59 62 —	70 73 —	— — —	— — —	— — —	— — —	
			—						56 58		64 66				
			—						—		—				
		3/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		420	490	—	—	69 72 —	76 79 —	— — —	— — —	— — —	— — —	
			—						63 65		68 70				
			—						—		—				
		Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		470	530	—	—	76 78 —	82 84 —	— — —	— — —	— — —	— — —	
—			68 69						72 73						
—			—						—						
Extra Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		540	600	—	—	83 85 —	87 89 —	— — —	— — —	— — —	— — —			
	—						72 73		75 76						
	—						—		—						
Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—		565	640	—	—	87 89 —	90 92 —	— — —	— — —	— — —	— — —			
	—						75 76		77 78						
	—						—		—						
Extra Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—		615	670	—	—	88 90 —	91 93 —	— — —	— — —	— — —	— — —			
	—						76 77		78 79						
	—						—		—						
C26000	Plate ^d , Sheet, Strip, Rolled Bar and Wire	Annealed	—		—	—	—	—	RF ^d		—	21	0.070	—	
			—						50	62					
			—						52	67					
			—						61	73					
			—						65	76					
		1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		340	405	—	—	RB ^b		—	—	—	—	
			40 44						61 65						
			—						—						
			—						43 46						
			—						57 60						
		1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		395	460	—	—	60 63 —	74 77 —	— — —	— — —	— — —	— — —	
			—						56 58		66 68				
			—						—		—				
		3/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—		440	510	—	—	72 75 —	70 82 —	— — —	— — —	— — —	— — —	
			—						65 67		70 72				
			—						—		—				

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units																
Copper or Copper Alloy UNS No. ^{ee}	Form	Temper	Size Section, mm	Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm				
			Over/Thru	Min	Max	0.5% Ext Under Load	In 4 × Dia or Thickness of Specimen	Min	Max	Min	Max	Min	Max			
C26000	Plate ^f , Sheet, Strip, Rolled Bar and Wire	Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	490	560	—	—	RB ^b		R30T ^d		—	—			
			70 81	84 86	— —	— —	— —	— —								
			— —	70 71	73 74	— —	— —									
		Extra Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	570	635	—	—	85 87	89 91	— —	— —	— —	— —			
			— —	— —	74 75	76 77	— —	— —								
			— —	— —	— —	— —	— —									
		Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	625	690	—	—	89 90	92 93	— —	— —	— —	— —			
			— —	— —	76 76	78 78	— —	— —								
			— —	— —	— —	— —	— —									
	Extra Spring	0.50/0.90 0.90/— 0.30/0.70 0.70/—	655	715	—	—	91 92	94 95	— —	— —	— —	— —				
		— —	— —	77 77	79 79	— —	— —									
		— —	— —	— —	— —	— —										
	Tube	Soft Anneal	Wall Thickness	—	—	—	—	RF ^b		—	—	—	—			
			—/0.75 0.75/—	—	—	—	—	—	80	—	40	0.025 0.025	0.060 0.060			
Light Anneal		—/0.75 0.75/—	—	—	—	—	—	90	—	60	Note a Note a	0.035 0.035				
Drawn (General Purpose)		All Sizes	370	—	—	—	—	—	53	—	—	—				
Hard Drawn		OD Wall —/100 0.5/6.5	455	—	—	—	—	—	70	—	—	—				
C26800	Plate ^f , Sheet, Strip and Rolled Bar	Annealed	Size Section, mm	—	—	—	—	RF ^d		R30T ^b		0.070 0.050 0.035 0.025 0.015 Note a	— 0.120 0.070 0.050 0.035 0.025			
			Over/Thru					—	—	—	—			—	—	—
			—	—	—	—	—	—	50 52 61 65 67 72	62 67 73 76 79 85	— 3 20 25 27 33	21 27 35 38 42 50				
			1/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	340	405	—	—	RB ^b		—	—	—	—		
				40 44	61 65	— —	— —	— —	— —							
				— —	— —	43 46	57 60	— —	— —							
		1/2 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	380	450	—	—	57 60	71 74	— —	— —	— —	— —			
			— —	— —	54 56	64 66	— —	— —								
		3/4 Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	425	495	—	—	70 73	77 80	— —	— —	— —	— —			
			— —	— —	65 67	69 71	— —	— —								
		Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	470	540	—	—	76 78	82 84	— —	— —	— —	— —			
			— —	— —	68 69	72 73	— —	— —								
		Extra Hard	0.50/0.90 0.90/— 0.30/0.70 0.70/—	545	615	—	—	RF ^b		—	—	—	—			
			83 85	87 90	— —	— —	— —	— —								
			— —	— —	73 74	75 76	— —	— —								

ed. TABLE 2A—MINIMUM MECHANICAL PROPERTIES OF WROUGHT COPPER ALLOYS (CONTINUED)

