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THE GOLD STANDARD IN PLASTICS

THERMOPLASTICS INFORMATION

& General Guidelines

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With more than 60 years of experience distributing the highest quality plastic resins, you can count on us. We are one of the leading North American distributors of application-specific products with strategically placed warehouses, packaging, and bulk terminal locations across North America – **www.mholland.com**

WE'RE RESPONSIVE

We always seek to exceed expectations. We put your needs first, making sure your business runs smoothly and efficiently.

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We see opportunities where others don't. We find solutions when others can't.

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Definitions & Test Methods

Property	Description	Units		ASTM Test
		English	Metric	
Brittle Temperature	The temperature at which a material will demonstrate a brittle failure when impacted.	°F	°C	D746
Bulk Density	The weight of a given unit of resin.	lb/ft^3	kg/m^3	D1895B
Chemical Resistance	Indication of suitability of a material in an end use environment.	Chemical Resistance Charts		
Coefficient of Linear Thermal Expansion (CLTE)	Change in dimension with temperature.	in/in-°F	cm/cm-°C	D696
Compressive Strength	Maximum load that a material can withstand without deformation in compression.	psi	kg/cm^2	D695
Continuous Service Temperature	The highest temperature that a material is known to be able to perform reliably; above this point material may be unsuitable for some applications.	°F	°C	
Crystallization Point (T_c)	The temperature at which a polymer will crystallize upon heating or cooling.	°F	°C	D3418
Deflection Temperature Under Load (DTUL)	The temperature at which a material deflects 0.01 inches at the reported load. The load is reported as either 66 psi or 264 psi. Also referred to as heat deflection temperature (HDT).	°F	°C	D648
Density	Mass per unit volume; similar to specific gravity. Within a polymer family, higher density can be indicative of a more crystalline polymer.	lb/in^3	g/cm^3	D792
Dielectric Constant	Measure of how easily a material is polarized.	Constant		D150
Dielectric Strength	Maximum electric field strength a material can withstand without loss in insulating properties.	V/10^{-3}-in	V/mm	D149
Dissipation Factor	Indication of how a material dissipates energy through heat.	Constant		D150
Elongation, Break	The amount of stretching a material will undergo in the direction of orientation at the point of failure.	%		D638
Elongation, Yield	The amount of stretching a material will undergo before permanent deformation occurs.	%		D638

Definitions & Test Methods cont.

Property	Description	Units		ASTM Test
		English	Metric	
Falling Dart Impact	A practical impact test used to determine the amount of energy needed to cause failure in a thin film or flexible sheet 50% of the time.	lb	g	D1709
Flexural Modulus	A 3-point bending test; the modulus is the slope of the line along the stress-strain curve between the origin and a selected point on the curve.	psi	kg/cm^2	D790
Flexural Strength, Yield	The maximum amount of flexural stress that can be applied prior to a material's permanent deformation.	psi	kg/cm^2	D790
Gardner Impact	A practical test used to evaluate the impact strength or toughness of a given material. The test provides the average impact energy that will break the sample 50% of the time.	in-lbf	J	D5420
Glass Transition Temperature (T_g)	The temperature at which a polymer changes from being hard and brittle to a soft rubbery state.	°F	°C	D3418
Hardness	Measure of a material's resistance to a permanent indentation. Different scales are used for different materials.	Shore A, Shore D, Rockwell		D2240 (Shore); D785 (Rockwell)
Injection Molding Pressure	Any of the pressures used to control the molding process (e.g. hydraulic pressure, plastic pressure, back pressure, etc.)	psi	kg/cm^2	
Izod Impact, Notched	A measure of brittleness of a pre-notched material in an impact deformation.	ft-lb/in	kg-cm/cm	D256
Linear Mold Shrinkage	The difference between the size of the part and the size of the mold cavity. Shrinkage is material dependent and influenced by part dimensions and molding conditions.	in/in		D955
Melt Flow	Melt flow is a measure of a material's resistance to flow at low shear; a lower melt flow material is more resistant to flow. The temperature and load test conditions are material specific (e.g. polyethylene at 190°C and 2.16 kg).	g/10 min		D1238

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Definitions & Test Methods cont.

