

**Typical Brinell hardness numbers (BHN)
for metals and plastics**

Material	BHN
Soft brass	60
Mild steel	130
Annealed chisel steel	235
White cast iron	415
Nitrided surface	750
PVC rigid	20
Polystyrene	25
Acrylic (Perspex)	34
Polythene (high density)	2
Epoxy resin (glass filled)	38

Comparison of hardness numbers

Rockwell C scale	Vicker's pyramid	Brinell hardness number	Rockwell C scale	Vicker's pyramid	Brinell hardness number	Rockwell C scale	Vicker's pyramid	Brinell hardness number
68	1030	-	49	515	468	30	299	286
67	975	-	48	500	458	29	291	279
66	935	-	47	485	447	28	284	272
65	895	-	46	470	436	27	277	266
64	860	-	45	456	426	26	271	260
63	830	-	44	442	416	25	265	255
62	800	-	43	430	406	24	260	250
61	770	-	42	418	396	23	255	245
60	740	-	41	406	386	22	250	240
59	715	609	40	395	376	21	245	235
58	690	594	39	385	366	20	240	230
57	670	579	38	375	356	-	220	210
56	650	564	37	365	346	-	200	190
55	630	549	36	355	337	-	180	171
54	610	534	35	345	328	-	160	152
53	590	519	34	335	319	-	140	133
52	570	504	33	325	310	-	120	114
51	550	492	32	315	302	-	100	95
50	532	480	31	307	294	-	-	-

Density of materials

In this table densities (ρ) are given for normal pressure and temperature.

Metals				Wood (15% moisture)	
Metal	ρ (kg m ⁻³)	Metal	ρ (kg m ⁻³)	Wood	ρ (kg m ⁻³)
Aluminium	2700	Monel	18900	Ash	660
Aluminium bronze (90%Cu, 10%Al)	7700	Nickel	8900	Balsa	100-390
Antimony	6690	Nimonic (average)	8100	Beech	740
Beryllium	1829	Palladium	12160	Birch	720
Bismuth	9750	Phosphor bronze (typical)	8900	Elm: English	560
Brass (60/40)	8520	Platinum	21370	Dutch	560
Cadmium	8650	Sodium	971	wych	690
Chromium	7190	Steel: mild	7830	Fir, Douglas	480-550
Cobalt	8900	stainless	8000	Mahogany	545
Constantan	8920	Tin: grey	5750	Pine: Parana	550
Copper	8930	rhombic	6550	pitch	640
Gold	19320	tetragonal	7310	Scots	530
Inconel	8510	Titanium	4540	Spruce, Norway	430
Iron: pure	7870	Tungsten	19300	Teak	660
cast	7270	Uranium	18680		
Lead	11350	Vanadium	5960		
Magnesium	1740	Zinc	7140		
Manganese	7430				
Mercury	13546				
Molybdenum	10200				

Physical properties of some plastics

Properties of plastic	ρ (kg m ⁻³)	Tensile strength (N mm ⁻²)	Elongation (%)	E (GN m ⁻²)	BHN	Machinability
<i>Thermoplastics</i>						
PVC rigid	1330	48	200	3.4	20	Very good
Polystyrene	1300	48	3	3.4	25	Average
PTFE	2100	13	100	0.3	-	Very good
Polypropylene	1200	27	200-700	1.3	10	Very good
Nylon	1160	60	90	2.4	10	Very good
Cellulose nitrate	1350	48	40	1.4	10	Very good
Cellulose acetate	1300	40	10-60	1.4	12	Very good
Acrylic (Perspex)	1190	74	6	3.0	34	Very good
Polythene (high density)	1450	20-30	20-100	0.7	2	Very good
<i>Thermosetting plastics</i>						
Epoxy resin (glass filled)	1600-2000	68-200	4	20	38	Good
Melamine formaldehyde (fabric filled)	1800-2000	60-90	-	7	38	Average
Urea formaldehyde (cellulose filled)	1500	38-90	1	7-10	51	Average
Phenol formaldehyde (mica filled)	1600-1900	38-50	0.5	17-35	36	Good
Acetals (glass filled)	1600	58-75	2-7	7	27	Good

