Plastics Data File – PC

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1. Introduction

PC is a type of polyester where the carbonate ester groups have been linked with aromatic groups. This structure gives a material with high melt viscosity and resistance to high temperatures.

The material is one of the oldest of the engineering thermoplastics and was first commercially developed over 50 years ago.

PC can be processed by most common polymer processing methods.

Polycarbonate is an amorphous thermoplastic with very low water absorption. When immersed in water it absorbs less than 0.5% moisture. However, when used long-term in water, precautions must be taken. Hot water produces a gradual chemical decomposition accompanied by a loss of impact strength. In such conditions it is recommended to employ hydrolysis-resistant grades.

PC has an average processing shrinkage of 0.7%.

2. Typical applications

Electrical: Terminal block covers, high voltage insulation, coil formers, edge connectors, valve sockets, TV chassis, displays, computer housings, magnetic disc storage housings, relays.

Optical: Street lamp covers due to resistance to impact damage and resistance to high internal temperatures, anti-vandal glazing due to transparency and resistance to vandal damage, car light covers for transparency and impact resistance, shutters, light meter housings, lenses, microscope parts, slide and cine film projectors, view-finders.

Household: dishwasher-resistant tableware, lighters, coffee filters, water containers for steam irons, kitchen machinery components.

Miscellaneous: Compact discs which require high dimensional accuracy and good surface finish with low stress levels in the moulding, safety helmets, machine guards and housings. instrument glasses, car bumpers for colouring and impact resistance, wheel covers, screen washer arms, headlamp reflectors, traffic indicators, ski clamp parts, protective spectacles, infant feeding bottles due to possibility of sterilization and resistance to sterilizing solutions.

3. Physical and mechanical properties

General

Polycarbonate exhibits a high strength and hardness with good toughness. It has impact properties down to -90°C. The stiffness is very good and is only slightly influenced by temperatures up to140˚C. Stability properties are also very good at high temperatures. Abrasion resistance is satisfactory at low loading, but polycarbonate is not suitable for bearings and gearwheels where there is a significant loading.

Mechanical properties

Property	Approximate Value
Tensile strength	55 - 80 MN/m^2
Tensile Modulus	2 - 3 GN/m^2
Elongation at Break	80 - 200 %
Flexural Strength	100 - 150 MN/m^2
Notched Impact Strength	>20 kJ/m^2
Specific Heat	1.25 - 1.70 kJ/kg/°C

Glass Transition Temperature	150°C
Heat Deflection Temperature	100 - 150°C
Coefficient of Thermal Expansion	5 - 10 x 10^{-5} /°C
Long Term Service Temperature	100 - 150°C
Specific Gravity	1.2 to 1.4
Mould Shrinkage	0.005 - 0.01 m/m
Water Absorption	0.1 - 0.5 % (50% rh)
Transparency	Transparent

4. Thermal, electrical and optical properties

Thermal properties

Polycarbonate has outstanding dimensional stability up to 130°C. For glass fibre reinforced grades this value is raised to 140°C. Above these temperatures, polycarbonate begins to soften. From about 220°C melting commences, reaching a state of flow at 240-260°C, which permits processing by injection moulding or extrusion.

On longer heating at temperatures above 320-340°C thermal decomposition commences with emission of carbon dioxide and discolouration.

The tough elastic properties of the plastic also remain down to very low temperatures.

A gradual embrittlement is first noticeable below -50°C.

The thermal expansion coefficient is lower than with many other thermoplastics and, with glass fibre-reinforced grades, it reaches the level of some light metal alloys.

Fire behaviour

PC fulfils the requirements for many flammability tests. The Underwriters Laboratory classification ranges from 94 V-0 to 94 V-2 according to type, wall thickness and surface treatment.

Electrical properties

The area of application lies mainly in the low voltage region, where the good electrical insulation properties are almost completely free of influence from moisture content and environmental temperature. In applications in the high voltage region, it must however be noted that the loss factor rises very rapidly at high frequencies.

PC exhibits no electrolytic corrosion.

Electrostatic charging can be eliminated by antistatic additives or by rinsing in a cleaning medium for a set period.

Optical properties

The basic material is glass-clear and is thus transparent in all colours and is available self-coloured. PC has a high surface gloss.