Property	Description	Units		ASTM Test
		English	Metric	
Melting Point (T_m)	The temperature at which a crystalline polymer melts.	°F	°C	D3418
Processing Temperature	The recommended temperatures required for processing a specific material.	°F	°C	
Refractive Index	Measure of how light passes through a material.	Constant		D542
Relative Temperature Index (RTI)	The maximum temperature below which a material maintains its electrical and mechanical integrity over a reasonable period; see UL 746B.	°C/mm		
Specific Gravity	The measure of the ratio of mass of a given volume of material to an equal amount of water.			D792
Surface Resistivity	Measure of loss of current at the surface of a material.	Ohm		D257
Tensile Modulus	The measure of the stiffness of a material. Also referred to as Young's Modulus.	psi	kg/cm^2	D638
Tensile Strength, Break	The highest stress that a material can undergo to the point of failure.	psi	kg/cm^2	D638
Tensile Strength, Yield	The highest stress that a material can undergo before permanent deformation.	psi	kg/cm^2	D638
Thermal Conductivity	The rate that a material transfers heat through a given thickness.	BTU-in/hr-ft^2-°F	cal-cm/sec-cm^2-°C	C177
Vicat Softening Point	Temperature at which a material begins to soften.	°F	°C	D1525
Volume Resistivity	Measure of loss of current through the thickness of a material; high resistivity equals low conductivity.	Ohm-cm		D257
Water Absorption	The capacity of a material to absorb water.	%		D570

Processing Guidelines for Injection Molding Materials

Material	Drying Time (Hours)	Drying Temperature °F (°C)	Barrel Set Temperature Range °F (°C)	Actual Melt Temperature Range °F (°C)	Mold Surface Temperature Range °F (°C)
Acrylonitrile - Butadiene - Styrene (ABS)	2 - 4	175 - 185 (80 - 85)	380 - 500 (195 - 260)	425 - 510 (220 - 265)	100 - 160 (40 - 70)
High Heat ABS	2 - 4	175 - 210 (80 - 100)	450 - 520 (230 - 270)	450 - 525 (230 - 275)	100 - 180 (40 - 80)
Flame Retardant (ABS)	3 - 5	180 - 190 (80 - 90)	350 - 420 (175 - 215)	390 - 430 (200 - 220)	120 - 160 (50 - 70)
Acetal - Copolymer	3 - 4	175 - 210 (80 - 100)	340 - 400 (170 - 205)	370 - 410 (190 - 210)	140 - 210 (60 - 100)
Acrylonitrile - Sytrene - Acrylic Rubber (ASA)	2 - 4	160 - 180 (70 - 80)	420 - 500 (215 - 260)	480 - 500 (250 - 260)	100 - 180 (40 - 80)
Polymethyl Methacrylate (Acrylic or PMMA)	4 - 6	170 - 190 (75 - 90)	430 - 480 (220 - 250)	460 - 490 (240 - 255)	120 - 180 (50 - 85)
Ethylene Vinyl Acetate (EVA)	NA	NA	300 - 380 (150 - 195)	350 - 380 (175 - 195)	60 - 80 (15 - 25)
Nylon 6	3 - 5	170 - 180 (75 - 80)	450 - 530 (230 - 275)	490 - 540 (255 - 280)	150 - 210 (65 - 100)
Nylon 6/6	3 - 5	170 - 180 (75 - 80)	480 - 550 (250 - 290)	520 - 580 (270 - 305)	150 - 210 (65 - 100)
Nylon 6/10	3 - 5	170 - 180 (75 - 80)	460 - 510 (240 - 265)	490 - 520 (255 - 270)	130 - 180 (55 - 80)
Nylon 6/12	3 - 5	170 - 180 (75 - 80)	460 - 540 (240 - 280)	480 - 550 (250 - 290)	120 - 180 (50 - 80)
Nylon/ABS Blends	3 - 5	170 - 180 (75 - 80)	450 - 500 (230 - 260)	480 - 510 (250 - 265)	130 - 180 (55 - 80)
Polybutylene Terephthalate (PBT)	3 - 5	220 - 250 (105 - 120)	480 - 520 (250 - 270)	480 - 530 (250 - 275)	130 - 180 (55 - 80)
Polycarbonate (PC)	3 - 5	250 - 265 (120 - 130)	480 - 560 (250 - 295)	520 - 580 (270 - 305)	150 - 210 (65 - 100)
PC/ABS	3 - 5	190 - 230 (90 - 110)	460 - 530 (240 - 275)	480 - 540 (250 - 280)	130 - 180 (55 - 80)
PC/ASA	3 - 5	190 - 210 (90 - 100)	460 - 510 (240 - 265)	490 - 520 (255 - 270)	130 - 180 (55 - 80)
PC/PET	4 - 6	215 - 230 (100 - 110)	480 - 520 (250 - 270)	490 - 540 (255 - 280)	130 - 180 (55 - 80)
Polyethylene Terephthalate (PET)	4 - 6	250 - 275 (120 - 135)	500 - 570 (260 - 300)	540 - 580 (280 - 305)	210 - 230 (100 - 110)
High Density Polyethylene (HDPE)	NA	NA	350 - 470 (175 - 245)	380 - 480 (195 - 250)	50 - 120 (10 - 50)
Low Density Polyethylene - Linear Low Density Polyethylene (LDPE/LLDPE)	NA	NA	350 - 410 (175 - 210)	380 - 420 (195 - 215)	60 - 110 (15 - 45)

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Processing Guidelines cont.

