

## 2b. Density of Solids

H. M. TRENT<sup>1</sup>

*U.S. Naval Research Laboratory*

D. E. STONE

*Vertex Corporation<sup>2</sup>*

R. BRUCE LINDSAY

*Brown University*

For the definition of density  $\rho$  consult Sec. 2a-3. The cgs unit of density is the gram per cubic centimeter and this is used throughout the tables in this subsection.

Densities of the elements in solid form are given in Table 2b-1. All data are taken from "Smithsonian Physical Tables" (9th revised edition, 1954) unless otherwise stated. The values marked \* are calculated densities from X-ray crystallographic data at room temperature and are taken from International Critical Tables (1926). All others are measured values for polycrystalline condition, save when otherwise stated. Standard room temperature is understood, unless otherwise stated.

TABLE 2b-1. DENSITY OF THE ELEMENTS IN SOLID FORM

Element	Physical state	Density, g/cm <sup>3</sup>	Temp., °C
Aluminum.....	Commercial hard-drawn solid	2.70	20
Aluminum.....	Single crystal	2.692*	
Antimony.....	Vacuo-distilled solid	6.62	20
Antimony.....	Single crystal	6.73*	
Argon.....	Solid	1.65	-233
Argon.....	Single crystal	1.645*	-253
Arsenic.....	Crystallized solid	5.73	14
Arsenic.....	Single crystal	5.75*	
Barium.....	Solid	3.5	20
Beryllium.....	Solid	1.85	20
Beryllium.....	Single crystal	1.83*	
Bismuth.....	Vacuo-distilled solid	9.78	20
Bismuth.....	Single crystal	9.86*	
Boron.....	Crystallized solid	2.535	
Bromine.....	Solid	4.2	-273
Cadmium.....	Vacuo-distilled solid	8.65	20
Cadmium.....	Single crystal	8.56*	
Calcium.....	Solid	1.55	20
Calcium.....	Single crystal	1.54*	
Carbon.....	Diamond	3.52	20

<sup>1</sup> Deceased.

<sup>2</sup> H. M. Childers of the Vertex Corporation provided valuable consultant service.

TABLE 2b-1. DENSITY OF THE ELEMENTS IN SOLID FORM (Continued)

Element	Physical state	Density, g/cm <sup>3</sup>	Temp., °C
Carbon.....	Graphite	2.25	20
Cerium.....	Solid	6.90	20
Cerium.....	Cubic crystal	6.90*	
Cerium.....	Hexagonal crystal	6.73*	
Cesium.....	Solid	1.873	20
Chlorine.....	Solid	2.2	-273
Chromium.....	Solid	7.14	20
Chromium.....	Crystal	7.22*	
Cobalt.....	Solid	8.71	21
Cobalt.....	Cubic crystal	8.67*	
Columbium.....	Solid	8.4	20
Copper.....	Vacuo-distilled solid	8.933	20
Copper.....	Single crystal	8.95*	
Erbium.....	Solid	4.77	
Fluorine.....	Solid	1.5	-273
Gallium.....	Solid	5.93	23
Germanium.....	Solid	5.46	
Germanium.....	Single crystal	5.38*	
Gold.....	Vacuo-distilled solid	18.88	20
Gold.....	Cast	19.3	20
Gold.....	Single crystal	19.4*	
Hafnium.....	Solid	13.3	20
Hafnium.....	Single crystal	11.3*	
Helium.....	Solid	0.19	-273
Hydrogen.....	Solid	0.0763	-260
Indium.....	Solid	7.28	
Indium.....	Single crystal	7.43*	
Iodine.....	Solid	4.94	20
Iridium.....	Solid	22.42	17
Iridium.....	Single crystal	22.8*	
Iron.....	Pure solid	7.86	
Iron.....	Single crystal Fe- $\alpha$	7.92*	
Krypton.....	Solid	3.4	-273
Lanthanum.....	Solid	6.15	
Lead.....	Vacuo-distilled	11.342	20
Lead.....	Single crystal	11.48*	
Lithium.....	Solid	0.534	20
Lithium.....	Single crystal	0.534*	
Magnesium.....	Solid	1.74	20
Magnesium.....	Single crystal	1.71*	
Manganese.....	Solid	7.3	
Manganese.....	Single crystal Mn- $\alpha$	7.21*	
Mercury.....	Solid	14.193	-38.8
Molybdenum.....	Solid	9.01	
Molybdenum.....	Single crystal	10.20*	
Niodymium.....	Solid	7.00	

TABLE 2b-1. DENSITY OF THE ELEMENTS IN SOLID FORM (Continued)

Element	Physical state	Density, g/cm <sup>3</sup>	Temp., °C
Neon.....	Solid	1.204	-245
Nickel.....	Solid	8.8	
Nickel.....	Single crystal	9.04*	
Nitrogen.....	Solid	1.14	-273
Osmium.....	Solid	22.5	
Osmium.....	Single crystal	22.8*	
Oxygen.....	Solid	1.568	-273
Palladium.....	Solid	12.16	
Palladium.....	Single crystal	12.25*	
Phosphorus.....	Solid, white	1.83	
Phosphorus.....	Solid, red	2.20	
Phosphorus.....	Solid, black	2.69	
Platinum.....	Solid	21.37	
Platinum.....	Single crystal	21.5*	
Potassium.....	Solid	0.87	20
Praseodymium.....	Solid	6.48	20
Radium.....	Solid	5(?)	
Rhenium.....	Solid	20.53	
Rhodium.....	Solid	12.44	
Rubidium.....	Solid	1.53	20
Ruthenium.....	Solid	12.1	19
Samarium.....	Solid	7.7-7.8	
Scandium.....	Solid	3.02(?)	
Selenium.....	Solid	4.82	
Selenium.....	Single crystal	4.86*	
Silicon.....	Solid crystal	2.42	20
Silicon.....	Single crystal	2.32*	
Silver.....	Vacuo distilled	10.492	20
Silver.....	Single crystal	10.49*	
Sodium.....	Solid	0.9712	20
Sodium.....	Single crystal	0.954*	
Strontium.....	Solid	2.60	
Sulfur.....	Solid, rhombic	2.07	
Sulfur.....	Solid, monoclinic	1.96	
Sulfur.....	Single crystal	2.02*	
Tantalum.....	Solid	16.6	
Tantalum.....	Single crystal	17.1*	
Tellurium.....	Solid, crystal	6.25	
Tellurium.....	Single crystal	6.26*	
Thallium.....	Solid	11.86	
Thallium.....	Single crystal	11.7*	
Thorium.....	Solid	11.00	17
Thorium.....	Single crystal	12.0*	
Tin.....	Solid, white tetragonal	7.29	20
Tin.....	Solid, white rhombic	6.55	
Tin.....	Solid, gray	5.75	20

