English version

ULTIMHEAT® MUSEUM

Jacques Jumeau

Technology of components used in heating.

Chapter 37

Comparative characteristics of thermoplastics

1ère édition 2010/04/23
Mise à jour 2019/02/20

Comparative table of the main thermoplastics used in electrothermal construction (average values for standard grades)

Material	Polyamide	Polycarbonate	Acrylonitrile butadiene styrene	Polypropylene	Polyphenylene sulfide	Polyphenylene Oxide
Acronym	PA66	PC	ABS	PP	PPS	PPO
Density (gr/cm3)	1.15	1.2	1.04	0.91	1.34	1.06
Tensile strenght (MPa)	2800	2400/2500	2300	1000	1100/3300	2500
Flexural strength (MPa)	2000	2200	2300	1300	3000	2450
Elongation at break (%)	70	80	10	650	3	45
Hardness (shore D)	80	78	65	73	88 /90	84
Resistance to shock (Izod) (J/m)	180	600/850	26	21/53	70	160/200
Melting point (°C)	260	228	130	165	288	250
Max temperature of permanent use (°C)	120	130	96	100	240	115
Momentary resistance to heat (°C)	160	145	103	120	270	135
Dielectric strength (kV/mm)	24	35	41	25	23	38
Electric resistance (Ω.cm)	10^{12}	10^{16}	10^{13}	10^{16}	10^{16}	10^{15}
Water absorption after 24H (%)	2	0.2	0.2	0.01	0.03	0.25
Saturation in water (%)	8	0.35	1	0.2	0.09	0.8
Flammability (UL 94)	HB*	V1	HB*	HB*	VO	V0 - 5VA

* Flammability can vary widely depending on the additives used

Resistance to chemicals

Material	Polyamide	Polycarbonate	Acrylonitrile butadiene styrene	Polypropylene	Polyphenylene sulfide	Polyphenylene Oxide
Acronym	**PA66**	**PC**	**ABS**	**PP**	**PPS**	**PPO**
Resistance to acids	Good up to PH 5	Attacked by strong acids	May be attacked by some strong acids	Excellent for weak acids. Low for strong acids.	Excellent	Good for weak acids. Medium for strong acids
Resistance to bases	Good up to PH 11	Attacked	None	Excellent	Excellent	Excellent
Resistance to organic solvents	Resistant to most organic solvents	Soluble in aromatic or chlorinated hydrocarbons	Soluble in ethers, ketones and ethylene dichloride	uniquement Soluble in aromatic chlorides only	Excellent	Soluble in benzene and chlorinated hydrocarbons.
Resistance to ozone (> 1000 ppm)	Bad	Excellent	Good	Good	Excellent	Good

Assembly

Material	Polyamide	Polycarbonate	Acrylonitrile butadiene styrene	Polypropylene	Polyphenylene sulfide	Polyphenylene Oxide
Acronym	**PA66**	**PC**	**ABS**	**PP**	**PPS**	**PPO**
Ultrasonic welding	**Difficult**	Easy	Easy	Very difficult	Complex	Complex
Gluing	**Difficult, preparation of the surface by flame, plasma or corona is needed**	Easy	Easy	Very difficult, preparation of the surface by flame, plasma or corona is needed	Difficult, gluing is possible with acrylic adhesives and surface preparation with primer, flame, plasma or corona	Difficult, gluing is possible with acrylic adhesives and surface preparation with primer, flame, plasma or corona

Main advantages

Polyamide	Polycarbonate	Acrylonitrile butadiene styrene	Polypropylene	Polyphenylene sulfide	Polyphenylene Oxide
PA66	**PC**	**ABS**	**PP**	**PPS**	**PPO**
- Good mechanical resistance - Low coefficient of friction - Good resistance to abrasion - Good electrical insulation - Good behavior at low temperatures - Resistant to most hydrocarbons, alkalis, organic chemicals - Can be used over a wide temperature range.	- Exists in transparent - Wide range of operating temperatures - Good UV resistance - Excellent mechanical properties, especially at impact between 80 ° C and 135 ° C - Good electrical insulation properties (the best transparent materials) - Good dimensional stability even in humid environment - Stain resistant surface.	- Good surface condition - Easy to machine - Easy to color by pigmentation in the mass - Good resistance to chemical attack - Excellent electrical insulation properties - Some varieties can receive an electrolytic metallization	- Translucent, - Great chemical inertia. - Very light. - Cheap. - Excellent resistance to salts and mineral acids as well as gases. - Withstands steam sterilization	- Remarkable chemical resistance. No known solvent below 200°C. - High elastic limit - Mechanical properties virtually unchanged up to 200°C. - Excellent electrical insulation properties. - very high creep resistance - Low coefficient of thermal expansion	- CTI up to 600V - Halogen free. - Strong dimensional stability - Excellent resistance to hydrolysis - Good mechanical properties up to 120°C - Good electrical and dielectric properties - Good resistance to temperature creeping

