Engineering materials

This data sheet is intended as a guide for users of engineering materials and will be useful for selection of the correct material for various applications.

Plastic Stock

	Nylon 66	Nylatron™ GS	Acetal (Copolymer)	PTFE	Polyethylene (UHMW)	PVC
Tensile strength (kgf/cm^2)	630/840	700/980	620	120/240	220/250	422-528
Elongation (%)	20/200	5/150	60	100/300	450	20
Modulus of elasticity (kgf/cm^2)	17,500/28,000	31,600/42,000	28,800	3,500/6,500	5,000	2,500
Hardness (Rockwell R)	112-120	110-125	120			
(Shore D)	80-85	80-90		60-65	64-67	65-80
Flexural strength (kgf/cm^2)	880-940	1,100-1,300	915		270	714
Deformation under load 140 kgf/cm^2 at 50°C after 24hrs (%)	1.0-3.0	0.5-2.5	1.0			—
Impact strength – 1Z0D 23°C (kgf.cm/cm notch	5.4	3.4	6.5	16	No break	4-10
Linear thermal expansion coefficient 30-100°C/C	100 510^{-6}	63 510^{-6}	95 510^{-6}	100-120 510^{-6}	200 510^{-6}	5-10 510^{-5}
Melting point °C	260	260	165	327	135/138	—
Flammability	Self extinguishing	Self extinguishing	Slow burning	Non flammable	Slow burning	Self extinguishing
Thermal conductivity (Kcal/m.hr.°C)	0.21	0.21	0.2	0.22	0.36	0.18
Deflection temp. °C at 4.6 kgf/cm^2 18.6 kgf/cm^2	204 93	204 93	158 110	132 49	95	60-82 60-77
Permitivity 50-10^6 Hz	3.4/4.1	3.5/4.2	3.7	2.0/2.1	2.3	2.8-4.0
Dielectric strength (kV/mm)	>12	>12	>16	>24	>28	>20
Volume resistivity (ohm.cm)	$>10^{13}$	$>10^{13}$	$>10^{14}$	$>10^{18}$	$>10^{17}$	$>10^{16}$
Chemical resistance	Resists common solvents and lubricants, hydrocarbons, esters, ketones, aqueous solutions of acids and alkalis between ph5 and ph11. Not resistant to phenols, cresols, formic acid, conc. mineral acid and alkalis, strong oxidising agents including halogens		As Nylon 66 but slightly more prone to attack	Only attacked by molten or dissolved alkali, metals and some fluorine compounds at high temperature	All commonly used chemicals. Not resistant to strong oxidising acids. Aromatic or halogenated hydrocarbons may cause slight swelling	Good resistance to dilute acids and alkalis. Fair resistance to alcohols, greases and oils, concentrated acids and halogens. Poor resistance to ketones and aromatic hydrocarbons
Specific gravity (g/cm^3)	1.14-1.15	1.14-1.18	1.4-1.42	2.1-2.3	0.94	1.30-1.60
Water absorption (%) 24hr (%) Saturation	0.6-1.5 7-9	0.5-1.3 6-8	0.22 0.80	0.01 <0.02	Non-absorbent	<0.4 N/A
Applications	Gears, seals, bearings, valve seats, bushes, washers, wheels, spacers, rollers, gaskets, cams, insulators, nuts, screws	Bearings, rollers, bushes, sleeves, gears, cams, valve seats, wheels, thrust washers	Bearings, impellers, bushes, gears, meter components, pump housing, valve and valve seating, tap washers and parts, lawn sprinkler parts, windscreen washer parts, cistern valves and bushes, carburettor components	Co-axial parts, bearing bushes, repetition turned parts, insulators, gaskets and rollers, components for food, manufacturing and chemical industries	Chemical tanks and vessels, electronic components, hospital equipment, valves, pumps and fans, photographic equipment, ducting	Chemical plant, tanks, ducting, electrical components, aircraft fitments, valves and pumps, photographic equipment

The data are typical values and are not intended to represent specifications. Nylatron™ is a registered trade mark of Polypenco Ltd.