Material	Drying Time (Hours)	Drying Temperature °F (°C)	Barrel Set Temperature Range °F (°C)	Actual Melt Temperature Range °F (°C)	Mold Surface Temperature Range °F (°C)
Polyether Etherketone (PEEK)	3 - 4	280 - 320 (140 - 160)	680 - 740 (360 - 395)	710 - 750 (375 - 400)	330 - 420 (165 - 215)
Polyphenylene Sulfide (PPS)	2 - 4	300 - 350 (150 - 175)	600 - 650 (315 - 345)	630 - 650 (330 - 345)	280 - 300 (140 - 150)
Polypropylene (PP)	NA	NA	380 - 470 (195 - 245)	400 - 480 (205 - 250)	80 - 120 (25 - 50)
Polypropylene – 20% Talc or $CaCO_3$ Filled	2 - 4	80 - 105	200 - 230	205 - 260	10 - 25
General Purpose Polystyrene (GPPS)	NA	NA	380 - 510 (195 - 265)	420 - 520 (215 - 270)	80 - 180 (25 - 80)
High Impact Polystyrene (HIPS)	NA	NA	380 - 490 (195 - 255)	420 - 500 (215 - 260)	80 - 180 (25 - 80)
Polysulfone (PSU)	3 - 6	280 - 320 (140 - 160)	600 - 720 (315 - 380)	630 - 730 (330 - 390)	250 - 320 (120 - 160)
Polyether Sulfone (PESU)	3 - 6	280 - 320 (140 - 160)	620 - 730 (325 - 390)	660 - 720 (350 - 380)	280 - 320 (140 - 160)
Polyphenyl Sulfone (PPSU)	3 - 6	300 - 310 (150 - 155)	670 - 720 (355 - 380)	680 - 740 (360 - 395)	250 - 330 (120 - 165)
Styrene Acrylonitrile (SAN)	2 - 4	170 - 180 (75 - 80)	400 - 500 (205 - 260)	460 - 520 (240 - 270)	120 - 180 (50 - 80)
Styrene Methylethacrylate (SMMA)	1 - 2	150 - 180 (65 - 80)	360 - 440 (180 - 225)	410 - 470 (210 - 245)	90 - 130 (30 - 55)
Thermoplastics Olefins (TPO)	1 - 3	130 - 160 (55 - 70)	360 - 410 (180 - 210)	380 - 420 (195 - 215)	90 - 130 (30 - 55)
Thermoplastic Vulcanizates (TPV)	2 - 4	170 - 180 (75 - 80)	370 - 430 (190 - 220)	370 - 430 (190 - 220)	90 - 130 (30 - 55)

"Our first choice is to go with M. Holland because they have the broadest range of materials and their expertise is top notch."

[M. Holland customer for over 20 years]

Nominal Comparative Properties Chart of Thermoplastic Materials[1]

Resin Family/Type	General Properties			Mechanical Properties					
	Sp. Gravity	Bulk Density of Pellets[2]	Post Mold Shrinkage 0.125" Wall[3]	Tensile Strength at Break	Elongation (Ultimate) or Yield (Y)	Tensile Modulus	Flex Strength	Flex Modulus	Hardness A,D,C,R,M[4]
ASTM	D792	D1895B		D638	D638	D638	D790	D790	
Units		lb/ft³	in/in of Wall Thk	kpsi	%	kpsi	kpsi	kpsi	
ABS – High Impact Gen Purpose	1.04	46-50	0.0055 - 0.008	6.4	25		10.5	350	R116
ABS – High Flow, gloss	1.05	46-50	0.0055 - 0.008	6.8	20		10	370	R115
ABS – Very High Impact	1.03	46-50	0.0055 - 0.008	5.7	40		9.1	320	R102
ABS – High Heat	1.06	46-50	0.0055 - 0.008	6.2	15		10.6	350	R115
ABS – FR	1.19	48-52	0.0055 - 0.008	5.7	15		8.5	300	R100
ABS – clear (mABS)	1.08	40-46	0.0045 - 0.0075	6.1	20	276	8.7		
ABS Nylon Alloy	1.07	44-48	0.008 - 0.010	7.3	20	320	10.7	320	
Acetal Copolymer (POM)	1.41	40-46	0.016 - 0.025	9.3	30	421	13.1	377	
Acrylic (PMMA)	1.19	40-44	0.003 - 0.008	10	5	470	17	490	M95
Acrylic – Impact	1.16		0.004 - 0.008	6.4	5	250	9.4	250	M37
ASA	1.07	46-50	0.0045 - 0.0075	7	9	334	10.2		
Nylon – High Temp – 35% GF	1.43		0.003 - 0.006	30.5	3	1740			
Nylon 6 (Dry)	1.13	40-44	0.012 - 0.022	12.3	7		16	450	R120
Nylon 6 – 30% GF	1.39		0.003 - 0.005	28.3	3.5		43.1	1,300	R120
Nylon 6/6 (Dry)	1.13	40-44	0.012 - 0.022	11.9	50	460	13.8	420	R121
Nylon 6/6 (Conditioned)	1.13	40-44	0.012 - 0.022	11.1	300			175	R108
Nylon 6/6 – 33% GF	1.41		0.002 - 0.008	29	3.1	1.465	40	1.335	M100
Nylon 6/6 – Med Impact	1.09	40-44	0.013 - 0.024	8.7	30			350	R115
Nylon 6/6 – High Impact	1.07	40-44	0.013 - 0.024	6.8	50			276	R112
Nylon 6/6 – FR – 35% GF	1.45		0.002 - 0.008	25.4	2.7	1,640		1552	M1
PC	1.2	40-45	0.005 - 0.007	9.5	120	350	12.5	350	M75
PC – FR	1.2	48-52	0.005 - 0.007	9.5	115	350	12.5	350	M75
PC – 20% GF	1.34		0.002 - 0.005	12	2.6	840	19	800	M75
PC/ABS	1.14	46-49	0.0045 - 0.008	7.8	>50	330	13	335	R110
PC/ABS – FR	1.18		0.004 - 0.008	8.7	>50	390	14	360	R120
PC/PET or PC/PBT Alloy	1.22	40-46	0.007 - 0.015	7	160		11	320	R116
PBT	1.3	46-50	0.013 - 0.018	8.7	50	363	12	334	R117

