Hyflon®

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# Hyflon® PFA

## Typical Properties

SPECIALTY POLYMERS

# Hyflon® PFA
## Perfluoroalkoxy Fluorocarbon Resins

Hyflon® PFA is the product name for the Solvay Specialty Polymers range of melt processable perfluoroalkoxy fluorocarbon resins specifically designed for high temperature service and virtually universal chemical resistance. It represents a family of semi-crystalline resins which combines exceptional value with high performance properties.

The Hyflon® PFA range consists of two product series: the P series and the M series. Both can be used in applications as diverse as tubing, fittings, tank linings, tower packing, fittings and valve linings, films, high purity, fibers, heat tracing wiring, avionics and specialty cables.

The P series features a higher melting point.

The M series can offer:

- Intrinsic processing stability due to the presence of the more stable methyl side chains
- Improved surface smoothness, which reduces the tendency for adhesion and growth of bacteria
- Remarkably higher transmittance values over the whole spectrum resulting in improved clarity

Perfluoroalkoxy fluorocarbon resins are copolymers of tetrafluoroethylene and perfluoroalkylvinylethers. The type and frequency of the side chains dictate the thermo-mechanical properties of the polymer. As a general rule a high number of side chains will provide:

- Lower thermal rating
  (low melting point and low creep resistance)
- High tenacity (high stress/strain at break)
- High flex-life

The polymer molecular weight is another important parameter affecting the mechanical properties of a specific composition. Usually the Melt Flow Index MFI (measured at 372 °C with a 5 kg weight) is used to provide an indication of the molecular weight: a high molecular weight leads to high viscosity that is low MFI resin.

As a general rule, low MFI resins show:

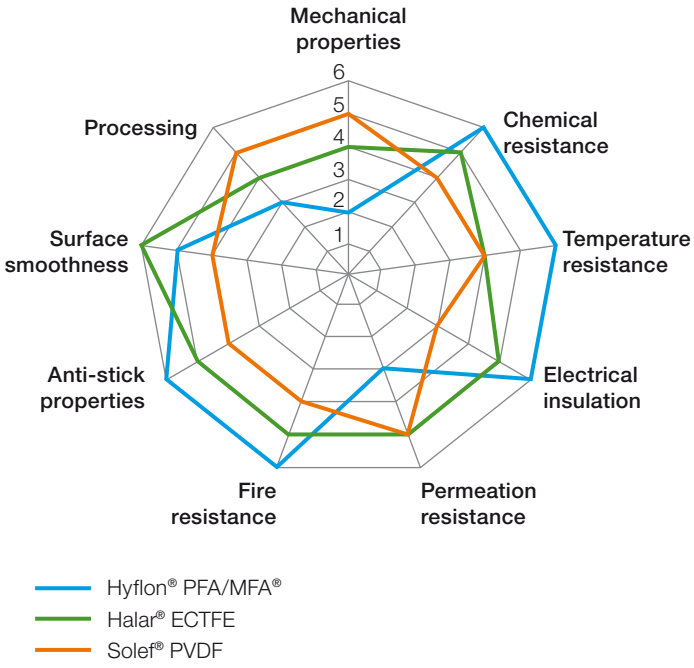
- High tenacity
- High flex-life

The size of the side chains can be used to balance the effect of low molecular weight and a big co-monomer will allow the design of high flex life materials also at high MFI.

In addition to the Hyflon® resins, Solvay Specialty Polymers offers a wide range of other fluoropolymers which are also easily processable by injection, extrusion, and all conventional processing techniques:

- Solef® PVDF (polyvinylidene fluoride)
- Halar® ECTFE (copolymer of ethylene and chlorotrifluoroethylene)
- Hylar® PVDF for coating applications

### Relative performance of melt processable fluoropolymers




### Hyflon® PFA grades

| Grade | Description |
|---|---|
| **P series** | |
| **Hyflon® P125** | High viscosity resin for pressure tubing with superior heat resistance for compression and transfer molding |
| **Hyflon® P120** | High viscosity resin for lining and special cables with superior heat resistance |
| **Hyflon® P420** | High viscosity resin for extrusion |
| **Hyflon® P450** | Low viscosity resin for cable extrusion and injection molding |
| **M series** | |
| **Hyflon® M620** | High viscosity resin for extrusion, compression and transfer molding |
| **Hyflon® M640** | Low viscosity resin for cable extrusion and injection molding |

