Appendix C Costs and Relative Costs for Selected Engineering Materials

This appendix contains price information for the same set of materials for which the properties are included in Appendix B. The collection of valid cost data for materials is an extremely difficult task, which explains the dearth of materials pricing information in the literature. One reason for this is that there are three pricing tiers: manufacturer, distributor, and retail. Under most circumstances, we have cited distributor prices. For some materials (e.g., specialized ceramics such as silicon carbide and silicon nitride), it was necessary to use manufacturers' prices. In addition, there may be significant variation in the cost for a specific material. There are several reasons for this. First, each vendor has its own pricing scheme. Furthermore, cost will depend on quantity of material purchased and, in addition, how it was processed or treated. We have endeavored to collect data for relatively large orders—that is, quantities on the order of 900 kg (2000 lb_m) for materials that are ordinarily sold in bulk lots—and also for common shapes/treatments. When possible, we obtained price quotes from at least three distributors/manufacturers.

This pricing information was collected in January 2007. Cost data are in U.S. dollars per kilogram; in addition, these data are expressed as both price ranges and single-price values. The absence of a price range (i.e., when a single value is cited) means either that the variation is small or that, on the basis of limited data, it is not possible to identify a range of prices. Furthermore, inasmuch as material prices change over time, it was decided to use a relative cost index; this index represents the per unit mass cost (or average per unit mass cost) of a material divided by the average per unit mass cost of a common engineering material—A36 plain carbon steel. Although the price of a specific material will vary over time, the price ratio between that material and another will, most likely, change more slowly.

Material/Condition	*Cost ($US/kg)*	*Relative Cost*
PLAIN CARBON AND LOW-ALLOY STEELS		
Steel alloy A36		
• Plate, hot rolled	0.90–1.50	1.00
• Angle bar, hot rolled	1.00–1.65	1.0
Steel alloy 1020		
• Plate, hot rolled	0.90–1.65	1.0
• Plate, cold rolled	0.85–1.40	0.9
Steel alloy 1040		
• Plate, hot rolled	0.90–0.95	0.7
• Plate, cold rolled	2.20	1.7

Material/Condition	*Cost ($US/kg)*	*Relative Cost*
Steel alloy 4140		
• Bar, normalized	1.50–2.60	1.6
• H grade (round), normalized	5.00	3.9
Steel alloy 4340		
• Bar, annealed	2.55	2.0
• Bar, normalized	3.60	2.8
STAINLESS STEELS		
Stainless alloy 304	6.20–9.20	6.0
Stainless alloy 316	6.20–11.70	7.3
Stainless alloy 17-7PH	9.20	7.1
CAST IRONS		
Gray irons (all grades)	1.75–2.40	1.7
Ductile irons (all grades)	2.00–3.20	2.0
ALUMINUM ALLOYS		
Aluminum (unalloyed)	2.65–2.75	2.1
Alloy 1100		
• Sheet, annealed	5.30–5.50	4.2
Alloy 2024		
• Sheet, T3 temper	12.50–19.50	12.9
• Bar, T351 temper	11.00–21.00	13.4
Alloy 5052		
• Sheet, H32 temper	4.85–5.10	3.9
Alloy 6061		
• Sheet, T6 temper	6.60–8.50	5.7
• Bar, T651 temper	5.10–7.50	5.0
Alloy 7075		
• Sheet, T6 temper	11.30–14.70	10.0
Alloy 356.0		
• As cast, high production	2.70–3.35	2.4
• As cast, custom pieces	17.50	13.6
• T6 temper, custom pieces	18.90	14.7
COPPER ALLOYS		
Copper (unalloyed)	5.60–7.00	4.8
Alloy C11000 (electrolytic tough pitch), sheet	7.60–11.60	7.4
Alloy C17200 (beryllium–copper), sheet	9.00–36.00	17.5
Alloy C26000 (cartridge brass), sheet	7.10–12.80	7.5
Alloy C36000 (free-cutting brass), sheet, rod	7.20–10.90	7.0
Alloy C71500 (copper–nickel, 30%), sheet	27.00	21.0
Alloy C93200 (bearing bronze)		
• Bar	9.70	7.5
• As cast, custom piece	23.00	17.9
MAGNESIUM ALLOYS		
Magnesium (unalloyed)	3.00–3.30	2.4
Alloy AZ31B		
• Sheet (rolled)	17.60–46.00	23.4
• Extruded	9.90–14.30	9.4
Alloy AZ91D (as cast)	3.40	2.6