TABLE 2b-1. DENSITY OF THE ELEMENTS IN SOLID FORM (Continued)

Element	Physical state	Density, g/cm <sup>3</sup>	Temp., °C
Tin.....	White single crystal	7.30*	
Titanium.....	Solid	4.5	18
Titanium.....	Single crystal	4.58*	
Tungsten.....	Solid	19.3	
Tungsten.....	Single crystal	19.3*	
Uranium.....	Solid	18.7	13
Vanadium.....	Solid	5.87	15
Vanadium.....	Single crystal	5.98*	
Yttrium.....	Solid	3.8	
Zinc.....	Solid, vacuo-distilled	6.92	20
Zinc.....	Solid	4.32	-273
Zinc.....	Single crystal	7.04*	
Zirconium.....	Solid	6.44	
Zirconium.....	Single crystal	6.47*	

TABLE 2b-2. DENSITY OF COMMON SOLIDS AT 20°C\*

Substance	Density, g/cm <sup>3</sup>	Substance	Density, g/cm <sup>3</sup>
Agate.....	2.5-2.7	Gypsum.....	2.31-2.33
Amber.....	1.06-1.11	Hematite.....	4.9-5.3
Anthracite.....	1.4-1.8	Hornblende.....	3.0
Aragonite.....	2.93	Ice.....	0.917
Asbestos.....	2.0-2.8	Ivory.....	1.83-1.92
Basalt.....	2.4-3.1	Lava, basaltic.....	2.8-3.0
Beeswax.....	0.96-0.97	Lava, trachytic.....	2.0-2.7
Beryl.....	2.69-2.7	Leather, dry.....	0.86
Bone.....	1.7-2.0	Leather, greased.....	1.02
Brick.....	1.4-2.2	Lime, mortar.....	1.65-1.78
Butter.....	0.86-0.87	Lime, slaked.....	1.3-1.4
Calcite.....	2.71	Limestone.....	2.68-2.76
Camphor.....	0.99	Magnetite.....	4.9-5.2
Caoutchouc.....	0.92-0.99	Malachite.....	3.7-4.1
Celluloid.....	1.4	Marble.....	2.6-2.84
Cement (set).....	2.7-3.0	Mica.....	2.6-3.2
Chalk.....	1.9-2.8	Olivine.....	3.27-3.37
Charcoal, oak.....	0.57	Opal.....	2.2
Charcoal, pine.....	0.28-0.44	Paper.....	0.7-1.15
Cinnabar.....	8.12	Paraffin.....	0.87-0.91
Clay.....	1.8-2.6	Pitch.....	1.07
Coal, soft.....	1.2-1.5	Porcelain.....	2.3-2.5
Coke.....	1.0-1.7	Pyrite.....	4.95-5.1
Cork.....	0.22-0.26	Quartz.....	2.65
Cork linoleum.....	0.55	Resin.....	1.07
Corundum.....	3.9-4.0	Rock salt.....	2.18
Dolomite.....	2.84	Rubber, hard.....	1.19
Ebonite.....	1.15	Rubber, soft.....	1.1
Emery.....	4.0	Rutile.....	4.2
Feldspar.....	2.55-2.75	Sandstone.....	2.19-2.36
Flint.....	2.63	Slate.....	2.6-3.3
Fluorite.....	3.18	Soapstone.....	2.6-2.8
Garnet.....	3.15-4.3	Starch.....	1.53
Gelatin.....	1.27	Sugar.....	1.61
Glass, common.....	2.4-2.8	Talc.....	2.7-2.8
Glass, flint.....	2.9-5.9	Tallow.....	0.91-0.97
Glue.....	1.27	Tar.....	1.02
Granite.....	2.64-2.76	Topaz.....	3.5-3.6
Graphite.....	2.30-2.72	Tourmaline.....	3.0-3.2
Gum arabic.....	1.3-1.4	Wax, sealing.....	1.8

\* The density varies with the state and previous treatment of the solids. The figures quoted may be considered reasonable limits (taken largely from "Smithsonian Physical Tables," 9th ed.).

TABLE 2b-3. DENSITY OF STEELS\*  
(At room temperature)