Polycarbonate has a high refractive index of 1.586. Transparent grades show up to 89% transparency in the visible spectrum. Ultra violet light is absorbed on the other hand and over the course of time produces yellowing and reduction in impact strength. In such areas of application UV stabilised grades should be employed.

5. Chemical resistance properties

PC is resistant to mineral acids up to high concentrations, and to many organic acids, oxidising and reducing agents, neutral and acidic salt solutions, a range of fats and oils, saturated aliphatic and cycloaliphatic hydrocarbons and alcohols excepting methyl alcohol.

PC is attacked by caustic solutions, ammonia gas, aromatic hydrocarbons, benzene, amine, ozone and ethylene chloride. Polycarbonate is soluble in some industrial solvents. Other organic compounds such as benzene, acetone and carbon tetrachloride cause swelling.

A detailed chemical resistance chart for PC is given in Section 11.

Resistance to weathering

The weathering resistance of PC is in general adequate. Where there is intensive UV radiation UV-stabilised grades must be used. A post-moulding UV protection treatment can also be carried out.

Resistance to stress cracking

Some chemicals, such as carbon tetrachloride, often produce stress cracking, particularly in injection moulded parts. Tempering can relieve the internal stresses and a high resistance to stress cracking can be produced.

6. Advantages and limitations

Advantages	Limitations
1. Impact resistant (tough).	1. Reasonable abrasion resistance but not good enough for anti-friction bearings and gears.
2.Transparent, light transmission as good as glass.	2. Not recommended for use in the presence of an electric arc.
3. Resistant to UV but yellows slowly with time.	3. Mechanical properties degrade after prolonged exposure to water at over 60°C.
4. Moderate outdoor weathering resistance.	4. Specially stabilised grades are required for UV light applications.
5. Good electrical insulation properties that are not influenced by water or temperature.	5. High price restricts applications.
6. Good abrasion resistance.	6. Slow burning.
7. Accepts paint, print and vacuum metallising.	7. Should be dried before processing as moisture can degrade properties.
8. Inert to blood and readily sterilised.	8. Poor resistance to petrol and moisture restricts the use in the automotive industry.

7. Processing

Injection moulding

Damp granules must be dried according to grade at 120 to 130°C for four hours minimum. The layer must be not exceed 2cm.

For very small parts an injection pressure of minimum 1200 bar is used in a ram injection machine. Otherwise, a machine with screw plasticising is used, where injection pressure should be at least 800bar. The melt temperature lies between 280 and 320°C, mould temperature between 80 and

120°C. Since PC is a poor-flowing plastic, wall thickness should not be too thin. If special requirements are placed on surface appearance, one would select a fast injection speed and high mould temperature.

The shrinkage is approximately the same in all directions and amounts to 0.7 to 0.8%, or 0.2 to 0.5% for glass fibre-reinforced grades. If production is interrupted the cylinder temperature should be reduced to 160°C, but not switched off.

Extrusion

For extrusion high viscosity grades must be used. Drying must be better than for injection. Melt temperature at the die is between 230 and 260°C. For temperature control a gradient decreasing from hopper to die has been proved effective. Low-stress semi- finished products require gradual cooling.

Process selector

Processing Method	Applicable
Injection Moulding	Yes
Extrusion	Yes
Extrusion Blow Moulding	Yes
Rotational Moulding	Yes
Thermoforming	Yes
Casting	No
Bending and joining	Yes

8. Finishing

Machining

Polycarbonate can be machined without difficulties. The propensity to melting at high temperature is small. Air or clean water can be used as a coolant. Very sharp cutting tools are necessary. For polishing to high gloss only alkali-free abrasive pastes should be employed, to avoid chemical damage to the surface.

Surface treatment

For painting, printing and stamping the producers offer special PC-based products. PC lends itself also to vacuum vapour metallisation without priming.

Welding

Welding is possible by means of ultrasonic, hotplate, hot gas and friction welding. It is recommended to dry the parts beforehand.

Bonding

Should parts be glued, the mating surfaces should be cleaned with petroleum ether or with benzene. As adhesives, solvents such as methylene chloride are used. Reactive adhesives based on epoxy resins are also suitable.