BHN = Brinell hardness number, ρ = density, E = Young's modulus

Physical properties of some common engineering materials

Material	Application	Tensile strength (N mm ⁻²)	<i>E</i> (GN m ⁻²)	ρ (kg m ⁻³)
Steel (070M20)	Structures, lightly stressed parts, bolts, brackets, levers	430	207	7850
Steel (060A96)	Springs	1300	207	7850
Steel (331S40)	Internal combustion engine valves	1100-1700	207	7850
Aluminium alloy (NS4)	Plate, sheet and strip	170	70	2700
Aluminium alloy (HE15TB)	Rolled sections	370	70	2700
Grey cast iron	Brittle. Castings not subject to heavy impact	150/400 (tension) 600/1200 (compression)	130	7200
Brass cold drawn	Bearings	168	100	8400
Phosphor bronze, rolled	Castings in contact with water. Non magnetic springs	410	116	8800
Timber	Frames	3-5 along grain, 35-60 across grain	8-16	350-800
Fibre glass	Cowls, motor bodies	100 (tension) 150 (compression)	10	1500
Nylon	Bearings	80	1.6	1100
Polystyrene	Moulded components	45 (tension) 110 (compression)	3	1070

Safe stresses in structural timbers (N mm⁻²)

Timber	Bending			Compression			
	Stress in extreme fibre		Horizontal shear stress	Stress parallel to grain		Stress perpendicular to grain	
	Outside location	Dry location		Outside location	Dry location	Outside location	Dry location
Oak	8.3	9.7	0.9	6.0	6.9	1.6	3.5
Douglas fir	7.6	9.0	0.6	6.0	6.9	1.6	2.1
Norway spruce	6.9	7.6	0.6	5.5	5.5	1.2	2.1

Mechanical properties of some timbers

Wood	Moisture (%)	Density, ρ (kg m ⁻³)	Fibre stress at elastic limit (N mm ⁻²)	Modulus of elasticity <i>E</i> (N mm ⁻²)	Modulus of rupture (N mm ⁻²)	Compressive strength papallel to grain (N mm ⁻²)	shear strength
Ash	15	657	60	10070	103	48	10
Beech	-	740	60-110	10350	-	27-54	8.3-14
Birch	9-10	710	85-90	15170	130-135	67-74	13-18.5
English elm	-	560	40-54	11790	-	17-32	8-11.3
Fir, Douglas	6-9	530	45-73	10340-15170	71-97	49-74	7.4-8.8
Mahogany	15	545	60	8690	80	45	6.0
Oak	-	740	56-87	14550	-	27-50	8-12
Scots pine	-	530	41-83	8550-10340	-	21-42	5.2-9.7
Poplar	-	450	40-43	7240	-	20	4.8
Spruce	-	430	36-62	7380-8620	-	18-39	4.3-8
Sycamore	-	625	62-106	8970-13450	-	26-46	8.8-15

Frictional characteristics of different materials

Materials	Lubrication	Approx. coefficient of friction (low pressure)
Metal on metal	none	0.20
Cast iron on hardwood	none	0.49
Cast iron on hardwood	some lubrication	0.19
Metal on hardwood	none	0.60
Metal on hardwood	some lubrication	0.20
Leather on metal	none	0.4
Rubber on metal	none	0.40
Rubber on road	none	0.90
Nylon on steel	none	0.3-0.5
Acrylic on steel	none	0.5
Teflon on steel	none	0.04
Metal on ice	-	0.02

Clutches and brakes

Materials	Coefficient of friction		Maximum temperature ((°C)	Maximum pressure (bar)
	wet	dry		
Cast iron/steel	0.06	0.15-0.2	250	8-13
Hard steel/hard steel	0.05	-	250	7
Wood/cast iron or steel	0.16	0.2-0.35	150	6
Leather/cast iron or steel	0.12-0.15	0.3-0.5	100	2.5
Cork/cast iron or steel	0.15-0.25	0.3-0.5	100	1
Felt/cast iron or steel	0.18	0.22	140	0.6
Vulcanized paper or fibre/ cast iron or steel	-	0.3-0.5	100	3
Moulded asbestos/ cast iron or steel	0.08-0.12	0.2-0.5	250	1
Impregnated asbestos/ cast iron or steel	0.12	0.32	350	10
Asbestos in rubber/ cast iron or steel	-	0.3-0.40	100	6
Carbon graphite/steel	0.05-0.1	0.25	500	20
Moulded phenolic plastic with cloth base/ cast iron or steel	0.1-0.15	0.25	150	7