[1] It is the sole responsibility of the end user for the testing, performance and safety of their product. M. Holland Company makes no recommendations for materials in any applications but only suggestions of materials to consider and test prior to producing a product for release to the market place.

The information contained in this brochure is to the best of our knowledge correct and has been collected from published sources available to the general public. M. Holland Company makes no guarantee that the information in this brochure is accurate or specific to any grade of material

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	Thermal Properties				Underwriters Laboratories				Typical Clarity (for this Resin Family)
	Izod Impact (Notched)	Heat Deflection Temp (HDT)	HDT	Co. Linear Thermal Exp. (CLTE)	Relative Thermal (RTI) Index (STR)	RTI / Impact	RTI / Electrical	Typical UL[5] Flame Rating	++ if Clear form is also available
ASTM	D256	D648	D648	D696 (73F)	746	746	746	UL 94 //	
ASTM	ft-lb/in	°F at 66psi	°F at 264psi	in/in/°F	°C	°C	°C	Min thk (mm)	
ABS – Hi Impact Gen Purpose	5.6	197	176	0.00005	90	80	90	HB//1.5	Opaque
ABS – High Flow, gloss	3.5	192	172	0.00005	90	80	90	HB//1.5	Opaque
ABS – Very High Impact	8.4	192	169	0.00005	90	80	90	HB//1.5	Opaque
ABS – High Heat	2.8		222	0.000053	60	60	60	HB//1.5	Opaque
ABS – FR	4		165	0.000045	80	80	80	V-0//1.5;5V-A//2.5	Opaque
ABS – clear (mABS)	0.2	199	189	0.00005	50	50	50	HB//1.5	Clear
ABS – Nylon Alloy	3	190	151	0.00006	60	60	60	HB//0.80	Opaque
Acetal Copolymer (POM)	1.2	310	212	0.000061	90	90	105	HB//0.75	Opaque
Acrylic (PMMA)	0.36		201	0.00004	90	90	90	HB//1.5	Clear
Acrylic – Impact	1		195	0.00005	90	90	90	HB//1.5	Clear
ASA	4	214	207	0.00005	90	90	90	HB//1.5	Opaque
Nylon – High Temp – 35% GF			518	0.000011					Opaque
Nylon 6 (Dry)	0.9	370	167	0.00004	105	105	130	V-2//1.5	Opaque
Nylon 6 – 30% GF	2.8	410	424	0.00004	140	115	140	HB	Opaque
Nylon 6/6 (Dry)	0.9	400	150	0.00004					Opaque
Nylon 6/6 (Conditioned)	2			0.00004	80	80	125	V-2//0.710	Opaque
Nylon 6/6 – 33% GF	2	500	482	0.000013	115	115	125	HB//1.5	Opaque
Nylon 6/6 – Med Impact	4	368	150	0.000045	65	65	65	HB//0.75	Opaque
Nylon 6/6 – High Impact	16	298	142	0.00005	65	65	65	HB//0.75	Opaque
Nylon 6/6 – FR – 35% GF	3		477	0.000015					Opaque
PC	15	279	255	0.000036	125	115	125	V-2//0.75; HB//2.5	Clear
PC – FR	15	271	255	0.000036	125	115	125	V-2//1.5; V-0//3	Opaque ++
PC – 20% GF	2	288	280	0.000017	125	125	130	V-0//1.5; V-0,5V-A//3	Opaque
PC/ABS	11	223	260	0.000042	60	60	60	HB//.85	Opaque
PC/ABS – FR	14	240	260	0.000042	85	85	95	V-0//1.5;V-0,5V-A//3	Opaque
PC/PET or PC/PBT Alloy	16	240	190	0.00004	75	75	75	HB//1.5	Opaque
PBT	1	327	150	0.000045		105	130	HB//1.5	Opaque

and assumes no liability for results connected with the use of information or data contained herein. Consult the material manufacturer for property data on specific grades.

