B

POLYPROPYLENE (PPR AND PPH)

Asahi/America is the pioneer of piping systems made of polypropylene in the United States. For over 15 years, polypropylene systems have been successfully applied for a wide variety of applications. Polypropylene is used in double containment systems, chemical piping, and pure water systems. It is chemically resistant to many strong and weak acids. In addition, it is one of the few materials that is recommended for strong bases such as sodium hydroxide. It is not ideal for strong oxidizing acids, aromatics, and chlorinated hydrocarbons. An all inclusive chemical resistant table is available in Section E. Polypropylene has an extended operating range up to a maximum temperature of 200° F. See Appendix A for pressure rating charts on all materials.

Polypropylene is a fairly ductile material at ambient temperatures and it demonstrates good impact strength. Polypropylene is available in two grades: copolymer and homopolymer. Homopolymer polypropylene is a Type I resin according to ASTM D 4101 and is produced from 100% propylene monomer. Copolymer polypropylene is a blend of (6%) ethylene and (94%) propylene. Copolymer resins generally exhibit better mechanical strength and offer higher safety factors into a system design. In addition, copolymer PP shows a greater purity level when tested in a static leach test, making it the ideal material for pure water systems. Table B-1 shows the differences between the two types of polypropylenes. Asahi/America uses both types of material based on the application.

Copolymer is referred to as PPR, with the R designating the term random copolymer. PPH is the standard designation for homopolymer polypropylene.

Toxicity

Polypropylene (PPR and PPH materials) comply with the relevant food stuff regulations as defined by ONÖRM B 5014, Part 1, FDA, BGA, KTW guidelines. Other modified polypropylenes are not compliant due to additives. Such materials include PPH-s, PPR-el, and PPR-s-el, which have been modified for improved fire ratings and electro-conductivity. These are discussed in the next section.

Table B-1. Polypropylene Physical Properties

Characteristic	Standard	Units	PPR	PPH
Density	ISO/R 1183	g/cm^3	0.91	0.91
Melt Flow Index	MFI 190/5 Code T ISO 1133 DIN 53 735	g/10 min	0.50	0.50
Tensile Strength at Yield	ISO/R 527 DIN 53 455	psi N/mm^2	3625 25	4350 30
Tensile Strength at Break	ISO/R 527 DIN 53 455	psi N/mm^2	5800 40	6525 45
Percent Elongation at Break	ISO/R 527 DIN 53 455	%	>50	>50
Modulus Elasticity (tensile test)	ISO 178 DIN 53 457	psi N/mm^2	108750 750	166750 1150
Charpy Impact Strength 23° C, notched	ISO 179/2C DIN 53 453	kJ/m^2	20	50
Charpy Impact Strength -30° C, notched	ISO 179/2D DIN 53 453	kJ/m^2	50	35
Coefficient of Thermal Expansion	DIN 53 752	1/° C 1/° F	1.5×10^{-4} 8.33×10^{-5}	1.5×10^{-4} 8.33×10^{-5}
Crystallinity Melt Temperature	DIN 53 736	° C ° F	150 - 154 302 - 309	160 - 165 320 - 329
Deflection Temperature Under Load Method A Method B	 DIN 53 461 ISO 75	 ° C/° F ° C/° F	 45/113 68/154	 50/122 90/194
UL 94 Fire Rating	UL 94	—	94-HB	94-HB
Thermal Conductivity (23° C)	DIN 52 612	W/mK	0.24	0.22
Surface Resistivity	DIN 53 482	Ohm	$>10^{13}$	$>10^{13}$
Specific Volume Resistivity	DIN 53 482 part 1	Ohm cm	$>10^{16}$	$>10^{16}$
Dielectric Strength	DIN 53 481	kV/mm	75	75
Color	RAL	—	gray	gray

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SPECIAL GRADE POLYPROPYLENE

- Self-extinguishing polypropylene: PPH-s
- Electro-conductive polypropylene: PPR-el
- Self-extinguishing electro-conductive polypropylene: PPR-s-el