Material/Condition	*Cost ($US/kg)*	*Relative Cost*
TITANIUM ALLOYS		
Commercially pure		
• ASTM grade 1, annealed	100.00–120.00	85.6
• ASTM grade 2, annealed	90.00–160.00	95.9
Alloy Ti–5Al–2.5Sn	110.00–120.00	89.3
Alloy Ti–6Al–4V	66.00–154.00	94.2
PRECIOUS METALS		
Gold, bullion	18,600–20,900	15,300
Platinum, bullion	32,100–40,000	28,400
Silver, bullion	350–450	313
REFRACTORY METALS		
Molybdenum, commercial purity	180–300	161
Tantalum, commercial purity	400–420	318
Tungsten, commercial purity	225	175
MISCELLANEOUS NONFERROUS ALLOYS		
Nickel, commercial purity	25.00–34.50	23.7
Nickel 200	35.00–74.00	46.8
Inconel 625	59.00–88.00	55.5
Monel 400	15.00–33.00	16.8
Haynes alloy 25	143.00–165.00	120
Invar	44.00–54.00	37.2
Super invar	44.00	34.2
Kovar	50.00–66.00	44.3
Chemical lead		
• Ingot	1.50–2.00	1.4
• Plate	2.15–4.40	2.5
Antimonial lead (6%)		
• Ingot	2.30–3.90	2.4
• Plate	3.10–6.10	3.4
Tin, commercial purity	9.75–10.75	8.0
Solder (60Sn–40Pb), bar	8.10–16.50	9.4
Zinc, commercial purity, ingot or anode	2.00–4.65	2.8
Zirconium, reactor grade 702, plate	46.00–88.00	52.2
GRAPHITE, CERAMICS, AND SEMICONDUCTING MATERIALS		
Aluminum oxide		
• Calcined powder, 99.8% pure, particle size between 0.4 and 5 μm	1.85–2.80	1.8
• Ball grinding media, 99% pure, ¼ in. dia.	39.00–52.00	35.1
• Ball grinding media, 96% pure, ¼ in. dia.	33.00	25.6
• Ball grinding media, 90% pure, ¼ in. dia.	16.00	12.4
Concrete, mixed	0.05	0.04
Diamond		
• Synthetic, 30–40 mesh, industrial grade	7700	6000
• Natural, powder, 45 μm, polishing abrasive	2300	1800
• Natural, industrial, ½ carat	50,000–85,000	52,400
Gallium arsenide		
• Mechanical grade, 75-mm-dia. wafers, ~625 μm thick	3900	3000
• Prime grade, 75-mm-dia. Wafers, ~625 μm thick	6500	5000