Metric (SI) Units														
Copper or Copper Alloy UNS No. ^a	Form	Temper	Size Section, mm	Tensile Strength, MPa		Yield Strength, Min MPa	Elongation, Min % ^c	Hardness				Grain Size, mm		
			Over/Thru	Min	Max			0.5% Ext Under Load	In 4 × Dia or Thickness of Specimen	Min	Max	Min	Max	Min
C26800	Plate ^d , Sheet, Strip and Rolled Bar	Spring	0.50/0.90	595	655	—	—	RF ^b		R30T ^b		—	—	
			0.90/—					87	90	—	—			
		0.30/0.70	89	92	75	77	—	—						
		0.70/—	—	—	76	78	—	—						
		Extra Spring	0.50/0.90	620	685	—	—	88	91	—	—	—	—	
			0.90/—					90	93	—	—			
		0.30/0.70	—	—	76	78	—	—						
		0.70/—	—	—	77	79	—	—						
C27000	Wire	Annealed	—	—	—	—	—	—	—	—	—	0.070	—	
		0.100 mm	—	—	—	—	—	—	—	—	—	0.050	0.100	
		0.070 mm	—	—	—	—	—	—	—	—	—	0.035	0.070	
		0.050 mm	—	—	—	—	—	—	—	—	—	0.025	0.050	
		0.035 mm	—	—	—	—	—	—	—	—	—	0.015	0.035	
		0.025 mm	—	—	—	—	—	—	—	—	—	Note a	0.025	
		0.015 mm	—	—	—	—	—	—	—	—	—	—	—	
		1/8 Hard	—	345	450	—	—	—	—	—	—	—	—	
		1/4 Hard	—	425	530	—	—	—	—	—	—	—	—	
		1/2 Hard	—	545	650	—	—	—	—	—	—	—	—	
3/4 Hard	—	635	740	—	—	—	—	—	—	—	—			
Hard ^h	—	705	805	—	—	—	—	—	—	—	—			
Extra Hard ⁱ	—	795	890	—	—	—	—	—	—	—	—			
		Spring ^j	—	825	—	—	—	—	—	—	—	—	—	
		C33000	Tube	Wall Thickness	—	—	—	—	—	80	R30T ^d		0.025	0.060
				—/0.75							—	40		
				0.75/—	—	—	—	—	—	—	60	Note a	0.035	
Light Anneal	—/0.75			—	—	—	—	—	90	Note a	0.035			
0.70/—	—	—	—	—	—	—	—	—	—					
Drawn (General Purpose)	All Sizes	370	—	—	—	—	—	53	—	—	—			
Hard Drawn ^f	OD	Wall	455	—	—	—	—	—	70	—	—	—		
	—/100	0.50/6.5												
C33100	Tube	Wall Thickness	—	—	—	—	—	—	80	—	40	0.025	0.060	
		—/0.75												—
		0.75/—	—	—	—	—	—	—	80	—	—			
		Light Anneal	—/0.75	—	—	—	—	—	90	—	60	Note a	0.035	
		0.75/—	—	—	—	—	—	—	—	Note a	0.035			
		Drawn (General Purpose)	All Sizes	370	—	—	—	—	—	53	—	—		
		Hard Drawn	OD	Wall	455	—	—	—	—	70	—	—	—	
			—/100	0.50/6.5										
C34200 C35000	Plate, Sheet, Strip and Rolled Bar	Over/Thru	—	—	—	—	—	RF ^b		R30T ^b		0.050	0.100	
		All Sizes						54	67	12	27			
		All Sizes	61	73	20	35	0.035	0.070						
		All Sizes	65	76	25	38	0.025	0.050						
		All Sizes	67	79	27	42	0.015	0.035						
		1/4 Hard	All Sizes	340	405	—	—	RB ^b		43	60	—	—	
			All Sizes	380	450	—	—	40	65					
			All Sizes	470	540	—	—	57	74					
			All Sizes	545	615	—	—	76	84					
		Extra Hard	All Sizes	—	—	—	—	83	89	73	76	—	—	
C34500 C35000	Rod	Soft	—/12.5	315	—	110	20	—	—	—	—	—	—	
		12.5/25	305	—	105	25	—	45	—	—	—	—		
		25/50	275	—	105	30	—	45	—	—	—	—		