Plastic Stock (cont'd)

Acrylic

Density (DIN 53 479)	g/cm^3	1.18
Tensile strength (DIN 53 455)	N/mm^2	70
Crushing stress (DIN 53 454)	N/mm^2	103
Flexural strength (DIN 53 452)	N/mm^2	120
Impact strength (DIN 53 453)	kJ/m^2	11
Notched impact strength (DIN 53 453)	kJ/m^2	2
Creep rupture strength (DIN 53 444)	N/mm^2	28
Ball indentation hardness (DIN 53 456) H 961/30	N/mm^2	190
Module of elasticity (DIN 53 457)	N/mm^2	3300
Thermal conductivity	W/m°C	0.19
Spec heat	Ws/g°C	1.5
Lin. coeff. of therm. expan.	1/°C	70×10^{-6}
Heat distortion temperature Vicat method (DIN 53 460)	°C	100
Heat distortion temperature Martene method	°C	72
Refractive index 20°C (DIN 53 491)	^nD	1,491
Water vapour permeability	$g.cm/gm^2hPg$	$4.5\ 10^{-15}$
Dielectric constand E 50Hz (DIN 53 483)	—	3.7
Dielectric Hz loss factor 1MHz	— —	0.06 0.03
Dielectric strength (DIN 53 481)	kV/mm	30
Spec. resistance (DIN 53 482)	Ω cm	10^{15}
Surface resist. after 24 hours water immersion	Ω cm	-10^{13}
Light transmission	%	92
Flammability DIN 4102 Tell 1	—	B2
Flammability UL94	mm/min	94 HB
Applications		Illumination signs, sanitary ware, machine guards, models/ prototypes, screens/ windows, catering equipment, name plates, covers

Tufnol™ Carp brand

Sheet: Cross breaking strength		kgf/cm^2	1530
Impact strength, notched, Charpy		kJ/m^2	8.6
Compressive strength, flatwise		kgf/cm^2	3570
Compressive strength, edgewise		kgf/cm^2	2040
Resistance to flatwise compression		%	1.4
Shear strength, flatwise		kgf/cm^2	1070
Water absorption $50mm^2$ sections oven dried then left in water for 24 hours	1.6mm	mg	55
	3mm	mg	70
	6mm	mg	90
	12mm	mg	125
Electric strength, flatwise in oil at 90°C	1.6mm	MV/m	7.2
	3mm	MV/m	4.9
	6mm	MV/m	4.0
Electric strength, edgewise in oil at 90°C		kV	23
Insulation resistance after immersion in water		ohms	7×10^9
Relative density		—	1.36
Maximum working temperature	continuous	°C	120
	intermittent	°C	130
Thermal classification		—	E
Thermal conductivity through laminae		W/(mK)	0.37
Thermal expansion in plane of laminae		$\times 10^{-5}/K$	1.9
Specific heat		kJ/(kgK)	1.5
Round rods: Flexural strength		kgf/cm^2	1734
Water absorption		mg/cm^2	2.5
Insulation resistance after immersion in water		ohms	5×10^8
Axial electric strength in oil at 90°C		kV	15
Relative density		—	1.35
Applications			Fine pitched gears, precision components, electrical test jigs

Test methods for Tufnol as BS 2572, BS 5102 or BS 3953.
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Plastic Stock (cont'd)

ABS (acrylonitrile butadiene styrene)