Type of steel	$\rho$ , g/cm <sup>3</sup>	Composition				Condition	
		% C	% Si	% Mn	% Cr		
Carbon steel	7.871	0.06	0.01	0.38		Annealed at 1700°F	
Carbon steel	7.859	0.23	0.11	0.635		Annealed at 1700°F	
Carbon steel	7.844	0.435	0.20	0.69		Annealed at 1580°F	
Carbon steel	7.830	1.22	0.16	0.35		Annealed at 1470°F	
Low-Cr steel	7.84	0.31		0.74	1.00	Oil-quenched at 1650°F, tempered at 1350°F	
Low-Cr steel	7.84	0.315		0.69	1.09	Annealed at 1580°F	
Low-Cr steel	7.83	0.35		0.24	1.56	Annealed at 1580°F	
Low-Cr steel	7.80	1.73		0.30	1.65	Annealed at 1580°F	
Low-Cr steel	7.82	0.80		0.28	1.07	Annealed at 1580°F	
Low-Cr steel	7.82	0.62		0.22	1.67	Annealed at 1580°F	
Low-Cr steel	7.81	0.98		0.28	1.68	Annealed at 1580°F	
Low-Cr steel	7.84	0.20		0.14	1.85	Oil-quenched at 1650°F, tempered at 1380°F	
Low-Cr steel	7.82	0.22		0.10	2.60	Oil-quenched at 1650°F, tempered at 1380°F	
Low-Cr steel	7.81	0.21		0.19	3.88	Oil-quenched at 1650°F, tempered at 1380°F	
Low-Cr steel	7.79	0.30		0.08	5.54	Oil-quenched at 1650°F, tempered at 1380°F	
Low-Cr steel	7.845	0.35		0.59	0.88 + 0.20 Mo	Annealed at 1580°F, tempered at 1185°F	
						% Ni	
Low-alloy Ni-Cr steel	7.85	0.33		0.53	0.80	3.38	Annealed at 1580°F, tempered at 1185°F
Low-alloy Ni-Cr steel	7.85	0.325		0.55	0.71	3.41	Annealed at 1580°F, tempered at 1185°F
Low-alloy Ni-Cr steel	7.92	1.28		0.24	1.80	3.46	Brine quenched at 2190°F
Low-alloy Ni-Cr steel	7.82	1.28		0.24	1.80	3.46	Annealed at 1435°F
Low-alloy Ni-Cr steel	7.855	0.325		0.55	0.17	3.47	Annealed at 1580°F
Low-alloy Ni-Cr steel	7.835	0.51		0.22	1.72	3.52	Annealed at 1435°F
Low-alloy Ni-Cr steel	7.86	0.34		0.55	0.78	3.53 + 0.39 Mo	Annealed at 1580°F, tempered at 1185°F

  

	$\rho$ , g/cm <sup>3</sup>	% C	% Cr	% Ni	% Mo	% Zr	% Ti	% Cu	% Mn	Condition
Wrought stainless and heat-resisting steels	7.93	0.10	18	9						
Wrought stainless and heat-resisting steels	7.93		18	9	0.5					
Wrought stainless and heat-resisting steels	7.98		23	13						
Wrought stainless and heat-resisting steels	7.98		25	20.5						
Wrought stainless and heat-resisting steels	7.98		17	12	2.25					
Wrought stainless and heat-resisting steels	8.02		18	10.5						
Wrought stainless and heat-resisting steels	7.75		12.5							
Wrought stainless and heat-resisting steels	7.73		13		0.5					

\* Metals Handbook, 48th ed., American Society for Metals.

TABLE 2b-3. DENSITY OF STEELS (Continued)

Type of steel	$\rho$ , g/cm <sup>3</sup>	Composition								Condition
		% C	% Cr	% Ni	% Mo	% Zr	% Ti	% Cu	% Mn	
Wrought stainless and heat-resisting steels...	7.70	....	13							
Wrought stainless and heat-resisting steels...	7.70	....	16							
Wrought stainless and heat-resisting steels...	7.68	....	17	.....	0.6					
Wrought stainless and heat-resisting steels...	7.80	....	25							
Wrought stainless and heat-resisting steels...	7.77	....	17.88	.....	.....	..	..	....	8.26	
Wrought stainless and heat-resisting steels...	7.76	....	17.55	.....	.....	..	..	....	10.48	
Wrought stainless and heat-resisting steels...	7.91	....	18.40	4.07	.....	..	..	0.78	5.33	
Wrought stainless and heat-resisting steels...	7.90	....	18.50	4.06	.....	..	..	....	6.79	
Wrought stainless and heat-resisting steels...	7.78	....	18.04	2.06	.....	..	..	....	7.90	
Wrought stainless and heat-resisting steels...	7.77	....	17.70	.....	.....	..	..	0.68	9.40	

  

	$\rho$ , g/cm <sup>3</sup>	% W	% Cr	% V	% Mo	% Co	% C	Condition
Tool steel.....	8.67	18	4	1				
Tool steel.....	8.67	18	4	2				
Tool steel.....	7.925	1.64	3.68	1.00	8.24	.....	0.80	Quenched at 2200°F
Tool steel.....	7.93	5.20	4.60	4.00	4.11	.....	1.32	Hardened
Tool steel.....	7.76	.....	4.39	4.10	7.75	.....	1.20	Hardened
Tool steel.....	8.89	20	4	2	.....	12	.....	Annealed
Tool steel.....	8.68	18	4	1	.....	5	.....	Annealed
Tool steel.....	8.16	.....	.....	2	5	.....	.....	Annealed
Tool steel.....	7.88	1.5	.....	1	8	.....	.....	
		% Ni	% Al	% Co	% Cu			
Permanent-magnet alloys.....	6.892	20	12	5	.....	.....	.....	Alnico
Permanent-magnet alloys.....	7.086	17	10	12.5	6	.....	.....	Cast Alnico
Permanent-magnet alloys.....	6.892	25	12	.....	.....	.....	.....	
Permanent-magnet alloys.....	7.003	28	12	5	.....	.....	.....	
Permanent-magnet alloys.....	7.307	14	8	24	3	.....	.....	
Permanent-magnet alloys.....	7.197	18	6	35	.....	.....	.....	8% Ti
		% Ni	% C	% Mn				
Miscellaneous ferrous alloys.....	8.16	28.37	.....	.....	.....	.....	.....	Quenched at 1740°F
Miscellaneous ferrous alloys.....	8.00	36	.....	.....	.....	.....	.....	Invar
Miscellaneous ferrous alloys.....	8.3	45	.....	.....	.....	.....	.....	Radio metal
Miscellaneous ferrous alloys.....	8.25	50	.....	.....	.....	.....	.....	Hipernik
Miscellaneous ferrous alloys.....	7.87	.....	1.2	13	.....	.....	.....	Austenitic manganese steel. Air-cooled at 1920°F

TABLE 2b-4. DENSITY OF ALUMINUM ALLOYS\*  
(At 20°C)