Polypropylene is also available in highly specialized grades developed for specific applications. PPH-s is a self-extinguishing homopolymer polypropylene with enhanced fire ratings as compared to standard polypropylenes. PPR-el is a copolymer polypropylene with the added property of being electro-conductive. Many applications call for a piping system to be grounded due to the transport of flammable materials. During operation, a static charge can build on the surface of a standard plastic pipe. If the material is not conductive, it cannot be properly grounded and, therefore, runs the risk of potential static discharge to the media. Electro-conductive polypropylene can be grounded to avoid this hazard. Finally, PPR-s-el is the combination of the electro-conductive property and the enhanced fire ratings. PPR-s-el is a copolymer polypropylene.

PPH-s, PPR-el, and PPR-s-el have slightly different properties than standard polypropylene. These changes in the material also change the chemical resistance of the material. While the resistance to chemical attack is similar to that of common polypropylenes, verification of each application with the Engineering Department at Asahi/America is recommended.

These materials are produced by Agru and are available from Asahi/America. Consult Asahi/America for availability.

Table B-2. Special Grade Polypropylene Physical Properties

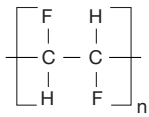
Characteristic	Standard	Units	PPH-S	PPR-EL	PPR-S-EL
Density	ISO/R 1183	g/cm^3	0.934	0.94	1.12
Melt Flow Index	MFI 190/5 Code T ISO 1133 DIN 53 735	g/10 min	0.5-0.8	1.0	1.0
Tensile Strength at Yield	ISO/R 527 DIN 53 455	psi N/mm^2	4060-5365 28-37	4350 30	4205 29
Tensile Strength at Break	ISO/R 527 DIN 53 455	psi N/mm^2	— —	4060 28	2900 20
Percent Elongation at Break	ISO/R 527 DIN 53 455	%	>50	15	>50
Modulus Elasticity (tensile test)	ISO 178 DIN 53 457	psi N/mm^2	152,250 1050	87,000 600	145,000 1000
Charpy Impact Strength 23° C, notched	ISO 179/2C DIN 53 453	kJ/m^2	10	3.5	4
Charpy Impact Strength -30° C, notched	ISO 179/2D DIN 53 453	kJ/m^2	40	2.5	—
Coefficient of Thermal Expansion	DIN 53 752	1/° C 1/° F	1.5×10^{-4} 8.33×10^{-5}	— —	1.5×10^{-4} 8.33×10^{-5}
Crystallinity Melt Temperature	DIN 53 736	° C ° F	164 - 168 327 - 334	— —	148 298
Deflection Temperature Under Load Method A Method B	 DIN 53 461 ISO 75	 ° C/° F ° C/° F	 55/131 83-110/181-230	 50/122 75/167	 — —
UL 94 Fire Rating	UL 94	—	V-2	94-HB	V-0
Thermal Conductivity (23 °C)	DIN 52 612	W/mK	0.22	—	—
Surface Resistivity	DIN 53 482	Ohm	$>10^{13}$	3×10^4	3×10^2
Specific Volume Resistivity	DIN 53 482 part 1	Ohm cm	$>10^{15}$	—	3×10^2
Dielectric Strength	DIN 53 481	kV/mm	30-45	—	—
Color	RAL	—	dark gray	black	black

POLYVINYLIDENE FLUORIDE (PVDF)

PVDF is a thermoplastic fluorocarbon polymer with wide thermal stability from -62° C (-80° F) to 148° C (300° F) and crystalline melting point of 171° C (340° F). In terms of piping systems, PVDF has a usage range of up to 121° C (250° F).

Material Grade

Purad PVDF pipe, valves, and fittings are manufactured of natural polyvinylidene fluoride resin. PVDF is part of the fluorocarbon family and has the following molecular structure.



PVDF resin is partially crystalline and has a high molecular weight. Purad is 100% PVDF with absolutely no antioxidants, anti-static agents, colorants, fillers, flame retardants, heat stabilizers, lubricants, plasticizers, preservatives, processing aids, UV stabilizers, or any other additives. Purad is also resistant to the effects of gamma radiation and has a V-O rating according to the UL-94 vertical flame test.

