Plastics Data File – PS

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1. Introduction

Polystyrene (PS) is one of the styrenic family (two of the others are ABS - acrylonitrile butadiene styrene and SAN - styrene acrylonitrile) and all of the family tend to be relatively brittle with poor outdoor performance. Basic PS is brittle, rigid, transparent, easy to process (shrinkage is low), is low cost and free from odour and taste. High Impact grades (PS-HI) are a rubber modified grade of PS where elastomers are introduced into the base polymer to improve the impact resistance and deformation before fracture.

Sometimes PS is referred to as crystal PS, this refers to the clarity of the finished product and does not imply that there the molecular structure is crystalline (as with most of the polyolefins such as PP etc.). In fact, the lack of a crystalline structure is responsible for many of the good points of PS such as the clarity of the product, the low energy input required for processing (no crystal to melt) and the ease of processing with low shrinkage.

General purpose PS is available in various grades such as easy flow, intermediate flow and high heat resins. PS is easily recycled and there is a great deal of experience of recycling PS.

The PS-HI (HIPS in the old terminology) grades incorporate a rubber component and by using different elastomers into the chain, products with a wide range of properties can be produced.

A particular application of PS is in the production of EPS or expanded polystyrene which is a foamed plastic with is extensively used in packaging applications. This product has a completely different set of properties and is not covered by this data sheet.

2. Typical applications

Packaging and disposables industry: Transparent yoghurt pots, vending and portion cups, jewellery boxes, food dishes, stacking and sorting crates, toys.

Electrical engineering: Tape recorder and film spools, distributor boxes, housings for kitchen appliances, relay parts, coil shells, slide frames, speaker units.

Household goods: Food storage containers, safety razors, party cutlery, flower tubs, freezer boxes, refrigerator liners and boxes, clothes hangers.

3. Physical and mechanical properties

General

Polystyrene is an amorphous thermoplastic with a density of 1.05 g/cm^3. Moisture absorption is extremely low, namely 0.05%.

Mechanical properties

Polystyrene is a hard, stiff and dimensionally stable but relatively inextensible material with a high tensile strength and low elongation at break. The mechanical strength is affected to a very large degree by the processing conditions. The highest values can be obtained with free-flowing materials at a low processing temperature.

Property	Approximate Value	
	PS	PS-HI (High Impact)
Tensile strength	55 - 80 MN/m^2	30 - 55 MN/m^2
Tensile Modulus	3-4 GN/m^2	2 - 3 GN/m^2
Elongation at Break	<10 %	10 - 50%
Flexural Strength	50 - 100 MN/m^2	50 - 100 MN/m^2

Notched Impact Strength	<3 kJ/m^2	3 - 15 kJ/m^2
Specific Heat	1.25 - 1.70 kJ/kg/°C	1.25 - 1.70 kJ/kg/°C
Glass Transition Temperature	100°C	100°C
Heat Deflection Temperature	<100°C	<100°C
Coefficient of Thermal Expansion	5 - 10 x 10-5 /°C	5 - 15 x 10-5 /°C
Long Term Service Temperature	70 - 85°C	60 - 80°C
Specific Gravity	1.0 - 1.2	1.0 - 1.2
Mould Shrinkage	0.001 - 0.005 m/m	0.001 - 0.01 m/m
Water Absorption	0.1 - 0.5 % (50% rh)	0.1 - 0.5 % (50% rh)
Transparency	Transparent	Opaque

4. Thermal, electrical and optical properties

Thermal properties

The glass transition zone is between 80 to 120°C and in this region the strength and hardness fall dramatically. Polystyrene can be used down to temperatures just below this range (70°C). PS can also be used at low temperatures down to -70°C.

Fire behaviour

PP can be ignited by a flame and continues to burn with a glowing, very sooty flame even after the source of ignition has been removed. It has the UL classification of 94 HB. Fire retardant PS is rated 94 V-2. When burning molten drips of burning polymer are created.

Electrical properties

Good electrical resistance values that are virtually independent of the moisture content. PS shows a marked tendency to form electrostatic charges - the old-style PS rulers can be used to demonstrate static electricity with small pieces of paper, the classic demonstration.

Optical properties

The transparent types of standard polystyrene have a light transmission of about 90 in the visible range. Absorption increases considerably in the UV range. The refractive index is 1.59.

Natural Colour

Transparent with a high surface gloss and can be produced in all colours, transparent or muted.

5. Chemical resistance properties

PS has good chemical resistance. It is resistant to alkalis, dilute mineral acids, alkalis, alcohols, water and aqueous salt solutions.

PS is attacked by aromatic and chlorinated hydrocarbons, ethers, ketones, esters and strong oxidising agents.

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

Resistance to weathering

PS is not recommended for long-term use in the open air as it is degraded by UV rays. This is reflected in yellowing and loss of surface gloss and by a decrease in mechanical strength. Darker formulations perform better than pale or transparent types.

Resistance to stress cracking

Polystyrene is very susceptible to stress cracking. Parts with internal stresses can form stress cracks even in media to which PS is usually resistant. It is therefore advisable to produce injection moulded parts with as few internal stresses as possible.