2 Bulk Density: Can vary greatly based on pellet cut and precise resin grade specific gravity.

Nominal Comparative Properties cont.

Resin Family/Type	General Properties			Mechanical Properties					
	Sp. Gravity	Bulk Density of Pellets	Post Mold Shrinkage 0.125" Wall	Tensile Strength at Break	Elongation (Ultimate) or Yield (Y)	Tensile Modulus	Flex Strength	Flex Modulus	Hardness A,D,C,R,M
ASTM	D792	D1895B		D638	D638	D638	D790	D790	
Units		lb/ft^3	in/in of Wall Thk	kpsi	%	kpsi	kpsi	kpsi	
PBT – 30% GF	1.53		0.002 - 0.006	19.6	2.7	1350	27.5	1170	M90
PBT – 30% GF-FR	1.68		0.002 - 0.006	20.3	2.1	1670	31.9	1400	M90
EVA (18%VA)	0.938	31-36	0.012 - 0.020	2.2	680			7.5	90A
LDPE	0.920	30-35	0.012 - 0.020	1.3	600			29	49D
LLDPE – Metallocene	0.885	20-28	0.015 - 0.030	0.37	>1000			5.5	85A
LLDPE	0.924	26-32	0.013 - 0.025	2	>600			50	
HDPE	0.952	35-39	0.016 - 0.034	3.9	900			184	63D
PEEK	1.3			13.8	25	508	21.2	587	M97
PEI	1.27	50-54	0.003 - 0.008	16	60	520	24	510	M109
PES	1.37	50-54	0.003 - 0.007	13					
PES – 30% GF	1.6		0.001 - 0.003	20.3	1.9	1450			
PSU	1.23	48-52	0.003 - 0.007	11.6	5.7 (Y)	377			
PPSU	1.29			10.7	7.4 (Y)	329			
PPS – 40% GF	1.68		0.001 - 0.005	22	1	2100	29		
PP – Homopolymer	0.904	33-37	0.013 - 0.019	4.8	11 (Y)	220		220	R103
PP – Impact Copolymer	0.904	31-35	0.013 - 0.019	3.6	8.5 (Y)			165	R80
PP – Random Copolymer	0.904	33-37	0.013 - 0.018	4.5	10 (Y)			150	
PP – 20% Talc	1.05		0.007 - 0.012	4.5	10			320	R92
PP – 20% $CaCO_3$	1.05		0.010 - 0.014	4	20			250	R92
PP – 20% GF CC	1.04		0.002 - 0.006	8.5	3		12	560	R94
PP – 20% Talc - Impact	1.05		0.008 - 0.014	3.7	15			260	R85
PPO or PPE	1.06	47-51	0.004 - 0.008	7.3	20		13	370	R119
GPPS	1.04	37-41	0.035 - 0.007	7.1	<1	390	12	460	
HIPS	1.04	39-43	0.004 - 0.007	3.3	50	310	6.4	330	
PVC – Flexible 70A	1.2			2.5	400				72A
PVC – Rigid	1.45	42-50	0.003 - 0.007	6.2		395	12.5	410	75D
SAN	1.08	40-46	0.003 - 0.007	11	5	551	19.6		
TPE (SEBS) 70A	0.892	46-50	0.016 - 0.024	1.3	1100 (Y)				70A
TPU (polyester based) 70A	1.18	46-50		5	580			2	
TPV 70R	0.93	44-48		0.82	500				73A

[3] Shrinkage: There are many factors that influence the final part shrinkage, including but not limited to: wall thickness, mold and melt temps, packing pressure, flow length, etc. The values are provided for informational purposes only, and NO tooling should be designed or cut based on these values. Always speak to your M. Holland Technical Service Engineer before beginning your mold design efforts.