9. Health and safety

PC is free of odour and taste and is approved for food-contact applications.

10. Other information

Identification

Difficult to ignite and no real flame formed.

Material forms a cellular structure and then decomposes.

11. Detailed chemical resistance

Important Note:

Whilst we try to ensure that this table is as accurate as possible, we cannot guarantee that the data contained in the tables is accurate for all blends and grades. In all cases the supplier of the material should be contacted to determine the exact chemical resistance of the material.

R = Resistant, LR = Limited Resistance, NR = Not Recommended, ND = No Data

Chemical	Resistance		
	20°C	60°C	100°C
Acetaldehyde	NR	NR	NR
Acetic acid (10%)	R	R	ND
Acetic acid (glac./anh.)	ND	ND	ND
Acetic anhydride	NR	NR	NR
Aceto-acetic ester	ND	ND	ND
Acetone	NR	NR	NR
Other ketones	NR	NR	NR
Acetonitrile	ND	ND	MD
Acetylene	R	ND	ND
Acetyl salicylic acid	ND	ND	ND
Acid fumes	ND	ND	ND
Alcohols	R	ND	ND
Aliphatic esters	ND	NR	NR
Alkyl chlorides	R	NR	NR
Alum	R	ND	ND
Aluminium chloride	R	ND	ND
Aluminium sulphate	NR	NR	NR
Ammonia, anhydrous	ND	NR	NR
Ammonia, aqueous	NR	NR	NR
Ammonium chloride	R	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Amyl acetate	ND	NR	NR
Aniline	NR	NR	NR
Antimony trichloride	R	ND	ND
Aqua regia	NR	NR	NR
Aromatic solvents	NR	NR	NR
Ascorbic acid	ND	ND	ND
Beer	R	ND	ND
Benzaldehyde	ND	ND	ND
Benzene	NR	NR	NR
Benzoic acid	R	NR	NR
Benzoyl peroxide	ND	ND	ND
Boric acid	R	ND	ND
Brines, saturated	R	R	ND
Bromide (K) solution	R	NR	NR
Bromine	NR	NR	NR
Bromine liquid, tech.	ND	ND	ND
Bromine water, saturated aqueous	ND	ND	ND
Butyl acetate	NR	NR	NR
Calcium chloride	R	R	R
Carbon disulphide	NR	NR	NR
Carbonic acid	R	ND	ND
Carbon tetrachloride	NR	NR	NR
Caustic soda & potash	NR	NR	NR
Cellulose paint	ND	ND	ND
Chlorates of Na, K, Ba	R	NR	NR
Chlorine, dry	ND	NR	NR

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Chemical	Resistance		
	20°C	60°C	100°C
Chlorine, wet	NR	NR	NR
Chlorides of Na, K, Ba	R	ND	ND
Chloroacetic acid	ND	NR	NR
Chlorobenzene	NR	NR	NR
Chloroform	NR	NR	NR
Chlorosulphonic acid	ND	NR	NR
Chromic acid (80%)	ND	NR	NR
Citric acid	R	R	ND
Copper salts (most)	R	R	ND
Cresylic acids (50%)	NR	NR	NR
Cyclohexane	R	NR	NR
Detergents, synthetic	R	R	NR
Emulsifiers, concentrated	NR	NR	NR
Esters	ND	ND	ND
Ether	NR	NR	NR
Fatty acids (>C6)	ND	NR	NR
Ferric chloride	R	R	NR
Ferrous sulphate	R	ND	NR
Fluorinated refrigerants	R	NR	NR
Fluorine, dry	ND	NR	NR
Fluorine, wet	ND	NR	NR
Fluorosilic acid	ND	NR	NR
Formaldehyde (40%)	R	R	NR
Formic acid	R	R	NR
Fruit juices	R	NR	NR
Gelatine	ND	NR	NR