Material/Condition	*Cost ($US/kg)*	*Relative Cost*
Glass, borosilicate (Pyrex), plate	9.20–11.30	7.9
Glass, soda–lime, plate	0.56–1.35	0.7
Glass-ceramic (Pyroceram), plate	12.65–16.55	11.3
Graphite		
• Powder, synthetic, 99+% pure, particle size, ~10 μm	1.80–7.00	3.1
• Isostatically pressed parts, high purity, ~20-μm particle size	50.00–125.00	65.3
Silica, fused, plate	1200–1700	1100
Silicon		
• Test grade, undoped, 100-mm-dia. wafers, ~425 μm thick	5100–9000	5500
• Prime grade, undoped, 100-mm-dia. wafers, ~425 μm thick	8000–14,000	8800
Silicon carbide		
• α-phase ball grinding media, ¼ in. dia., sintered	250.00	194
Silicon nitride		
• Powder, submicron particle size	100–200	100
• Balls, finished ground, 0.25 in. to 0.50 in. diameter, hot isostatically pressed	1000–4000	1600
Zirconia (5 mol% Y_2O_3), 15-mm-dia. ball grinding media	50–200	97.1
POLYMERS		
Butadiene-acrylonitrile (nitrile) rubber		
• Raw and unprocessed	4.00	3.1
• Extruded sheet (¼–⅛ in. thick)	8.25	6.4
• Calendered sheet (¼–⅛ in. thick)	5.25–7.40	4.9
Styrene-butadiene (SBR) rubber		
• Raw and unprocessed	1.70	1.3
• Extruded sheet (¼–⅛ in. thick)	5.05	3.9
• Calendered sheet (¼–⅛ in. thick)	3.25–3.75	2.7
Silicone rubber		
• Raw and unprocessed	9.90–14.00	9.5
• Extruded sheet (¼–⅛ in. thick)	28.00–29.50	22.4
• Calendered sheet (¼–⅛ in. thick)	7.75–12.00	7.7
Epoxy resin, raw form	2.20–2.80	1.9
Nylon 6,6		
• Raw form	3.20–4.00	2.8
• Extruded	12.80	9.9
Phenolic resin, raw form	1.65–1.90	1.4
Poly(butylene terephthalate) (PBT)		
• Raw form	4.00–7.00	4.3
• Sheet	40.00–100.00	54.3
Polycarbonate (PC)		
• Raw form	3.00–4.70	2.9
• Sheet	10.50	8.2
Polyester (thermoset), raw form	3.10–4.30	2.7
Polyetheretherketone (PEEK), raw form	90.00–105.00	76.0
Polyethylene		
• Low density (LDPE), raw form	1.60–1.85	1.3
• High density (HDPE), raw form	1.20–1.75	1.2
• Ultrahigh molecular weight (UHMWPE), raw form	2.20–3.00	2.1

Material/Condition	*Cost ($US/kg)*	*Relative Cost*
Poly(ethylene terephthalate) (PET)		
• Raw form	1.50–1.75	1.3
• Sheet	3.30–5.40	3.4
Poly(methyl methacrylate) (PMMA)		3.1
• Raw form	2.60–5.40	3.1
• Extruded sheet (¼ in. thick)	4.65–6.05	4.1
Polypropylene (PP), raw form	1.05–1.70	1.2
Polystyrene (PS), raw form	1.55–1.95	1.4
Polytetrafluoroethylene (PTFE)		
• Raw form	14.80–16.90	11.9
• Rod	21.00	16.3
Poly(vinyl chloride) (PVC), raw form	1.10–1.85	1.2
FIBER MATERIALS		
Aramid (Kevlar 49), continuous	35.00–100.00	38.8
Carbon (PAN precursor), continuous		
• Standard modulus	40.00–80.00	48.1
• Intermediate modulus	60.00–130.00	69.1
• High modulus	220.00–275.00	193
E-glass, continuous	1.55–2.65	1.6
COMPOSITE MATERIALS		
Aramid (Kevlar 49) continuous-fiber, epoxy prepreg	75.00–100.00	66.8
Carbon continuous-fiber, epoxy prepreg		
• Standard modulus	49.00–66.00	43.1
• Intermediate modulus	75.00–240.00	123
• High modulus	120.00–725.00	330
E-glass continuous-fiber, epoxy prepreg	24.00–50.00	28.3
Woods		
• Douglas fir	0.61–0.97	0.6
• Ponderosa pine	1.15–1.50	1.0
• Red oak	3.35–3.75	2.8