Properties	Test condition DIN	ISO IEC	ASTM		Unit	Values	Applications
Mechanical							Easily vacuum formed it is an ideal material for making trays, covers, housings, cases, etc.
1 Tensile strength	53455	R 527	D 638	N/mm^2	45		
2 Yield strength	53455	R 527	D 638	N/mm^2	45		
3 Tensile strength at break	53455	R 527	D 638	N/mm^2	34		
4 Elongation at yield	53455	R 524	D 638	%	3		
5 Elongation at maximum load	53455	R 524	D 638	%	3.5		
6 Elongation at break	53455	R 527	D 638	%	14		
7 Youngs-modulus	53457	R 524	D 638	N/mm^2	2350		
8 Shear modulus	53445	R 537	D 2236	N/mm^2			
9 Flexural stress	53452	R 178	D 790	N/mm^2	70		
10 Impact strength at 23°C	53453	R 179		kJ/m^3	without break		
11 Impact strength at –40°C					70-80		
12 Impact strength notched 23°C	53453	R 179		kJ/m^3	12		
13 Impact strength notched –40°C							
14 Izod impact strength notched at 23°C		R 180	D 256	J/m			
15 Indentation hardness	53456	–	–	N/mm^2	80	H_{20}	
16 Rockwell hardness	–	–	D 785/A	–			
Thermal							
17 Vicat softening point – VST	53460	R 306		°C	93	Process B	
18 ISO/R 75 process A	53461	R 75	D 648	°C			
19 ISO/R 75 process B	53461	R 75	D 648	°C			
20 Continuous working temperature				°C	90		
21 Thermal coefficient of linear expansion				$10^{-6}/K$	9		
22 Thermal conductivity between –40° and +80°C	52612			W/Km	0.087		
23 Spec/Heat				kJ/kgK	2.4		
Electrical							
24 Dielectric constant at 1MHz	53483	IEC 250	D 150	–	2.9	dry	
25 Dissipation factor	53483	IEC 250	D 150	–	0.011	dry	
26 Spec. volume resistivity	53482	IEC 167	D 257	Ωcm	2×10^{15}	dry	
27 Surface resistivity	53482	IEC 167	D 257	Ω	6×10^{12}	dry	
28 Dielectric strength	53481	IEC 243	–	kV/mm	31	dry	
29 Resistance of tracking	53480		–	level			
Physical							
30 Water absorption proc. A	53495	R 82	D 570	%	0.3		
31 Density	53479	R 1183	D 792	g/cm^3	1.04-1.06		

Polycarbonate

Properties	Test method	Units	Values	Applications
Mechanical				Suitable for general glazing applications which are vulnerable to vandalism or accidents. Other applications include machine guards/shields, safety visors and light fittings.
Tensile stress at yield	DIN 53455	N/mm^2	60	
Elongation at break	DIN 53455	%	>100	
Tensile modulus of elasticity	DIN 53457	N/mm^2	2300	
Unnotched impact strength (Charpy)	DIN53453	kJ/m^2	no break	
Notched impact strength: Charpy	DIN 53453	kJ/m^2	>30	
Izod	ASTMD 256	J/m	600-800	
Thermal				
Glass transition temperature		°C	140	
Thermal conductivity	DIN 52612	W/km	0.21	
Coeff. of linear thermal expansion, average value between 0 and 60°C		K^{-1}	65×10^6	
Heat deflection temperature under load acc. to ISO/R75 method A: $1.81N/mm^2$	DIN53461	°C	135-140	
Max. service temperature in air:				
for short periods		°C	145	
continuously		°C	120	
Min. service temperature		°C	–100	
Flammability				
acc. to ASTM (oxygen-index)	ASTM D 2863	%	25	
acc. to UL 94: 1.5mm thick sheet	UL94	rating	V-2	
6mm thick sheet	UL94	rating	V-0	
acc. to French standard: 3mm thick sheet		rating	M3	
acc. to British standard: surface spread of flame test 4mm thick sheet	BS476 Part 1	rating	Class O	
Electrical				
Dielectric strength	DIN 53481	kV/mm	>30	
Volume resistivity	DIN 53482	Ohm.cm	$>10^{16}$	
Surface resistivity	DIN 53482	Ohm	$>10^{15}$	
Dielectric constant at 10^3 Hz	DIN 53483	–	3	
Dissipation factor tg δ at 10^3 Hz	DIN 53483	–	0.001	
Tracking resistance	DIN 53480	rating	KC 250-300	
Physical				
Density	DIN 53479	g/cm^3	1.2	
Moisture absorption: saturated at 23°C/50% RH		%	0.15	
Index of refraction n_D at 20°C	DIN 53491		1.585	