Material	$\rho$ , g/cm <sup>3</sup>	% Al	% Mn	% Cu	% Pb	% Bi	% Mg	% Si	% Ni	% Cr	% Zn
Wrought alloys:											
Pure aluminum... (Commercially pure Al) 2S...	2.6989	99.996									
3S.....	2.71	99.0+									
11S.....	2.73	98.8	1.2								
R-317.....	2.82	93.5		5.5	0.5	0.5					
14S.....	2.81	93.8	0.6	4.0	0.5	0.5	0.6				
R-30I (clad).....	2.80	93.6	0.8	4.4			0.4	0.8			
17S.....	2.78	93.3	0.8	4.5			0.4	1.0			
18S.....	2.79	95.0	0.5	4.0			0.5				
24S.....	2.80	93.5		4.0			0.5				
25S.....	2.77	93.4	0.6	4.5			1.5				
32S.....	2.79	93.9	0.8	4.5				0.8			
A51S.....	2.69	84.7		0.9			1.0	12.5	0.9		
52S.....	2.69	98.15					0.6	1.0		0.25	
53S.....	2.68	97.25					2.5			0.25	
56S.....	2.69	97.75					1.3	0.7		0.25	
61S.....	2.64	94.6	0.1				5.2			0.10	
75S.....	2.70	97.9		0.25			1.0	0.6		0.25	
R-303.....	2.80	90.0	0.20	1.5			2.5			0.30	5.5
	2.82	89.9		1.2			2.5				6.4

Material	$\rho$ , g/cm <sup>3</sup>	% Al	% Mn	% Mg	% Cu	% Zn	% Cr	% Si	% Ni	% Bi	% Sn	% Ti
Casting alloys:												
13 alloy.....	2.66	88						12				
43 alloy.....	2.69	95						5				
85 alloy.....	2.78	91			4			5				
108 alloy.....	2.79	93			4			3				
Allcast.....	2.76	92			3			5				
A108 alloy.....	2.79	90			4.5			5.5				
113 alloy.....	2.91	89.3			7	1.7		2				
C113 alloy.....	2.91	89.5			7			3.5				
122 alloy.....	2.95	89.8		0.2	10							
A132 alloy.....	2.68	83.5		1.2	0.8			12	2.5			
Red X-13.....	2.7	85.1	0.7	0.7	1.5			12				
142 alloy.....	2.81	92.5		1.5	4				2			
195 alloy.....	2.81	95.5			4.5							
B195 alloy.....	2.78	93.0			4.5			2.5				
214 alloy.....	2.65	96.2		3.8								
A214 alloy.....	2.65	94.4		3.8		1.8						
218 alloy.....	2.53	92.0		8								
220 alloy.....	2.58	90.0		10								
319 alloy.....	2.77	90.5			3.5			6				
355 alloy.....	2.70	93.2		0.5	1.3			5				
356 alloy.....	2.68	92.7		0.3				7				
Red X-8.....	2.73	89.9	0.3	0.3	1.5			8				
360 alloy.....	2.68	90.0		0.5				9.5				
380 alloy.....	2.70	88.0			3.5			8.5				
750 alloy.....	2.89	91.5			1.0				1.0		6.5	
40E alloy.....	2.81	93.2		0.6		5.5	0.5					0.2

\* "Metals Handbook," 48th ed., American Society for Metals.



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TABLE 2b-5. DENSITY OF COBALT ALLOYS\*

Material	$\rho_s$ g/cm <sup>3</sup>	% Co	% W	% Ni	% Cr	% Mo	% Cb	% Fe
Pure cobalt.....	8.9	100						
61 alloy (cast).....	8.54	70.0	5.0	2.0	23.0			
Vitallium.....	8.30	65.0	...	2.0	27.0	6.0		
X-40 alloy.....	8.61	60.0	7.0	10.0	23.0			
422-19 alloy.....	8.31	55.0	...	16.0	23.0	6.0		
S-816 alloy.....	8.59	50.0	4.0	20.0	19.0	...	4.0	3.0
6059.....	8.21	39.0	...	32.0	23.0	6.0		

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-6. DENSITY OF COPPER ALLOYS\*

Material	$\rho$ , g/cm <sup>3</sup>	% Cu	% O	% P	% Zn	% Pb	% Sn	% Fe	% Mn	% Al	% Ni	% Si	% Be
Wrought alloys:													
Pure copper.....	8.96	100											
Electrolytic tough-pitch copper...	8.89-8.91	99.92	0.04										
Deoxidized copper.....	8.94	99.94		0.02									
Gilding metal.....	8.86	95.0			5.0								
Commercial bronze.....	8.80	90.0			10.0								
Red brass.....	8.75	85.0			15.0								
Low brass.....	8.67	80.0			20.0								
Cartridge brass.....	8.53	70.0			30.0								
Yellow brass.....	8.47	65.0			35.0								
Muntz metal.....	8.39	60.0			40.0								
Leaded commercial bronze.....	8.83	89.0			9.25	1.75							
Low-leaded brass.....	8.47	64.5			35.0	0.5							
Low-leaded brass (tube).....	8.50	67.0			32.5	0.5							
Medium-leaded brass.....	8.47	64.5			34.5	1.0							
High-leaded brass.....	8.47	62.5			35.75	1.75							
Extra-high-leaded brass.....	8.50	62.5			35.0	2.5							
Free-cutting brass.....	8.50	61.5			35.5	3.0							
Leaded muntz metal.....	8.41	60.0			39.5	0.5							
Free-cutting muntz metal.....	8.41	60.5			38.4	1.1							
Forging brass.....	8.44	60.0			38.0	2.0							
Architectural bronze.....	8.47	57.0			40.0	3.0							
Admiralty metal.....	8.53	71.0			28.0		1.00						
Naval brass.....	8.41	60.0			39.25		0.75						
Leaded naval brass.....	8.44	60.0			37.5	1.75	0.75						
Manganese bronze.....	8.53	58.5			39.0		1.00	1.4					0.1