Purad PVDF has been tested for its inherent purity through extensive testing performed by internationally recognized independent laboratories. The outstanding performance of Purad material, with respect to extreme conditions, is well documented and available upon request. Therefore, it is well suited to handle such aggressive media as ultra pure water and ultra pure, electronic grade acids. Just as importantly, it conforms to FDA regulations as outlined in Title 21, Chapter 1, Part 177-2510 (contact with food).

Corrosion Resistance

Purad PVDF systems offer the broadest protection for the chemical process industries, pulp mill bleaching, bromine processing, and electronic product manufacturing in both etching operations and ultra pure deionized water lines. Purad-PVDF resins resist most corrosive chemicals and many organic solvents. It is particularly good against strong oxidants, strong acids, all salts, and solvents such as chlorinated, aromatic, and aliphatic. Strong base amines and ketones such as hexamethylene diamine and propyldimethylformamide, and methylethyl ketone are not recommended for use with PVDF. A comprehensive table is available in Section E, *Chemical Resistance*.

Solvay Solef Resin

Purad PVDF is exclusively produced from Solvay Solef 1000 Series high-purity resin. Solef 1000 Series resins use a suspension production process according to ASTM D 3222, Type II PVDF resin.

The suspension process, as opposed to emulsion or Type I PVDF, allows the manufacture of polymers with fewer structural defects in the molecular chain. In other words, the PVDF polymers are more crystalline. Thus, the melting temperature and the mechanical characteristics are higher than homopolymers with the same average molecular weights obtained by emulsion polymerization.

Solef PVDF is thus manufactured by suspension polymerization of vinylidene fluoride. The process uses a recipe where the monomer is first introduced in an aqueous suspension and then polymerized by means of a special organic peroxide-type polymerization initiator at low dosage. The polymerization is performed in a heated autoclave under high pressure.

The polymer powder form is then subjected to extensive washing and rinsing operations, and then, after drying, is stored in homogenizing silos. All the while, strict inspections are performed on line in order to ensure optimal quality control.

When complete, Solef PVDF contains a high percentage of fluorine. The bond between the highly electronegative fluorine and carbon atom is extremely strong with a dissociation energy of 460 kj/mol. Thus, the importance of exclusively using Solef PVDF high-purity resin is two fold:

1. Provides for a cleaner, mechanically superior system.
2. Allows the closest melt flow indices between system components, which in turn, provides superior welding/joining capabilities.

Table B-4. Polyvinylidene Fluoride Physical Properties

Characteristic	Standard	Units	Value
Specific Gravity	ASTM D 792	g/cm^3	1.78
Tensile Strength	ASTM D 638	psi	7975
Ultimate Tensile Strength	ASTM D 638	psi	6960
Elongation at Break	ASTM D 638	%	50
Flexural Strength	ASTM D 790	psi	12,180
E-Modulus	ASTM D 790	psi	435,000
Impact Strength	ASTM D 256	ft-lb/in	2.80
Hardness–Shore D	ASTM D 2240	—	80
Abrasion Resistance	DIN 53 754	mg/100 cycle	0.5–1
Friction Coefficient	DIN 375	—	0.4–5
Dynamic Friction Coefficient	—	—	0.34
Crystalline Melting Point	DIN 53 736	° C ° F	350 177
Vicat Point	ASTM D 3418	° C ° F	293 144
Brittleness Temperature	ASTM D 746	° C ° F	-40 -40
Thermal Conductance	ASTM D 177	Btu–in/hr ft^2•°F	1.32
Coefficient of Thermal Expansion	DIN 53 453	° F^{-1}	6.7 x 10^{-5}
Specific Volume Resistivity	ASTM D 257	Ohm•cm	5 x 10^{14}
Surface Resistivity	DIN 53 482	Ohm	>10^{13}
Dielectric Strength	ASTM D 149	kv/mm	40
Burning Rate	UL94	—	V-O
Limiting Oxygen Index	ASTM D 2863	%	44

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