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	Thermal Properties				Underwriters Laboratories				Typical Clarity (for this Resin Family)
	Izod Impact (Notched)	Heat Deflection Temp (HDT)	HDT	Co. Linear Thermal Exp. (CLTE)	Relative Thermal (RTI) Index (STR)	RTI / Impact	RTI / Electrical	Typical UL Flame Rating	++ if Clear form is also available
ASTM	D256	D648	D648	D696 (73F)	746	746	746	UL 94 //	
ASTM	ft-lb/in	°F at 66psi	°F at 264psi	in/in/°F	°C	°C	°C	Min thk (mm)	
PBT – 30% GF	1.7	428	410	0.000014		105	130	HB//1.5	Opaque
PBT – 30% GF-FR	1.1	428	390	0.000014	130	130	140	V-0//1.5	Opaque
EVA (18%VA)	NB								Translucent
LDPE	NB								Translucent
LLDPE – Metallocene	NB								Translucent
LLDPE		117							Opaque
HDPE		163			50	50	50	HB//1.5	Opaque
PEEK	1.7		315	0.000024	50	50	50	V-1//0.75;V-0//1.6	Opaque
PEI	1	410	394	0.000031	170	170	170	V-0//0.75; 5V-A//3	Amber Transparent
PES	1.5		400	0.000052	190	180	180	V-0//1.5	Amber Transparent
PES – 30% GF	2		428	0.000015	190	180	180	V-0//1.5	Opaque
PSU	1.2		332	0.000053	155	130	155	HB//0.75	Clear/translucent
PPSU	15		385	0.000055				V-0//1.5	Opaque
PPS – 40% GF	1.4		>500	0.000011					Opaque
PP – Homopolymer	0.7	230						HB//3	Opaque
PP – Impact Copolymer	2.5				100	100	100	HB//0.9	Opaque
PP – Random Copolymer	1								Clear/translucent
PP – 20% Talc	0.8	250	165	0.000033	65	65	65	HB//1.5	Opaque
PP – 20% $CaCO_3$	0.9	215	140	0.000031	65	65	65	HB//1.5	Opaque
PP – 20% GF CC	1.2	305	265	0.000024				HB//1.5	Opaque
PP – 20% Talc - Impact	1.4	210	155	0.000033				HB//2	Opaque
PPO or PPE	4	269	244	0.000051	221	194	221	HB//1.5	Opaque
GPPS	0.3		200		50	50	50	HB//1.5	Clear
HIPS	2.5		195		50	50	50	HB//1.0	Opaque
PVC – Flexible 70A	NB								Opaque to clear
PVC – Rigid	15		168	0.00003				V-0//1.5	Opaque to clear
SAN	0.37	214	192	0.000039					Clear
TPE (SEBS) 70A	NB							HB 1.5	Opaque-translucent
TPU (polyester based) 70A									Opaque-translucent
TPV 70R	NB								Opaque

4 Hardness: The hardness values provided are approximate and may vary in test technique, indentor type, and delay time. Note that various hardness tests and scales are shown; do not attempt to cross reference from one scale to another, except for approximate , informational purposes.

5 UL: The UL information given – Flame rating and RTI – are a composite, loosely representing a general capability of a family of polymer resins. Be sure to refer to the UL Yellow Card information for UL status of a precise resin grade prior to material selection.

Conversion Table

	US	To Metric	Conversion Factor	Metric	To US	Conversion Factor
Bulk Density	lb/ft³	kg/m³	16.019	kg/m³	lb/ft³	0.0624259
Density	lb/in³	g/cm³	27.68	g/cm³	lb/in³	0.0361272
	lb/ft³	kg/m³	16.019	kg/m³	lb/ft³	0.0624259
Force	lbf	N	4.448	N	lbf	0.2248201
	lbf	kN	0.004448	kN	lbf	224.8201439
Impact Energy	ft-lbf/in	J/m	53.38	J/m	ft-lbf/inch	0.0187336
	ft-lbf/in²	KJ/m²	2.103	KJ/m²	ft-lbf/in²	0.4755112
	ft-lbf	J	1.356	J	ft-lbf	0.7374631
Length	inch	mm	25.4	mm	inch	0.0393701
	inch	cm	2.54	cm	inch	0.3937008
	inch	m	0.0254	m	inch	39.3701
	ft	m	3.281	m	ft	0.3047851
Mass	lb	kg	0.4536	kg	lb	2.2046
	lb	g	453.6	g	lb	0.002205
	lb	metric ton	0.0004536	metric ton	lb	2204.6
	oz	g	28.35	g	oz	0.0353
Pressure (Stress)	psi	Pa	6895	Pa	psi	0.000145
	psi	Mpa	0.006895	Mpa	psi	145.0
	psi	Gpa	0.000006895	Gpa	psi	145032.63
	psi	atm	0.0680	atm	psi	14.71
	psi	bar	0.0689	bar	atm	14.50
Specific Heat Capacity	Btu/(lb*°F)	J/(kg*°C)	4186.8	J/(kg*°C)	Btu/(lb*°F)	0.0002388
Temperature	F	C	(F - 32)/1.8	C	F	1.8*C + 32
Velocity	in/min	cm/s	0.0423	cm/s	in/min	23.64
	ft/min	m/min	0.3048	m/min	ft/min	3.281
	ft/s	m/s	0.3048	m/s	ft/s	3.281
Volume	gallon	liter	3.785	liter	gallon	0.2642
	in³	cm³	16.3871	cm³	in³	0.0610
	ft³	m³	0.0283	m³	ft³	35.34
	ft³	cm³	28316.8	cm³	ft³	0.0000353