Aluminum brass.....	8.33	76.0	22.0	.....	.....	.....	.....	.....	.....	.....
Aluminum brass.....	8.33	95.0	.....	.....	.....	.....	.....	.....	.....	.....
Phosphor bronze.....	8.86	92.0	.....	.....	5.0	.....	.....	.....	.....	.....
Phosphor bronze 8% grade C.....	8.80	90.0	.....	.....	8.0	.....	.....	.....	.....	.....
Phosphor bronze 10% grade D.....	8.78	98.75	.....	.....	10.0	.....	.....	.....	.....	.....
Phosphor bronze 1.25% grade E.....	8.89	70.0	.....	.....	1.25	.....	.....	.....	.....	.....
Cupronickel, 30%.....	8.94	55.0	.....	.....	.....	.....	.....	.....	.....	.....
Nickel silver, 18% alloy A.....	8.73	55.0	.....	.....	.....	.....	.....	.....	.....	.....
Ni-Ag, 18%, alloy B.....	8.70	55.0	.....	.....	.....	.....	.....	.....	.....	.....
Silicon bronze, type A.....	8.53	97.0	.....	.....	.....	.....	.....	.....	.....	.....
Silicon bronze, type B.....	8.75	98.5	.....	.....	.....	.....	.....	.....	.....	.....
5% aluminum bronze.....	8.17	95.0	.....	.....	.....	.....	.....	.....	.....	.....
8% aluminum bronze.....	?	92.0	.....	.....	.....	.....	.....	.....	.....	.....
10% aluminum bronze.....	7.58	90.0	.....	.....	.....	.....	.....	.....	.....	.....
Aluminum bronze.....	7.58	32.5	.....	.....	.....	.....	.....	.....	.....	.....
Constantan.....	8.9	35.0	.....	.....	.....	.....	.....	.....	.....	.....
Beryllium copper.....	8.23 ± 0.02	97.65	.....	.....	.....	.....	.....	.....	.....	.....
Casting alloys (room temp.):										
Lead-tin bronze.....	8.7	38.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead-tin bearing bronze.....	8.80	37.0	.....	.....	.....	.....	.....	.....	.....	.....
High-lead tin bronze.....	8.87	35.0	.....	.....	.....	.....	.....	.....	.....	.....
High-lead tin bronze.....	8.93	33.0	.....	.....	.....	.....	.....	.....	.....	.....
High-lead tin bronze.....	8.80	30.0	.....	.....	.....	.....	.....	.....	.....	.....
High-lead tin bronze.....	9.25	78.0	.....	.....	.....	.....	.....	.....	.....	.....
High-lead tin bronze.....	9.30	70.0	.....	.....	.....	.....	.....	.....	.....	.....
85-5-5-5.....	8.86	35.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead red brass.....	8.6	33.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead semired brass.....	8.70	31.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead semired brass.....	8.6	76.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead yellow brass.....	8.50	71.0	.....	.....	.....	.....	.....	.....	.....	.....
Lead yellow brass.....	8.4	36.0	.....	.....	.....	.....	.....	.....	.....	.....

\* "Metals Handbook," 4th ed., American Society for Metals.

TABLE 2B-6. DENSITY OF COPPER ALLOYS\* (Continued)

Material	$P_1$ g/cm <sup>3</sup>	% Cu	% O	% P	% Zn	% Pb	% Sh	% Fe	% Mn	% Al	% Ni	% Si	% Be
Leaded yellow brass.....	8.40	60.0	.....	.....	38.0	1.0	1.0	.....	.....	.....	.....	.....	.....
High-strength yellow brass.....	7.9	62.0	.....	.....	26.0	.....	.....	3.0	3.5	5.5	.....	.....	.....
High-strength yellow brass.....	8.2	58.0	.....	.....	39.25	.....	.....	1.25	0.25	1.25	.....	.....	.....
Leaded manganese brass.....	8.2	59.0	.....	.....	37.0	.....	0.75	1.25	0.50	0.75	.....	.....	.....
Nickel silver.....	8.8-8.9	66.0	.....	.....	2.0	1.5	5.0	.....	.....	.....	25.0	.....	.....
Nickel silver.....	8.85	64.0	.....	.....	8.0	4.0	4.0	.....	.....	.....	20.0	.....	.....
Nickel silver.....	8.95	57.0	.....	.....	20.0	9.0	2.0	.....	.....	.....	12.0	.....	.....
Leaded nickel brass.....	8.95	60.0	.....	.....	16.0	5.0	3.0	.....	.....	.....	16.0	.....	.....
Aluminum bronze.....	?	89.0	.....	.....	.....	.....	.....	1.0	.....	10.0	.....	.....	.....
Aluminum bronze.....	7.4	87.5	.....	.....	.....	.....	.....	3.5	.....	9.0	.....	.....	.....
Aluminum bronze.....	7.5	86.0	.....	.....	.....	.....	.....	4.0	.....	10.0	.....	.....	.....
Aluminum bronze.....	?	79.0	.....	.....	.....	.....	.....	5.0	.....	11.0	5.0	.....	.....

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-7. DENSITY OF LEAD ALLOYS\*

Material	$\rho$ , g/cm <sup>3</sup>	% Pb	% Ca	% Sb	% Sn	% As	% Co
Pure lead.....	11.34	99.73					
Chemically pure lead....	11.34						
Cable-sheath alloy.....	11.34	99.8	0.02S				
1% antimonial lead.....	11.27	99.0	.....	1.0			
Hard lead.....	11.04	96.0	.....	4.0			
Hard lead.....	10.88	94.0	.....	6.0			
8% antimonial lead.....	10.74	92.0	.....	8.0			
Grid metal.....	10.66	91.0	.....	9.0			
ASTM-12 bearing metal..	10.67	90.0	.....	10.0			
ASTM-11 bearing metal..	10.28	85.0	.....	15.0			
Lead-base babbitt.....	10.24	85.0	.....	10.0	5.0		
G lead-base babbitt.....	10.1	83.0	.....	12.75	0.75	3.0	
S lead-base babbitt.....	10.1	83.0	.....	15.0	1.0	1.0	
ASTM-10 bearing metal..	10.07	83.0	.....	15.0	2.0		
Lead-base babbitt.....	10.04	80.0	.....	15.0	5.0		
Lead-base babbitt.....	9.73	75.0	.....	15.0	10.0		
ASTM-6 bearing metal..	9.33	63.5	.....	15.0	20.0	...	1.5
Tin-lead solder.....	11.0	95.0	.....	.....	5.0		
Tin-lead solder.....	10.2	80.0	.....	.....	20.0		
50-50 half and half.....	8.89	50.0	.....	.....	50.0		