Non-ferrous metals

	Brass	Copper	Aluminium	Phosphor Bronze
Chemical analysis	BS2874/CZ121M Copper 56.5/58.5 Lead 2.5/4.5	BS2870/C101 BS2874/C101 Copper 99.90 Lead 0.005 Bismuth 0.0010	BS1474/1987 HE30 Si 0.7-1.3 Ni – Fe 0.5 Zn 0.20 Cu 0.1 Bi – Mn 0.40-1.0 Pb – Mg 0.6-1.2 Ti 0.10 Cr 0.25 Al remainder BS1470 SIC (1987) Si 0.05 Ni 0.10 Fe 0.05 Zn 0.10 Cu 0.05 Bi – Mn – Pb – Mg – Ti 0.05 Cr – Al remainder	BS1400:1985:PBI-C Sn 10.0-11.5% Zn 0.05 max % Pb 0.25 max. % P 0.50-1.00% Ni 0.10 max % Fe 0.10 max % Si 0.02 max % S 0.05 max. % Cu * *The percentage of copper present shall be the remainder of the analysis. Apart from the main elements (copper, tin and phosphorus) the total of residual elements shall not exceed 0.60%.
Mechanical properties	Tensile strength 400 N/mm^2	Rod/Bar: Tensile strength 240 N/mm^2 Sheet: Tensile strength soft 210 h-hard 240	0.2% proof stress N/mm^2 270 (TF) Tensile strength N/mm^2 310 (TF)	0.2% proof stress N/mm^2 170-280 Tensile strength N/mm^2 360-500 Elongation on 5.65/S. 6-25% Hardness HB 100-150
Description and application	Machining quality Free turning brass – limited cold working properties	Rod and bar: high conductivity, corrosion resistant, malleable. Silver increases the softening temperature and has negligible effect on conductivity. Used for electrical conductors and also cold heading applications. Sheet: high conductivity copper. General purpose electrical applications. Also used for presswork	Rod and bar: good resistance to atmospheric attack. Good formability. Very good machinability. Very suitable for inert gas welding, fair for oxy gas and resistance welding. Offers good suitability for protection anodising Sheet: very good resistance to atmospheric attack. Very good formability. Fair machinability. Very suitable for inert gas, oxy gas and resistance welding. Very suitable for anodising	Tube: Produced by continuous casting, the material possesses high mechanical strength, is of consistent quality with freedom from porosity. Machining qualities are excellent. Typical applications include bearings, bushes, thrust washers, gears, worm wheels. For bearing applications involving high work loads, high speeds and impact loading, hardened shafts or journals are advised.

TF=Material which has been solution treated and precipitation treated. The information contained in this data sheet should be treated as a guide only. Data compiled with assistance from Polypenco Ltd, Macreadys, Tufnol Ltd and Righton Ltd.

Ferrous metals

	Ground flat stock	Silver steel	Key steel	Stainless steel
Chemical analysis	% min. % Max. Carbon 0.85 1.00 Silicon — 0.40 Manganese 1.10 1.35 Chromium 0.40 0.60 Tungsten 0.40 0.60 Vanadium — 0.25	% min. % Max. Carbon 0.95 1.25 Manganese 0.25 0.45 Silicon — 0.40 Chromium — 0.50 Sulphur — 0.045 Phosphorus — 0.045	% min. % Max. *Permitted variation Carbon 0.26 0.34 ±0.03 Manganese 0.60 1.00 ±0.04 †Silicon — — — Sulphur — 0.050 +0.008 Phosphorus — 0.050 +0.008 †Silicon content depends on whether the steel is rimming, balanced or killed. *Variations in analysis permissible within the specification	BS970 – Part 1 1983 303 S31 – rod % max. unless range stated / BS970 – Part 1 1983 316 S31 – bar/sheet Carbon 0.12 0.07 Manganese 2.0 2.0 Silicon 1.0 1.0 Sulphur 0.15/0.35 0.030 Chromium 17.0/19.0 16.5/18.5 Phosphorus 0.060 0.045 Molybdenum 1.00 2.00/2.50 Nickel 8.0/10.0 10.5/13.5
Characteristics	A high quality electrically melted alloy tool steel, ground to close tolerances. It can be easily hardened by oil quenching and possesses excellent dimensional stability. The high carbon content, in conjunction with chromium, gives good wear resistance. Material removal during grinding ensures that the ground flat stock is free of decarburisation	Silver steel is a high carbon tool steel ground to very close tolerances. It is so called because of the highly polished appearance created by the extremely fine surface finish. The high carbon content of this steel means that it can be hardened to give considerable wear resistance and the chromium content increases strength and hardenability. It is readily machinable as supplied in the annealed condition	A medium carbon bright drawn steel possessing tensile strengths in the range 35/45tsi. This key steel complies with BS46: Part 1: 1958 'Keys and Keyways'	303 S31 – An austenitic, free cutting steel. Contains additional sulphur to induce free machine properties and has a high corrosion resistance. Non-magnetic 316 S31 – A very high corrosion resistant steel due to additional molybdenum. Non-magnetic.
Typical applications	Widely used in tool rooms for applications where a close tolerance ground steel is required. Suitable for gauges, dies, punches, jigs, templates, cams and machine parts	Punches, dowels, mandrels, spindles, shafts, gauges, collets, knurls, lathe centres, engraving tools, etc	Square parallel keys. Square taper, gib-head and plain keys	303 S31 – Used for automatic turning, boring, cutting, etc. 316 S31 – Used for photography, food, chemical, marine equipment etc.
Tolerances	Imperial sizes: Width –0.000in +0.005in Thickness ±0.001in Length Nominal	Rounds Imperial sizes Below .005in ±0.00025in .005in and over ±0.0005in	Imperial sizes of key steel are drawn to plus tolerances (BS46) Squares <1in –0.000in +0.002in Metric sizes of key steel are drawn to minus tolerances (BS4235): Squares +0.0mm –0.030mm	
Heat treatment	Annealing: 760-780°C Hardening: 780-820°C Tempering: 150-300°C Ground flat stock is supplied annealed. Figures below show hardness values at selected tempering degrees Temp. (°C) Hardness (Rc) 150 62 200 60-61 250 58-59 300 56-58	Hardening: heat to 770-790°C and when thoroughly soaked through, quench in water. (Sizes up to $\frac{5}{16}$in dia. May be oil hardened from 800-810°C.) Tempering: tempering should be carried out immediately after hardening in the range 150-300°C according to the hardness required. The figures below show what can be achieved. Temp. (°C) Hardness (Rc) 120 65-63 150 64-62 200 62-61 250 59-58 300 56-55 350 54-53 400 50-48	—	—
Mechanical properties	—	—	Size (mm) Tensile Strength N/mm^2 Elongation % min <19 540-695 8	—