Main disadvantages

Polyamide	Polycarbonate	Acrylonitrile butadiene styrene	Polypropylene	Polyphenylene sulfide	Polyphenylene Oxide
PA66	**PC**	**ABS**	**PP**	**PPS**	**PPO**
- Poor performance in aerated or brewed boiling water - High sensitivity to water vapor (water absorption)	- Bad resistance to hydrocarbons and basic detergents - Slight UV discolouration over time, especially for transparent parts	- Faible tenue en température - Not suitable for outdoor use if exposed to direct sunlight. - Low temperature resistance	- Average mechanical resistance - Creeps easily	- High coefficient of friction - Decreased hardness in the presence of nitric acid.	In Europe it is mainly used a PPO modified by mixing with PS

Main standards for thermoplastics

Standards	Measuring unit	Description
ISO 1210 UL 94 (USA)		Burning Behaviour
ISO 1183 D792 (USA)	kg/m³	Density

IEC 60695-10-2	°C	Ball Pressure Test
IEC 60112	Volts	CTI Comparative Tracking Index
IEC 60695-2-12	°C	Glow Wire Flammability Index (GWFI)
ISO 8302		Thermal Conductivity
ISO 11359-1, -2 D696 (USA)	cm/cm/°C	Coefficient of linear thermal expansion
IEC 60243-1 D149 (USA)	kV/mm	Dielectric strength
D150 (USA)		Dielectric constant and dissipation factor
IEC 60093 D257 (USA)	Ohms.cm	Electrical resistance, insulation resistance, volume resistivity, volume resistance
ISO 62 D570 (USA)	%	Water Absorption, Moisture Absorption
ISO 527	%	Nominal strain at break, Yield strain
ISO 178 D790 (USA)	MPa	Flexural properties
D495 (USA)		Arc resistance
D746B (USA)		Relative Temp Index RTI, Mechanical and electrical
ISO 2039-1 D785 (USA)		R, M or L Rockwell or Shore D hardness
ISO 179/1e	kJ/m^2	Charpy notched and un-notched impact strenght
ISO180/1 D256 (USA)	kJ/m^2 J/m	Notched and Unnotched Izod Impact
ISO 75 D621 (USA)	°C	Deformation under load
D648 (USA)	°C	Deflection temperature
D746 (USA)	°C	Brittleness temperature
ISO 294 D789 (USA)	°C	Injection Molding, melt temperature
ISO 527 D638 (USA)	MPa %	Tensile properties, Tensile Elongation at yield
D955 (USA)	Cm/cm	Mold Shrinkage
ISO 294 D569 (USA)	mm/sec	Injection Molding, injection velocity
ISO 10724	°C	Injection Molding, mold temperature
ISO 1133	$cm^3/10min$	Melt volume-flow rate
ISO 306 D1525 (USA)	°C	Vicat softening point
D1693 (USA)		Environmental stress cracking
ISO 4589 D2863 (USA)		Oxygen index

Table of Common Trade Names of Thermoplastics named

Name	Material	Manufacturer
Terluran	ABS	B.A.S.F
Novodur	ABS	Bayer
Cycolac	ABS	Borg Wagner
Magnum	ABS	Dow
Lustran	ABS	Monsanto
Ugikral	ABS	P.C.U.K

Altuchoc	PC	Altulor
Orgalan	PC	ATO Chimie
Makrolon	PC	Bayer, Vacour
Calibre	PC	Enichem
Sinvet	PC	Enichem
PP Appryl	PP	Appryl
Novolen	PP	B.A.S.F
Cestilène	PP	DSM
Profax	PP	Hercules
Noplen	PP	Himont
Techtron	PPS	DSM
Supec	PPS	Vacour
Tedur	PPS	Vacour
Akulon	PA	AKZO
Minlon	PA	AKZO
Leona	PA	Asahi
Rilsan	PA	ATO Chimie
Orgamide	PA	ATO Chimie
Pebax	PA	Atochem
Ultramid	PA	B.A.S.F
Duréthan	PA	Bayer
Ertalon	PA	DSM
Nylatron	PA	DSM
Vespel	PA	Dupont de Nemours
Zytel	PA	Dupont de Nemours
Grillon	PA	EEMS
Vestamid	PA	Hüls
Dynyl	PA	Rhône Poulenc
Technyl	PA	Rhône Poulenc
Sniamid	PA	SNIA
Noryl	PPO (PPE+PS)	General electric plastics
Ashlene	PPO (PPE+PS)	Ashley Polymers
Lubricomp	PPO (PPE+PS)	LNP
Thermocomp	PPO (PPE+PS)	LNP
Lupliace	PPO (PPE+PS)	Mitsubishi Eng
PPX	PPO (PPE+PS)	Polymer Resources
1707	PPO (PPE+PS)	RTP
SC8	PPO (PPE+PS)	Spartech Polycom