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-8. DENSITY OF MAGNESIUM ALLOYS\*

Material	$\rho$ , g/cm <sup>3</sup>	% Mg	% Al	% Mn	% Zn	% Sn	Remarks
Magnesium....	1.74	99.8					
A10 alloy.....	1.81	89.9	10.0	0.1	...	...	Wrought, sand cast, and permanent-mold cast
AZ91 alloy....	1.81	.....	9.0	0.2	0.7	...	Die cast
AZ92 alloy....	1.82	.....	9.0	0.1	2.0	...	Sand cast and permanent-mold cast
A8 alloy.....	1.80	.....	8.0	0.2	...	...	Sand cast
AZ61X alloy..	1.80	.....	6.0	0.2	1.0	...	Wrought
AM244 alloy..	1.76	.....	4.0	0.2	...	...	Sand cast
AM11 alloy...	1.70	.....	1.25	1	...	...	Die cast
AZ80X alloy..	1.80	.....	8.5	0.15	0.5	...	Wrought
AZ63 alloy....	1.84	.....	6.0	0.2	3.0	...	Sand cast
AZ51X alloy..	1.79	.....	5.0	0.25	1.0	...	Wrought
AZ31X alloy..	1.78	.....	3.0	0.3	1.0	...	Wrought
M1.....	1.76	.....	.....	1.5	...	...	Wrought
TA54.....	1.84	.....	3.0	0.5	...	5.0	Wrought
Mg-Al alloy... 1.75	98.0	2.0					
Mg-Al alloy... 1.77	96.0	4.0					
Mg-Al alloy... 1.78	94.0	6.0					
Mg-Al alloy... 1.80	92.0	8.0					
Mg-Al alloy... 1.81	90.0	10.0					
Mg-Al alloy... 1.82	88.0	12.0					

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-9. DENSITY OF NICKEL ALLOYS\*

Material	$\rho$ , g/cm <sup>3</sup>	% Ni	% Co	% Si	% Mn	% C	% Al	% Cu	% Fe	% Mo	% Cr	% W
Nickel.....	8.902	99.95										
A nickel.....	8.885	99.4										
Cast nickel.....	8.34	97.0	..	1.5	0.5	0.5						
D nickel.....	8.78	95.2	..	..	4.5							
Z nickel.....	8.75	94	..	..	..	..	4.5					
Monel.....	8.84	67	..	..	1.0	0.15	..	30	1.4			
Cast monel.....	8.63	63	..	1.6	..	0.2	..	32				
K monel.....	8.47	66	..	..	..	..	3	29				
S monel.....	8.36	63	..	4	..	..	..	30	2			
Hastelloy A.....	8.80	60	..	..	..	..	..	..	20	20		
Hastelloy B.....	9.24	65	..	..	..	..	..	..	5	30		
Hastelloy C.....	8.94	58	..	..	..	..	..	..	5	17	15	5
Hastelloy D.....	7.8	85	..	8-11	..	..	..	3				
Inconel G.....	8.58	58	..	..	..	0.2	..	6	6	6	22	
Inconel.....	8.51	80	..	..	..	..	..	..	6	..	14	
Cast Inconel.....	8.3	77.5	..	2	..	..	..	..	6	..	13.5	
Chromel A.....	8.4	80	..	..	..	..	..	..	..	..	20	
Nichrome.....	8.25	60	..	..	..	..	..	..	24	..	16	
Chromax.....	7.95	35	..	..	..	..	..	..	50	..	15	
Constantan (wrought).....	8.9	45	..	..	..	..	..	55				
Ni-Fe alloys.....	8.8	90	..	..	..	..	..	..	10			
Ni-Fe alloys.....	8.6	80	..	..	..	..	..	..	20			
Ni-Fe alloys.....	8.5	70	..	..	..	..	..	..	30			
Ni-Fe alloys.....	8.35	60	..	..	..	..	..	..	40			
Permalloy.....	8.6	78	..	..	..	..	..	..	22			
Numetal.....	8.6	76	..	..	..	..	..	6	16		2	

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-10. DENSITY OF ZINC ALLOYS\*

Material	$\rho$ , g/cm <sup>3</sup>	% Zn	% Al	% Cu	% Mg	% Pb	% Cd
Zinc.....	7.133	100					
Zamak (2).....	6.7	92	4	3	0.03		
Zamak (3).....	6.6	95	4	..	0.04		
Zamak (5).....	6.7	94	4	1	0.04		
SAE 63, T-11 (cast).....	6.9	86	4	10			
Commercial rolled zinc.....	7.14	99	..	..	..	0.08	
Commercial rolled zinc.....	7.14	99	..	..	..	0.06	0.06
Commercial rolled zinc.....	7.14	99	..	..	..	0.3	0.3
Zilloy 40 (rolled).....	7.18	98	..	1	..	0.08	
Zilloy 15 (rolled).....	7.18	98	..	1	0.01	0.1	

\* "Metals Handbook," 48th ed., American Society for Metals.

