Plastics Data File – PEEK

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1. Introduction

PEEK was one of the first of the 'new generation' of engineering thermoplastics introduced and was developed by ICI in 1977 and first marketed in 1978. The material is one of the polyaryletherketone family – a group of partially crystalline polymers that are suitable for use at high temperatures. The polyether ether ketones have repeating monomers of two ether and ketone groups and PEEK is one of the highest rated thermoplastic materials in terms of heat resistance. The useful properties of the material are retained at temperatures as high as 315°C.

The materials have excellent chemical resistance, high strength and good resistance to burning but equally the high cost of these materials makes applications limited to those where the properties are very necessary.

2. Typical applications

Automotive: Piston components, bearing linings.

Electrical engineering: Wire insulation for extremely high temperature applications, cable couplings and connectors.

Appliances: Handles, cooking equipment.

Medicine: Prosthetics, instruments.

Others: Aircraft parts and wire insulation, pump casings and impellers, monofilament for production of woven products for filters, belting and meshes.

3. Physical and mechanical properties

General physical properties

PEEK is greater strength and rigidity than many of the engineering thermoplastics and is tough and impact resistant over a wide range of temperatures.

PEEK has good mechanical properties and these are retained over a wide temperature range. The co-efficient of friction and wear rate are low over a wide temperature range.

Mechanical properties

Property	Approximate Value
Tensile strength (@23°C)	97 MN/m^2
Tensile Modulus (@ 1% strain @ 23°C)	3.5 GN/m^2
Elongation at Break (@23°C)	Up to 60 %
Flexural Strength (@23°C)	170 MN/m^2
Notched Impact Strength (@23°C)	7.5 kJ/m^2
Specific Heat (Melt)	2.16 kJ/kg°C
Glass Transition Temperature	143°C
Heat Distortion Temperature	152°C

Coefficient of Thermal Expansion	< Tg 4.7 x 10^{-5} / °C > Tg 10.8 x 10^{-5} / °C
Long Term Service Temperature	Up to 260°C
Specific Gravity	1.32
Mould Shrinkage	0.01 - 0.02 m/m
Water Absorption	Up to 0.5 % (50% rh)
Transparency	Opaque

4. Thermal, electrical and optical properties

Thermal properties

The thermal oxidative stability of PEEK is excellent and the material has a UL rated continuous operating temperature of around 250°C

Fire behaviour

PEEK has excellent resistance to burning and very low flame spread being rated as UL 94 V-0 for thicknesses down to 2 mm. The LIO (Limiting Oxygen Index) is 35%) and even when burning the material has very low smoke generation.

Electrical properties

Good dielectric properties with high volume and surface resistivities and good dielectric strength. These properties are retained at temperatures as high as 200°C.

Optical properties

N/A

Natural colour

Grey/brown

5. Chemical resistance properties

General

PEEK has excellent chemical resistance and is extremely resistant to many organic and inorganic chemicals. It is dissolved or decomposed only by concentrated anhydrous or strong oxidizing agents.

The material has exceptionally good resistance to hydrolysis in hot water and remains unaffected after several thousand hours at more than 250oC in pressurised water.

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

Weathering resistance

PEEK is not greatly resistant to UV radiation but has good resistance to beta, gamma and X-rays.

6. Advantages and limitations

Advantages	Limitations
1. Excellent high temperature performance for all mechanical properties.	1. Extremely high cost (even for engineering polymers) but the properties can sometimes justify this when it becomes almost the only polymer capable of being used.
2. Excellent electrical performance at high temperatures.	2. Limited supplier base.
3. High rigidity at high temperatures.	
4. Excellent gamma radiation resistance.	
5. Excellent hydrolysis resistance.	

7. Processing

PEEK can be processed on standard processing equipment and the only concern is that the processing temperatures required are quite high.

Material should be pre-dried at 150°C for 3 hours before processing.

Injection moulding

Injection moulding is best screws with an L/D ratio of 18 to 22. Melt temperatures should be in the range 370 to 400°C. Mould temperatures should be in the range 160 to 215°C.

Injection pressure is 1500 bar, decreasing to 1000 bar for the second stage. Injection speed can be high because the material does not suffer from degradation due to shearing. Screw speed can also be high.

Mouldings do not require any thermal post-treatment.

Extrusion

Extrusion is best with 3 section screws and an L/D ratio of 22 to 30. Melt temperatures in the range 400 to 430°C and feed temperatures of at least 425oC are recommended.

Can be reprocessed at up to 30%.

Process selector

Processing Method	Applicable
Injection Moulding	Yes
Extrusion	Yes
Extrusion Blow Moulding	Yes
Rotational Moulding	Yes
Thermoforming	Yes
Casting	Yes
Bending and joining	Yes

8. Finishing

Machining

PEEK can be machined easily and accurately.

Surface treatment

PEEK can be printed, hot-foiled or treated with most common methods.

Welding

PEEK can be welded by most common thermoplastic welding techniques.

Bonding

PEEK can be bonded using epoxies, cyanoacrylates, polyurethanes or silicones.

9. Health and safety

PEEK has no significant Health and Safety implications.

10. Other information

Identification

Material has a hard, stiff feel and cannot be cut easily. The high density (1.2–1.4) means it sinks in water. Natural colour is grey/brown and colours are sometimes dulled by this base colour.

Flame is slightly orange with yellow edges. Low smell and small amounts of smoke.

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	R
Acetic acid (10%)	R	R	R
Acetic acid (glac./anh.)	R	R	NR
Acetic anhydride	ND	ND	ND
Aceto-acetic ester	ND	ND	ND
Acetone	R	R	R
Other ketones	R	R	R
Acetonitrile	ND	ND	ND
Acetylene	R	R	R
Acetyl salicylic acid	ND	ND	ND
Acid fumes	R	R	R
Alcohols	R	R	R
Aliphatic esters	R	R	R
Alkyl chlorides	ND	ND	ND
Alum	R	R	R
Aluminium chloride	R	R	R
Aluminium sulphate	R	R	R
Ammonia, anhydrous	R	R	R
Ammonia, aqueous	R	R	R
Ammonium chloride	R	R	R
Amyl acetate	R	R	R

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

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

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

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

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

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