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Chemical	Resistance		
	20°C	60°C	100°C
Glycerine	R	NR	NR
Glycols	R	NR	NR
Glycol, ethylene	R	ND	NR
Glycollic acid	ND	ND	ND
Hexamethylene diamine	ND	ND	ND
Hexamine	ND	NR	ND
Hydrazine	ND	NR	ND
Hydrobromic acid (50%)	ND	NR	ND
Hydrochloric acid (10%)	R	R	ND
Hydrochloric acid (conc.)	NR	NR	ND
Hydrocyanic acid	ND	NR	ND
Hydrofluoric acid (40%)	R	NR	ND
Hydrofluoric acid (75%)	ND	NR	ND
Hydrogen peroxide (30%)	R	R	ND
Hydrogen peroxide (30 - 90%)	ND	NR	ND
Hydrogen sulphide	ND	NR	ND
Hypochlorites	R	NR	ND
Hypochlorites (Na 12-14%)	R	NR	ND
Iso-butyl-acetate	NR	NR	ND
Lactic acid (90%)	R	NR	ND
Lead acetate	ND	NR	ND
Lead perchlorate	NR	NR	ND
Lime (CaO)	NR	NR	ND
Maleic acid	ND	NR	ND
Manganate, potassium (K)	R	NR	ND
Meat juices	ND	NR	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Mercuric chloride	R	R	ND
Mercury	R	NR	ND
Methanol	NR	NR	ND
Methylene chloride	NR	NR	ND
Milk products	R	NR	ND
Moist air	R	NR	ND
Molasses	ND	NR	ND
Monoethanolamine	ND	NR	ND
Naptha	ND	NR	ND
Napthalene	ND	NR	ND
Nickel salts	ND	NR	ND
Nitrates of Na, K and NH3	R	NR	ND
Nitric acid (<25%)	R	NR	ND
Nitric acid (50%)	NR	NR	ND
Nitric acid (90%)	NR	NR	ND
Nitric acid (fuming)	NR	NR	ND
Nitrite (Na)	ND	ND	ND
Nitrobenzene	ND	ND	ND
Oils, diesel	R	ND	ND
Oils, essential	ND	NR	ND
Oils, lubricating + aromatic additives	NR	NR	ND
Oils, mineral	R	NR	ND
Oils, vegetable and animal	R	R	ND
Oxalic acid	R	NR	ND
Ozone	R	R	ND
Paraffin wax	ND	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Perchloric acid	R	ND	ND
Petroleum spirits	R	ND	ND
Phenol	NR	NR	ND
Phosphoric acid (20%)	R	R	ND
Phosphoric acid (50%)	R	R	ND
Phosphoric acid (95%)	R	R	ND
Phosphorous chlorides	NR	NR	ND
Phosphorous pentoxide	ND	NR	ND
Phthalic acid	ND	NR	ND
Picric acid	ND	NR	ND
Pyridine	NR	NR	ND
Salicyl aldehyde	NR	NR	ND
Sea water	R	NR	ND
Silicic acid	R	ND	ND
Silicone fluids	R	R	ND
Silver nitrate	R	ND	ND
Sodium carbonate	NR	NR	ND
Sodium peroxide	ND	NR	ND
Sodium silicate	ND	NR	NR
Sodium sulphide	ND	ND	ND
Stannic chloride	ND	ND	ND
Starch	R	ND	NR
Sugar, syrups & jams	R	NR	NR
Sulphamic acid	ND	ND	ND
Sulphates (Na, K, Mg,Ca)	R	R	R
Sulphites	R	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Sulphonic acids	ND	ND	ND
Sulphur	ND	ND	ND
Sulphur dioxide, dry	ND	ND	ND
Sulphur dioxide, wet	NR	NR	NR
Sulphur dioxide (96%)	R	ND	ND
Sulphur trioxide	ND	NR	NR
Sulphuric acid (<50%)	NR	R	NR
Sulphuric acid (70%)	R	R	ND
Sulphuric acid (95%)	NR	NR	NR
Sulphuric acid, fuming	R	NR	NR
Sulphur chlorides	NR	NR	NR
Tallow	R	ND	NR
Tannic acid (10%)	ND	NR	NR
Tartaric acid	R	R	NR
Trichlorethylene	R	NR	NR
Urea (30%)	R	R	ND
Vinegar	ND	ND	ND
Water, distilled.	R	R	R
Water, soft	R	R	R
Water, hard	R	R	R
Wetting agents (<5%)	R	NR	NR
Yeast	ND	NR	NR
Zinc chloride	R	R	NR