TABLE 2b-11. DENSITY OF WOODS (OVEN-DRY)\*

Common name	Botanical name	$\rho$ , g/cm <sup>3</sup>
Applewood or wild apple.....	<i>Pyrus malus</i>	0.745
Ash, black.....	<i>Fraxinus nigra</i>	0.526
Ash, blue.....	<i>Fraxinus quadrangulata</i>	0.603
Ash, green.....	<i>Fraxinus pennsylvanica lanceolata</i>	0.610
Ash, white.....	<i>Fraxinus americana</i>	0.638
Aspen.....	<i>Populus tremuloides</i>	0.401
Aspen, large-toothed.....	<i>Populus grandidentata</i>	0.412
Balsa, tropical American.....	<i>Ochroma</i>	0.12-0.20†
Basswood.....	<i>Tilia glabra</i> or <i>Tilia americanus</i>	0.398
Beech.....	<i>Fagus grandifolia</i> or <i>Fagus americana</i>	0.655
Beech, blue.....	<i>Carpinus caroliniana</i>	0.717
Birch, gray.....	<i>Betula populifolia</i>	0.552
Birch, paper.....	<i>Betula papyrifera</i>	0.600
Birch, sweet.....	<i>Betula lenta</i>	0.714
Birch, yellow.....	<i>Betula lutea</i>	0.668
Buckeye, yellow.....	<i>Aesculus octandra</i>	0.383
Butternut.....	<i>Juglans cinera</i>	0.404
Cedar, eastern red.....	<i>Juniperus virginiana</i>	0.492
Cedar, northern white.....	<i>Thuja occidentalis</i>	0.315
Cedar, southern white.....	<i>Chamaecyparis thyoides</i>	0.352
Cedar, tropical American.....	<i>Cedrela odorata</i>	0.37-0.70†
Cedar, western red.....	<i>Thuja plicata</i>	0.344
Cherry, black.....	<i>Prunus serotina</i>	0.534
Cherry, wild red.....	<i>Prunus pennsylvanica</i>	0.425
Chestnut.....	<i>Castanea dentata</i>	0.451
Corkwood.....	<i>Leitneria floridana</i>	0.207
Cottonwood, eastern.....	<i>Populus deltoides</i>	0.433
Cypress, southern.....	<i>Taxodium distichum</i>	0.482
Dogwood (flowering).....	<i>Cornus florida</i>	0.796
Douglas fir (coast type).....	<i>Pseudotsuga taxifolia</i>	0.512
Douglas fir (mountain type).....	<i>Pseudotsuga taxifolia</i>	0.446
Ebony, Andaman marblewood (India).....	<i>Diospyros Kurzii</i>	0.978†
Ebony, Ebene marbre (Mauritius, East Africa).....	<i>Diospyros melanida</i>	0.768†
Elm, American.....	<i>Ulmus americana</i>	0.554
Elm, rock.....	<i>Ulmus racemosa</i> or <i>Ulmus thomasi</i>	0.658
Elm, slippery.....	<i>Ulmus fulva</i> or <i>Ulmus pubescens</i>	0.568
Eucalyptus, Karri (west Australia).....	<i>Eucalyptus diversicolor</i>	0.829†
Eucalyptus, mahogany (New South Wales).....	<i>Eucalyptus hemilampra</i>	1.058†
Eucalyptus, west Australian mahogany.....	<i>Eucalyptus marginata</i>	0.787†
Fir, balsam.....	<i>Abies balsamea</i>	0.414
Fir, silver.....	<i>Abies amabilis</i>	0.415
Greenheart (British Guiana).....	<i>Nectandra rodrici</i>	1.06-1.23†

See page 2-35 for footnotes.

TABLE 2b-11. DENSITY OF WOODS (OVEN-DRY)\* (Continued)

Common name	Botanical name	$\rho$ , g/cm <sup>3</sup>
Gum, black.....	<i>Nyssa sylvatica</i>	0.552
Gum, blue.....	<i>Eucalyptus globulus</i>	0.796
Gum, red.....	<i>Liquidambar styraciflua</i>	0.530
Gum, tupelo.....	<i>Nyssa aquatica</i>	0.524
Hemlock, eastern.....	<i>Tsuga canadensis</i>	0.431
Hemlock, mountain.....	<i>Tsuga martensiana</i>	0.480
Hemlock, western.....	<i>Tsuga heterophylla</i>	0.432
Hickory, bigleaf shagbark.....	<i>Hicoria laciniosa</i>	0.809
Hickory, mockernut.....	<i>Hicoria alba</i>	0.820
Hickory, pignut.....	<i>Hicoria glabra</i>	0.820
Hickory, shagbark.....	<i>Hicoria ovata</i>	0.836
Hornbeam.....	<i>Ostrya virginiana</i>	0.702
Ironwood, black.....	<i>Rhamnidium ferreum</i>	1.077
Jacaranda, Brazilian rosewood.....	<i>Dalbergia nigra</i>	0.85†
Larch, western.....	<i>Larix occidentalis</i>	0.587
Locust, black or yellow.....	<i>Robinia pseudacacia</i>	0.708
Locust, honey.....	<i>Gleditsia triacanthos</i>	0.666
Magnolia, cucumber.....	<i>Magnolia acuminata</i>	0.516
Mahogany (West Africa).....	<i>Khaya ivorensis</i>	0.668†
Mahogany (East India).....	<i>Swietenia macrophylla</i>	0.54†
Mahogany (East India).....	<i>Swietenia mahogani</i>	0.54†
Maple, black.....	<i>Acer nigrum</i>	0.620
Maple, red.....	<i>Acer rubrum</i>	0.546
Maple, silver.....	<i>Acer saccharinum</i>	0.506
Maple, sugar.....	<i>Acer saccharum</i>	0.676
Oak, black.....	<i>Quercus velutina</i>	0.669
Oak, bur.....	<i>Quercus macrocarpa</i>	0.671
Oak, canyon live.....	<i>Quercus chrysolepsis</i>	0.838
Oak, chestnut.....	<i>Quercus montana</i>	0.674
Oak, laurel.....	<i>Quercus laurifolia</i>	0.703
Oak, live.....	<i>Quercus virginiana</i>	0.977
Oak, pin.....	<i>Quercus palustris</i>	0.677
Oak, post.....	<i>Quercus stellata</i> or <i>Quercus minor</i>	0.738
Oak, red.....	<i>Quercus borealis</i>	0.657
Oak, scarlet.....	<i>Quercus coccinea</i>	0.709
Oak, swamp chestnut.....	<i>Quercus prinus</i>	0.756
Oak, swamp white.....	<i>Quercus bicolor</i> or <i>Quercus platanoides</i>	0.792
Oak, white.....	<i>Quercus alba</i>	0.710
Persimmon.....	<i>Diospyros virginiana</i>	0.776
Pine, eastern white.....	<i>Pinus strobus</i>	0.373
Pine, jack.....	<i>Pinus banksiana</i> or <i>Pinus divaricata</i>	0.461
Pine, loblolly.....	<i>Pinus taeda</i>	0.593
Pine, longleaf.....	<i>Pinus palustris</i>	0.638
Pine, pitch.....	<i>Pinus rigida</i>	0.542
Pine, red.....	<i>Pinus resinosa</i>	0.507

\* See page 2-35 for footnotes.