6. Advantages and limitations

Advantages	Limitations
1. Low cost.	1. Negligible mechanical properties above 70°C
2. Easy to process.	2. Brittle at room temperature.
3. Low shrinkage.	3. Degrades rapidly in outdoor use due to UV.
4. Transparent and wide range of colours available.	
5. Suitable for food use.	
6. PS-HI products can be tailored to application.	
7. Good chemical resistance properties.	

7. Processing

Injection moulding

A 2–3 hour pre-drying operation at 80°C is recommended for antistatic formulations or when high transparency and high surface gloss is required. Pre-drying is not necessary for standard grades of PS but may be necessary for some grades of PS-HI.

Low injection pressures are possible due to the easy flow properties and a relatively short and low (30-60%) follow-up pressure is required. The injection speed should be as high as possible, especially for thin-walled mouldings and high screw speeds are possible. Processing parameters: PS should be processed at between 180 and 280°C. The material may be thermally degraded at high temperatures. The temperature of the mould chosen can be between 10 and 50°C. Shrinkage is between 0.4 and 0.7% depending on the grade used.

Extrusion

Styrene types with a low melt index and high Vicat softening point are suitable for extrusion. The materials are not hygroscopic and do not require drying.

For non-foamed applications a two-stage vented extruder is generally used with extrusion temperatures of between 180 and 220°C (in the final zone).

Process selector

Processing Method	Applicable	
	PS	PS-HI (High Impact)
Injection Moulding	Yes	Yes
Extrusion	Yes	Yes
Injection Blow Moulding	Yes	Yes
Rotational Moulding	Yes	Yes
Thermoforming	Yes	Yes
Casting	No	No
Bending and joining	Yes	Yes

8. Finishing

Machining

The low thermal conductivity and the relatively low softening temperatures of the material, the cutting surfaces must either be fanned with air or cooled with water. If this is not done the PS will melt due to heat generated during machining. The impact resistant types are less likely to splinter.

Surface treatment

Printing, lacquering and hot stamping are all possible. PS can be given a mirror finish with a metallic gloss by high-vacuum metallising with a clear lacquer applied for protection.

Welding

Ultrasonic welding is normally used. High strengths can be achieved with impulse welding. HF welding is not suitable.

Bonding

Only parts of the same type can be bonded together. Solvent adhesives such as toluene or methylene chloride are normally used. Impact adhesives are used for bonding with different materials.

9. Health and safety

PS is physiologically safe.

10. Other information

Identification

Easily ignited by a flame and burns with a glowing, very sooty flame even after the source of ignition has been removed. Burning drips fall from the sample. Sweet smelling odour.

Standard PS has a very distinctive ringing sound when a sample is tapped on a hard surface. The sound is less distinct for the PS-HI variety but experience can identify the PS family simply from the sound on a surface.

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

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

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Chemical	Resistance		
	20°C	60°C	100°C
Chlorides of Na, K, Ba	R	R	ND
Chloroacetic acid	ND	ND	ND
Chlorobenzene	NR	NR	ND
Chloroform	NR	NR	ND
Chlorosulphonic acid	ND	ND	ND
Chromic acid (80%)	NR	NR	ND
Citric acid	R	NR	ND
Copper salts (most)	R	NR	ND
Cresylic acids (50%)	ND	ND	ND
Cyclohexane	NR	NR	ND
Detergents, synthetic	R	R	ND
Emulsifiers, concentrated	ND	ND	ND
Esters	ND	ND	ND
Ether	NR	NR	ND
Fatty acids (>C_6)	R	R	ND
Ferric chloride	R	R	ND
Ferrous sulphate	R	R	ND
Fluorinated refrigerants	NR	NR	ND
Fluorine, dry	NR	NR	ND
Flourine, wet	NR	NR	ND
Fluorosilic acid	ND	ND	ND
Formaldehyde (40%)	NR	NR	ND
Formic acid	ND	ND	ND
Fruit juices	R	NR	ND
Gelatine	ND	ND	ND
Glycerine	R	R	ND

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

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Chemical	Resistance		
	20°C	60°C	100°C
Mercury	R	R	ND
Methanol	R	NR	ND
Methylene chloride	ND	ND	ND
Milk products	R	NR	ND
Moist air	R	R	ND
Molasses	ND	ND	ND
Monoethanolamine	ND	ND	ND
Naptha	NR	NR	ND
Napthalene	R	NR	ND
Nickel salts	R	R	ND
Nitrates of Na, K and NH_3	R	R	ND
Nitric acid (<25%)	NR	NR	ND
Nitric acid (50%)	NR	NR	ND
Nitric acid (90%)	NR	NR	ND
Nitric acid (fuming)	NR	NR	ND
Nitrite (Na)	R	ND	ND
Nitrobenzene	ND	ND	ND
Oils, diesel	NR	NR	ND
Oils, essential	NR	NR	ND
Oils, lubricating + aromatic additives	NR	NR	ND
Oils, mineral	NR	NR	ND
Oils, vegetable and animal	R	NR	ND
Oxalic acid	R	R	ND
Ozone	NR	NR	ND
Paraffin wax	R	NR	ND
Perchloric acid	NR	NR	ND

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

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