# Typical Properties of Hyflon® PFA P Series Grades

| | Unit | P125 | P120 | P420 | P450 | Test Method |
|---|---|---|---|---|---|---|
| **Physical properties** | | | | | | |
| Density at 23 °C/73 °F | g/cm³ (lb/ft³) | 2.12–2.17 (132–135) | 2.12–2.17 (132–135) | 2.12–2.17 (132–135) | 2.12–2.17 (132–135) | ASTM D792 |
| Water absorption (7 days at 100 °C/212 °F) | % | < 0.1 | < 0.1 | < 0.1 | < 0.1 | ASTM D570 |
| Melt flow index at 372 °C/702 °F, 5 kg | g/10 min | 1.5–3.0 | 2.5–5.0 | 1.5–3.0 | 10–17 | ASTM D1238 |
| **Mechanical properties** | | | | | | |
| Tensile at 23 °C/73 °F | | | | | | ASTM D1708 |
| Stress at yield (50 mm/min) | MPa (psi) | 14–15 (2,000–2,150) | 14–15 (2,000–2,150) | 14–15 (2,000–2,150) | 14–15 (2,000–2,150) | |
| Stress at break (50 mm/min) | MPa (psi) | > 26 (3,750) | > 26 (3,750) | > 26 (3,750) | > 21 (3,045) | |
| Elongation at yield (50 mm/min) | % | 9–11 | 9–11 | 9–11 | 9–11 | |
| Elongation at break (50 mm/min) | % | > 300 | > 300 | > 300 | > 275 | |
| Modulus (1 mm/min) | MPa (kpsi) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | |
| Flexural at 23 °C/73 °F | | | | | | ASTM D790 |
| Modulus (2.5 mm/min) | MPa (kpsi) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | |
| Notched charpy strength (4 mm thick, 2 m/s, 23 °C/73 °F) | J/m (ft·lbf/in) | no break | no break | no break | no break | ASTM D6110 |
| Shore D hardness (2 mm thick) | | 55–60 | 55–60 | 55–60 | 55–60 | ASTM D2240 |
| Abrasion resistance | mg/1,000 rev | 10–20 | 10–20 | 10–20 | 10–20 | TABER CS 17, 1 kg |
| Friction coefficient | | 0.1–0.2 | 0.1–0.2 | 0.1–0.2 | 0.1–0.2 | ASTM D1894 |
| Folding endurance (0.3 mm film, 90 cycles/min) | 1,000 cycles | 50–80 | 50–80 | 90–120 | 4–6 | ASTM D2176 |

| | Unit | P125 | P120 | P420 | P450 | Test Method |
|---|---|---|---|---|---|---|
| **Thermal properties** | | | | | | |
| Crystallinity by DSC | | | | | | |
| Melting point | °C (°F) | 310–316 (590–601) | 310–316 (590–601) | 300–310 (572–590) | 300–310 (572–590) | ASTM D3418 |
| Heat of fusion (250 °C/482 °F to end of melting) | J/g (BTU/lb) | 25–35 (10.7–15.0) | 34–45 (14.6–19.3) | 25–35 (10.7–15.0) | 25–35 (10.7–15.0) | ASTM D3418 |
| Crystallization point | °C (°F) | 275–285 (527–545) | 275–285 (527–545) | 275–285 (527–545) | 275–285 (527–545) | ASTM D3418 |
| Crystallization heat | J/g (BTU/lb) | 25–35 (10.7–15.0) | 35–45 (15.0–19.3) | 25–35 (10.7–15.0) | 25–35 (10.7–15.0) | ASTM D3418 |
| Glass transition (Tg) | °C (°F) | 90 (194) | 90 (194) | 90 (194) | 90 (194) | DMTA |
| Molding shrinkage (linear) | % | 3–5 | 3–5 | 3–5 | 3–5 | ASTM D955 |
| Thermal stability | °C (°F) | 420–440 (788–824) | 420–440 (788–824) | 420–440 (788–824) | 420–440 (788–824) | TGA. T° for 1% w loss in air |
| Linear thermal expansion coefficient | $10^{-6}$/K ($10^{-6}$/°F) | 120–200 (67–111) | 120–200 (67–111) | 120–200 (67–111) | 120–200 (67–111) | ASTM D696 |
| Thermal conductivity at 23 °C/73 °F | W/m·K (BTU·in/h·ft²·°F) | 0.15–0.25 (1.0–1.7) | 0.15–0.25 (1.0–1.7) | 0.15–0.25 (1.0–1.7) | 0.15–0.25 (1.0–1.7) | ASTM C177 |
| Specific heat at 23 °C/73 °F | J/g·K (BTU/lb·°F) | 0.9–1.1 (0.21–0.26) | 0.9–1.1 (0.21–0.26) | 0.9–1.1 (0.21–0.26) | 0.9–1.1 (0.21–0.26) | ASTM E1269 |
| **Electrical properties** | | | | | | |
| Surface resistivity | Ω | > $10^{17}$ | > $10^{17}$ | > $10^{17}$ | > $10^{17}$ | ASTM D257, DIN 53483 |
| Volume resistivity | Ω·cm | > $10^{17}$ | > $10^{17}$ | > $10^{17}$ | > $10^{17}$ | ASTM D257, DIN 53483 |
| Dielectric constant (50 Hz–100 kHz) | | 2.0 | 2.0 | 2.0 | 2.0 | ASTM D150 |
| Dissipation factor (50 Hz–100 kHz) | | < $5 \cdot 10^{-4}$ | < $5 \cdot 10^{-4}$ | < $5 \cdot 10^{-4}$ | < $5 \cdot 10^{-4}$ | ASTM D150 |
| **Fire resistance** | | | | | | |
| UL-94 flammability test | Class | V–0 | V–0 | V–0 | V–0 | UL-94 |
| Limiting oxygen index (sheet 3 mm thick) | % | 95 | 95 | 95 | 95 | ASTM D2863 |