## DENSITY OF SOLIDS

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TABLE 2b-11. DENSITY OF WOODS (OVEN-DRY)\* (Continued)

Common name	Botanical name	$\rho$ , g/cm <sup>3</sup>
Pine, shortleaf.....	<i>Pinus echinata</i>	0.584
Poplar, balsam.....	<i>Populus balsamifera</i> or <i>Populus</i> <i>candicans</i>	0.331
Poplar, yellow.....	<i>Liriodendron tulipifera</i>	0.427
Redwood.....	<i>Sequoia sempervivens</i>	0.436
Sassafras.....	<i>Sassafras variafolium</i>	0.473
Satinwood (Ceylon).....	<i>Chloroxylon swietenia</i>	1.031†
Sourwood.....	<i>Oxydendrum arboreum</i>	0.593
Spruce, black.....	<i>Picea mariana</i>	0.428
Spruce, red.....	<i>Picea rubra</i> or <i>Picea rubens</i>	0.413
Spruce, white.....	<i>Picea glauca</i>	0.431
Sycamore.....	<i>Platanus occidentalis</i>	0.539
Tamarack.....	<i>Larix laricina</i> or <i>Larix americana</i>	0.558
Teak (India).....	<i>Tectona grandis</i>	0.582†
Walnut, black.....	<i>Juglans nigra</i>	0.562
Willow, black.....	<i>Salix nigra</i>	0.408

\* "Handbook of Chemistry and Physics," 30th ed.

† Air-dry.

TABLE 2b-12. DENSITY OF PLASTICS\*

Resin group and subgroup	Trade names	$\rho$ , g/cm <sup>3</sup>	
		Lower limit	Upper limit
Acrylate and methacrylate.....	Lucite, Crystalite, Plexiglas	1.16	1.20
Casein.....	Ameroid	1.34	1.35
Cellulose acetate (sheet).....	Bakelite, Lumarith, Plastecel, Protectoid	1.27	1.60
Cellulose acetate (molded).....	Fibestos, Hercules, Nixonite, Tenite	1.27	1.60
Cellulose acetobutyrate.....	Tenite II	1.14	1.23
Cellulose nitrate.....	Celluloid, Nitron, Nixonoid, Pyralin	1.35	1.60
Ethyl cellulose.....	Ditzler, Ethocel, Ethofoil, Lumarith, Nixon, Hercules	1.05	1.25
Phenol-formaldehyde compounds:			
Wood-flour-filled (molded).....	Bakelite, Durez, Durite, Micarta, Catalin, Haveg, Indur, Makalot, Resinox, Textolite, Formica	1.25	1.52
Mineral-filled (molded).....	Bakelite, Durez, Durite, Micarta, Catalin, Haveg, Indur, Makalot, Resinox, Textolite, Formica	1.59	2.09
Macerated-fabric-filled (molded)...	Bakelite, Durez, Durite, Micarta, Catalin, Haveg, Indur, Makalot, Resinox, Textolite, Formica	1.36	1.47
Paper-base (laminated).....	Bakelite, Durez, Durite, Micarta, Catalin, Haveg, Indur, Makalot, Resinox, Textolite, Formica	1.30	1.40
Fabric base (laminated).....	Bakelite, Durez, Durite, Micarta, Catalin, Haveg, Indur, Makalot, Resinox, Textolite, Formica	1.30	1.40
Cast (unfilled).....	Bakelite, Catalin, Gemstone, Marblette, Opalon, Prystal	1.20	1.10
Phenolic furfural (filled).....	Durite	1.3	2.0
Polyvinyl acetals (unfilled).....	Alvar, Formvar, Saflex, Butacite, Vinylite X, etc.	1.05	1.23
Polyvinyl acetate.....	Gelva, Vinylite A, etc.	1.19	(?)
Copolyvinyl chloride acetate.....	Vinylite V, etc.	1.34	1.37
Polyvinyl chloride (and copolymer) plasticized.....	Koroseal, Vinylite	1.2	1.7
Polystyrene.....	Bakelite, Loalin, Lustron, Styron	1.054	1.070

\* "Handbook of Chemistry and Physics," 30th ed., p. 1282.

TABLE 2b-12. DENSITY OF PLASTICS (Continued)

Resin group and subgroup	Trade names	$\rho$ , g/cm <sup>3</sup>	
		Lower limit	Upper limit
Modified isomerized rubber.....	Pliofilm, Pliolite	1.06	(?)
Chlorinated rubber.....	Torneseit, Parlon	1.64	(?)
Urea formaldehyde.....	Bakelite, Beetle, Plascon	1.45	1.55
Melamine formaldehyde filled.....	Catalin, Melmac, Plaskon	1.49	1.86
Vinylidene chloride.....	Saran, Velon	1.68	1.75

TABLE 2b-13. DENSITY OF RUBBERS\*

Rubber; raw polymer	Trade Name	At 25°C
Natural rubber.....	Hevea	0.92
Butadienestyrene copolymer.....		0.94
Butadieneacrylonitrile copolymer.....		1.00
Polychloroprene (neoprene).....		1.25
Isobutylenediolefin copolymer (butyl).....		0.91
Alkylene polysulfide.....		1.35

\* "Handbook of Chemistry and Physics," 30th ed., p. 1282.

