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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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01801

1. Scope—This standard[1] 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—Specificaiton 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, unles 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)											
	Cu	Fe	Zn	Pb	Sn	Mn	Ni	Al	Si	P	Be	Other Named Elements
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[i]	—	—	—	—	—	—	—	—	.004–.012[k]	—	Te, .40–.60
C14700	99.9 min[i]	—	—	—	—	—	—	—	—	—	—	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[n]
C17200	99.5 min[m]	Note n	—	—	—	—	Note n	—	—	—	1.8–2.0	Co[n]
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 Li, .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[t]	.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[o]	1.0–1.8	1.0[u]	.05[u]	—	1.0	9.0–11.0	—	—	—	—	See Note u
C71000	99.5 min[o]	1.0	1.0	.05	—	1.0	19.0–23.0	—	—	—	—	—
C71500	99.5 min[o]	.40–.70	1.0[u]	.05[u]	—	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 troy 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.
Ni + Fe, + Co, 0.6% max.

[o] 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.

[p] For pipe and tube, the Cu limit may be 83.0% minimum and the Pb 0.06% max.

[q] For tube over 5 in O.D., the Pb may be less than 0.20%.

[r] Copper 61.0% min for rod.

[s] This includes Cu + Sn + P.

[t] This includes Cu + Sn + P + Pb + Zn.

[u] 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.

[v] 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.[ee]	Form	Temper	Size Section, mm Over/Thru	Tensile Strength, MPa Min	Tensile Strength, MPa Max	Yield Strength, Min MPa 0.5% Ext Under Load	Elongation, Min %[c] In 4 × Dia or Thickness of Specimen	Hardness Min	Hardness Max	Hardness Min	Hardness Max	Grain Size, mm Min	Grain Size, mm Max
								RF[b]		R30T[b]			
C10200 C11000 C11100 C11300 C11400 C11500 C11600 C12000 C12200	Plate, Sheet, Strip, and Rolled Bar	Soft Anneal	—	—	—	—	—	—	65	—	—	Note a	—
		Deep-Drawing Anneal	—	—	—	—	—	30	75	—	—	Note a	0.050
		Light Cold Rolled	—	220	275	—	—	40	82	—	49	—	—
		1/2 Hard[r]	—	225	315	—	—	77	80	43	57	—	—
		Hard[r]	—	285	360	—	—	86	93	54	62	—	—
		Spring[r]	—	345	400	—	—	91	97	60	66	—	—
		Extra Spring[r]	—	360	—	—	—	92	—	61	—	—	—
		Hot Rolled	—	205	260	—	—	—	75	—	41	—	—
		Hot Rolled and Annealed	—	205	260	—	—	—	65	—	31	—	—
				Type B Matl[u]			Type B[u]	Type A[a,u]					
C10200 C11000 C12000 C12200	Rod, Bar and Shapes	Soft Anneal	All Sizes[m]	—	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[x]	290	—	—	12	68	95	—	—	—	—
			9.5/13[x]	275	—	—	12	68	95	—	—	—	—
			13/50[x]	230	—	—	15	68	95	—	—	—	—
			50/100[x]	220	—	—	15	68	95	—	—	—	—
			All Sizes[y]	220	—	—	15	—	—	—	—	—	—
			OD / Wall				In 50 mm			R15T[d]			
C10200 C12000 C12200	Tube	Soft Anneal	All Sizes / 0.4/0.9	—	—	—	40[e]	—	—	—	60	0.040	—
			All Sizes / 0.9/—	—	—	—	—	—	50[d]	—	—	0.040	—
		Light Anneal	All Sizes / 0.4/0.9	—	—	—	—	—	—	—	65	—	0.040
			All Sizes / 0.9/—	—	—	—	—	—	55[d]	—	—	—	0.040
										R30T[d]			
		Light Drawn	All Sizes / All Sizes	250	325	—	—	—	—	30	60	—	—
		Drawn	All Sizes / All Sizes	250	—	—	—	—	—	30	—	—	—
		Hard Drawn	—/25 / 0.5/3.0	310	—	—	—	—	—	55	—	—	—
			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]			
C10200 C11000	Wire	Annealed	0.08/0.25	—	—	—	15	—	—	—	—	—	—
			0.25/0.50	—	—	—	20	—	—	—	—	—	—
			0.50/2.5	—	—	—	25	—	—	—	—	—	—
			2.5/7.5	—	—	—	30	—	—	—	—	—	—
			7.5/12	—	—	—	35	—	—	—	—	—	—
							In 4 × Dia						
C14500	Rod	1/2Hard[r]	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	—	—	—	—	—	—
			30/50	275	—	240	8	—	—	—	—	—	—
C14700	Rod	1/2 Hard[r]	1.6/6.5		—	205	8	—	—	—	—	—	—
			6.5/65		—	205	12	—	—	—	—	—	—
		Hard[s]	1.6/6.5		—	275	4	—	—	—	—	—	—
			6.5/30		—	260	8	—	—	—	—	—	—
			30/50		—	240	8	—	—	—	—	—	—
C15000	Round Rod												