VALUABLE FORMULAS

Oz/in³ = Sp. Grav * 16.4/28.375
$/in³ = $/lb* 0.3611 * Sp. Grav

Actual Shot size = Sp. Grav. (selected resin)/ Sp. Grav. (PS) * Machine rated shot size
Sp. Grav. (PS) = 1.04

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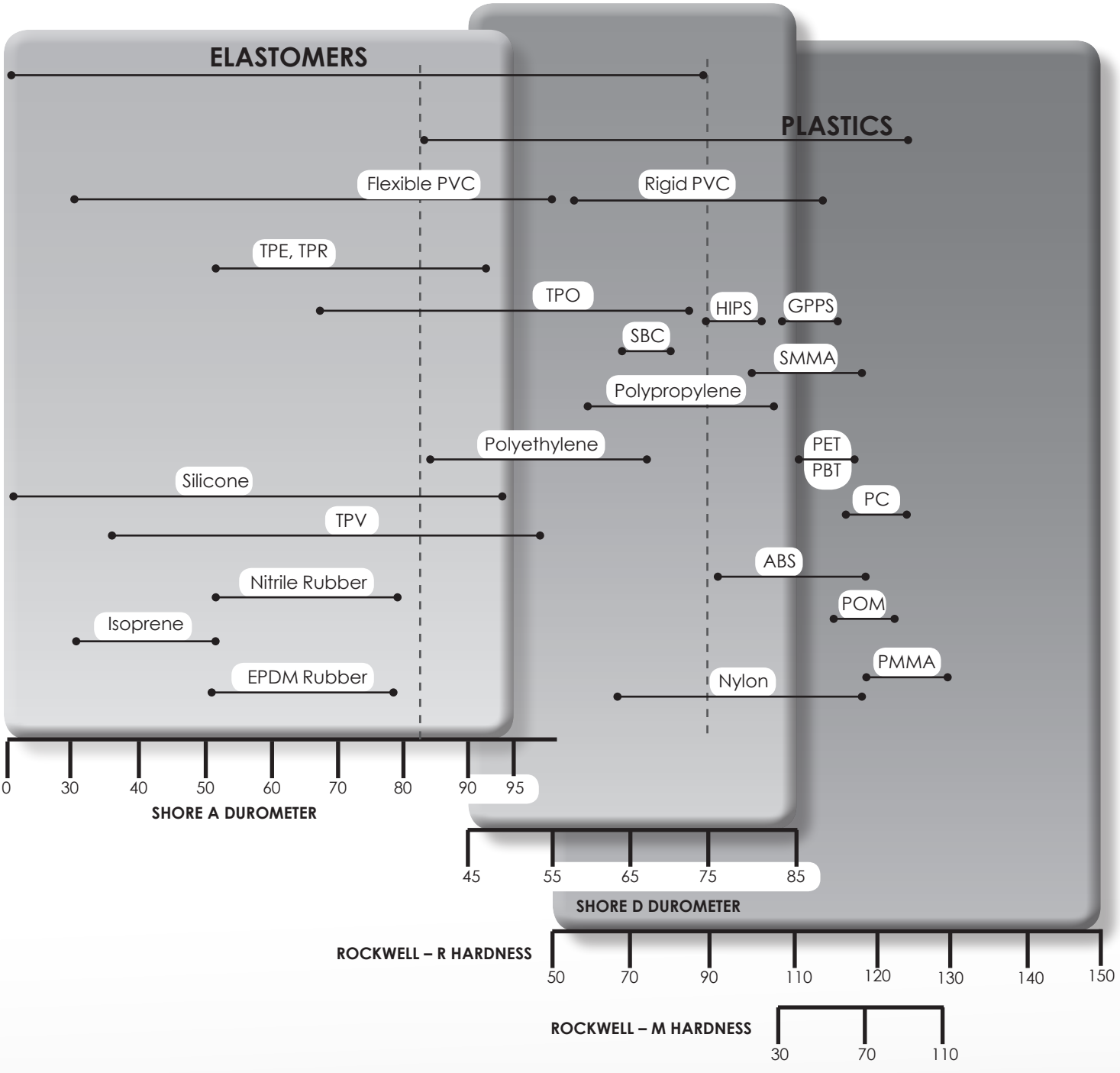
Material Hardness Comparison



This chart is for comparative reference only. All values are approximate and a specific grade may vary from the range depicted.