Shim stock

	Shim steel: (cold rolled steel strip)	Brass shim: (cold rolled brass strip)	Plastic shim:
Chemical analysis	% min. / % Max. Carbon — 0.12 Manganese — 0.60 Silicon — 0.050 Phosphorus — 0.050	Copper 62.0-65.0% Lead 0.30% (max) Iron 0.20% (max) Zinc* Remainder *The percentage of zinc present shall be the remainder of the analysis except that the total impurities (excluding lead) shall not exceed 0.50%	0.002in to 0.010in polyester 0.015in and 0.020 in polypropylene
Characteristics	Complies with the requirements of BS1449: Part 1 Specification for carbon and carbon-manganese plate, sheet and strip. It is cold rolled and the surface finish falls within the BR category ie. bright finish	Complies with BS2870: CZ 108 common brass. It is produced by the cold rolling process and the edges are rotary sheared. The surface finish is of a high quality, free from blemishes and with tolerances controlled to close limits.	Polyester has a high tensile strength of up to 276MPa and has an excellent resistance to moisture and most chemicals. Polypropylene has a tensile strength of 25MPa and is resistant to aqueous solutions of non-oxidising or inorganic compounds, most alcohols, ketones and mineral oils.
Typical applications	Shims for tolerance compensation, alignment, end play adjustment, washers, small pressing and a wide range of uses in tool rooms, maintenance, shops, etc.	Shim stock is used in toolrooms, maintenance workshops, prototype shops and production departments for a range of applications such as alignment, end play adjustment, tolerance and wear compensation.	Coloured coded plastic shims are an effective replacement for metal shims of various descriptions.
Tolerances	Thickness / Tolerance ± Up to and including 0.006in: 0.006in Over 0.006in up to and including 0.015in: 0.010in	Thickness / Tolerance ± Up to and including 0.006in: 10% Over 0.006in up to and including 0.010in: 0.0006in 0.015in: 0.0008in	Thickness / Tolerance ± Up to and including 0.004in: ±10% Over 0.005in up to and including 0.010in: ±5% 0.015in and 0.020in: ±10%
Physical properties	Tensile strength N/mm^2 540 Hardness VPN min 165	Tempers and VPN hardness: Temper / Hardness VPN Soft: 80 max Quarter hard: 75-110 Half Hard: 110-135 Hard: 135-165 Extra hard: 165min	Polyester: Impact strength 2350N-cm/mm Density 1,377 Moisture absorption <0.8% (Immersion for 24 hrs at 23˚C) Polypropylene: Impact strength 240psi Specific gravity 1.395-1.405 Moisture absorption (prolonged immersion) 0.6%