# Typical Properties of Hyflon® PFA M Series Grades

| | Unit | M620 | M640 | Test Method |
|---|---|---|---|---|
| **Physical properties** | | | | |
| Density at 23 °C/73 °F | g/cm³ (lb/ft³) | 2.12–2.17 (132–135) | 2.12–2.17 (132–135) | ASTM D792 |
| Water absorption (7 days at 100 °C/212 °F) | % | < 0.1 | < 0.1 | ASTM D570 |
| Melt flow index at 372 °C/702 °F, 5 kg | g/10 min | 2–5 | 10–17 | ASTM D1238 |
| **Mechanical properties** | | | | |
| Tensile at 23 °C/73 °F | | | | ASTM D1708 |
| Stress at yield (50 mm/min) | MPa (psi) | 12–15 (1,750–2,150) | 12–15 (1,750–2,150) | |
| Stress at break (50 mm/min) | MPa (psi) | > 26 (3,750) | > 21 (3,045) | |
| Elongation at yield (50 mm/min) | % | 9–11 | 9–11 | |
| Elongation at break (50 mm/min) | % | > 300 | > 275 | |
| Modulus (1 mm/min) | MPa (kpsi) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | |
| Flexural at 23 °C/73 °F | | | | ASTM D790 |
| Modulus (2.5 mm/min) | MPa (kpsi) | 500–600 (72.5–87.0) | 500–600 (72.5–87.0) | |
| Notched charpy strength (4 mm thick, 2 m/s, 23 °C/73 °F) | J/m (ft·lbf/in) | no break | no break | ASTM D6110 |
| Shore D hardness (2 mm thick) | | 55–60 | 55–60 | ASTM D2240 |
| Abrasion resistance | mg/1,000 rev | 10–20 | 10–20 | TABER CS 17, 1 kg |
| Friction coefficient | | 0.1–0.2 | 0.1–0.2 | ASTM D1894 |
| Folding endurance (0.3 mm film, 90 cycles/min) | 1,000 cycles | 70–100 | 4–6 | ASTM D2176 |

| | Unit | M620 | M640 | Test Method |
|---|---|---|---|---|
| **Thermal properties** | | | | |
| Crystallinity by DSC | | | | |
| Melting point | °C (°F) | 280–290 (536–554) | 280–290 (536–554) | ASTM D3418 |
| Heat of fusion (250 °C/482 °F to end of melting) | J/g (BTU/lb) | 18–26 (7.7–11.2) | 18–26 (7.7–11.2) | ASTM D3418 |
| Crystallization point | °C (°F) | 255–265 (491–509) | 255–265 (491–509) | ASTM D3418 |
| Crystallization heat | J/g (BTU/lb) | 18–26 (7.7–11.2) | 18–26 (7.7–11.2) | ASTM D3418 |
| Glass transition (Tg) | °C (°F) | 85 (185) | 85 (185) | DMTA |
| Molding shrinkage (linear) | % | 3–5 | 3–5 | ASTM D955 |
| Thermal stability | °C (°F) | 420–440 (788–824) | 420–440 (788–824) | TGA. T° for 1% w loss in air |
| Linear thermal expansion coefficient | $10^{-6}$/K ($10^{-6}$/°F) | 120–200 (67–111) | 120–200 (67–111) | ASTM D696 |
| Thermal conductivity at 23 °C/73 °F | W/m·K (BTU·in/h·ft²·°F) | 0.15–0.25 (1.0–1.7) | 0.15–0.25 (1.0–1.7) | ASTM C177 |
| Specific heat at 23 °C/73 °F | J/g·K (BTU/lb·°F) | 0.9–1.1 (0.21–0.26) | 0.9–1.1 (0.21–0.26) | ASTM E1269 |
| **Electrical properties** | | | | |
| Surface resistivity | Ω | $> 10^{17}$ | $> 10^{17}$ | ASTM D257, DIN 53483 |
| Volume resistivity | Ω·cm | $> 10^{17}$ | $> 10^{17}$ | ASTM D257, DIN 53483 |
| Dielectric constant (50 Hz–100 kHz) | | 2.0 | 2.0 | ASTM D150 |
| Dissipation factor (50 Hz–100 kHz) | | $< 5 \cdot 10^{-4}$ | $< 5 \cdot 10^{-4}$ | ASTM D150 |
| **Fire resistance** | | | | |
| UL-94 flammability test | Class | V–0 | V–0 | UL-94 |
| Limiting oxygen index (sheet 3 mm thick) | % | 95 | 95 | ASTM D2863 |

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