Regulatory Information

CONEG - Coalition of North East Governors

- Non-partisan association of the Governors of CT, ME, MA, NH, NJ, RI, and VT
- Formed the Toxics in Packaging Clearinghouse in an effort to reduce the amount of heavy metals in packaging and packaging components
- Specifically targets:
  - Cadmium (Cd)
  - Hexavalent Chromium (Cf VI)
  - Mercury (Hg)
  - Lead (Pb)
- The sum of the concentration of these substances has to be less than 100 ppm by weight

DMF – Drug Master File

- A submission to the Food and Drug Administration (FDA) that may be used to provide confidential detailed information about facilities, processes, or articles used in manufacturing, processing, packaging, and storing of one or more human drugs
- Producer issues Letters of Authorization to the FDA to allow customers to refer to a DMF
- A copy of the letter will be sent to the applicant

FDA – U.S. Food and Drug Administration

- Federal Agency responsible for ensuring foods are safe, wholesome and sanitary; human and veterinary drugs, biological products, and medical devices are safe and effective; cosmetics are safe; and electronic products that emit radiation are safe
- Food for Human Consumption Regulation applicable to polymers: 21 CFR 177
  - Has different levels of compliance

  QUESTIONS TO ASK:
  - What is the application (e.g. part used for cooking, room temperature storage, frozen storage, etc.)?
  - What type of foods will come in contact with the resin (e.g. acidic, alcoholic, oils or fats, etc.)?

IMDS - International Material Data System

- Material data system for the automotive industry
- Joint development of Audi, BMW, Daimler Chrysler, Ford, Opel, Porsche, VW and Volvo
- Some materials used for car manufacture are archived and maintained in IMDS
- Some of our suppliers do NOT participate in IMDS

NSF - National Sanitation Foundation, International

- Develops national standards for food, water, indoor air, and the environment
- Applicants have to submit formulation for toxicology review (tests are normally done on the finished part)
- Most common standards for plastic:
  - Standard 014 – Plastics Piping System Components and Related Materials
  - Standard 051 – Food Equipment Materials
  - Standard 061 – Drinking Water System Components - Health Effects

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PROP 65 – California Proposition 65

- Intended to protect California citizens and the State's drinking water sources from chemicals known to cause cancer, birth defects (or other reproductive harm), and to inform citizens about exposures to such chemicals
- Requires Governor to revise and republish at least once per year the list of chemicals known to the State of California to cause cancer or reproductive toxicity

REACH – Registration, Evaluation, and Authorization of Chemicals

- European Union law that came into effect in June 2007
- Requires ALL chemicals of one ton or more in volume that are manufactured in or imported into the European Union each year to be tested for health and safety and registered with a new central European authority
- Substances of Very High Concern (SVHC) – List of chemicals for which it has been proposed that the use within the European Union be subject to authorization under REACH. Chemicals on this list can be: carcinogenic, mutagenic, toxic for reproduction, and/or persistent, bioaccumulative and toxic. List updates at least once annually

RoHS – Restriction of the Use of Certain Hazardous Substances

- EU Directive (2011/65/EU)
- Specifically addresses the reduction of use and ultimate banning of the following substances:
  - Cadmium (Cd)
  - Hexavalent Chromium (Cr VI)
  - Mercury (Hg)
  - Lead (Pb)
  - Polybrominated biphenyls (PBBs)
  - Polybrominated diphenyl ethers (PBDEs)
- The maximum concentrations are 0.1% or 1000 ppm (except Cd which is limited to 0.01% or 100 ppm) by weight of homogenous material

UL – Underwriters Laboratories

- Independent product safety certification organization
- Main UL evaluations for plastic materials:

UL 94 Flammability:

- HB – Horizontal Burning Test
- V-0, V-1 & V-2 – Vertical Burning Test (V-0 is the highest performance)
- 5V-A & 5V-B – Vertical Burning test and a Burn Through Test (most stringent tests)

UL 746B Relative Thermal Index (RTI)

- Long-term thermal aging

UL 746C Outdoor Suitability:

- f1: Material has met both UV and water immersion requirements
- f2: Material has only met or has been tested partially for UV or water immersion

USP - United States Pharmacopeia

- Official public standards-setting authority for all prescription and over-the-counter medicines, dietary supplements, and other healthcare products manufactured and sold in the United States
- There are a variety of levels of classifications for plastic parts in medical devices
- Most common: Class VI (Long-term or permanent contact with human tissue or fluids, or permanent implantation in the body)

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Known as an industry leader in technical knowledge of thermoplastic resins, M. Holland has compiled this general guide to provide valuable technical information that can assist in the selection of the materials needed for your next project.

Authors

This information was compiled by M. Holland and Christler Chemical and Plastics, Inc. These companies will build upon the companies' complementary goals of providing value added, technically driven solutions to customers and continued growth to their world class suppliers.

Properties listed on these charts are typical values stated on data sheets from material producers and are presented in this book for comparative purposes only. Consult M. Holland technical service for property data for specific grades.

The information contained on these charts, to the best our knowledge is true and accurate, however all recommendations or suggestions are made without guarantee. The M. Holland Company disclaims any liability for results connected with the use of information contained herein.

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