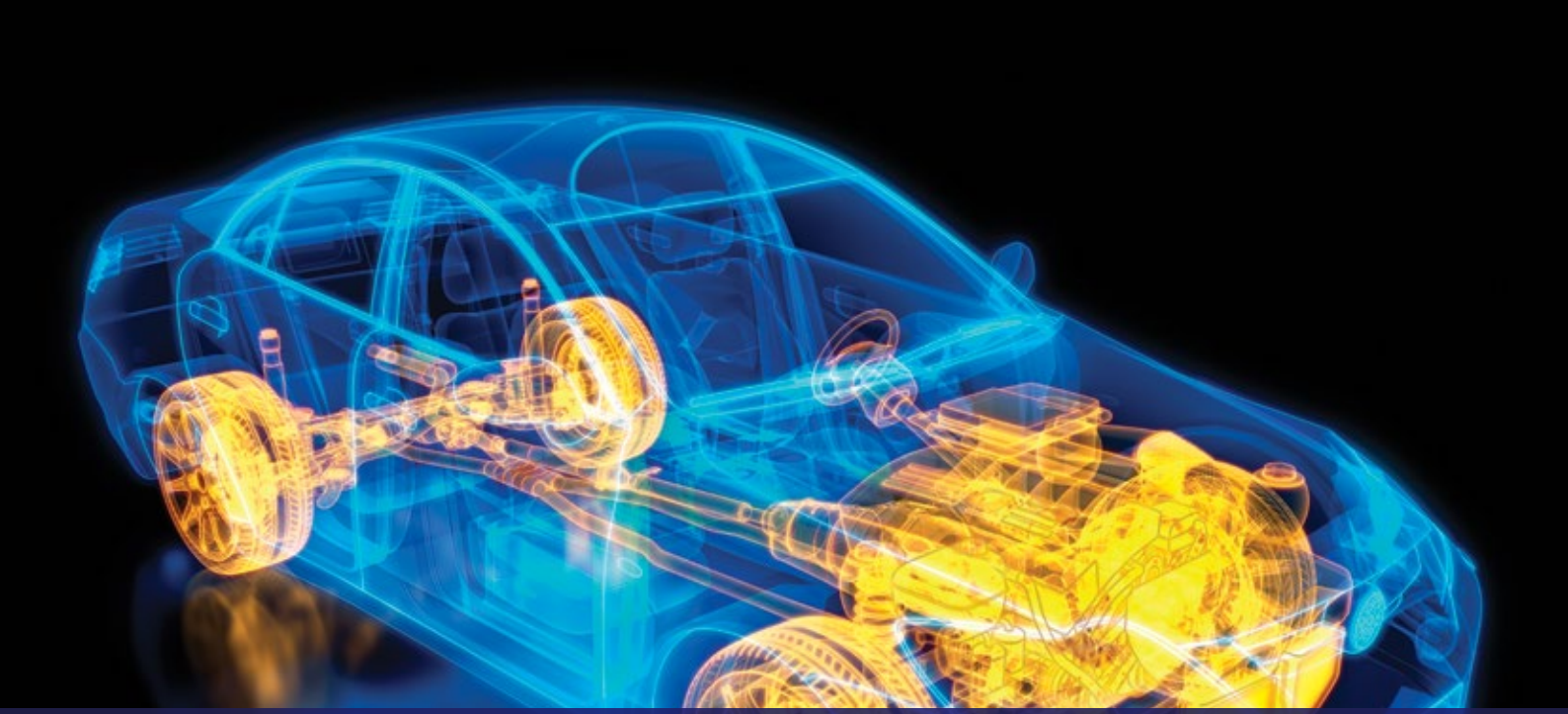
SOLVAY

asking more from chemistry®

High-Performance Plastics for

# Drivetrain Systems

SPECIALTY POLYMERS



# Designed for Higher Performance

## Better than Metal

- Light weight for improved fuel efficiency
- Parts consolidation for lower manufacturing and assembly costs
- Noise and vibration dampening
- Compatible with transmission fluids
- Abrasion and corrosion resistance
- High-temperature wear resistance in dry and lubricated environments

## More Transmission Designs

- Dual clutch (DCT)
- Automated manual (AMT)
- Continuously variable (CVT)
- Automatic
- Front wheel drive
- Rear wheel drive
- All wheel drive
- High torque

Smaller, more complex transmissions must deliver higher performance and better fuel economy, yet cost less to manufacture. Solvay's broad selection of high and ultra-high performance plastics can help you meet these challenges.



## Torlon® PAI
polyamide-imide

Torlon® PAI provides exceptional wear resistance in both dry and lubricated environments and retains its toughness, high strength and high stiffness up to 275 °C (525 °F). It exhibits outstanding creep and chemical resistance – including strong acids and most organics – and is ideally suited for harsh environments.

## KetaSpire® PEEK
polyetheretherketone

KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240 °C (464 °F), enabling it to replace metal in some of the most severe end-use environments.

## AvaSpire® PAEK
polyaryletherketone

AvaSpire® PAEK is a versatile family of polymers that are tailored to provide new and unique combinations of performance and value. Products in the AV-700 Series offers comparable performance to PEEK at up to 30 % lower cost.

## Amodel® PPA
polyphthalamide

Amodel® PPA is stronger, stiffer and has higher thermal capabilities than standard nylons. It is less sensitive to moisture and retains excellent mechanical properties – including fatigue and creep resistance – when exposed to a wide range of operating temperatures, high humidity and aggressive chemicals.

## Seal Rings

- Excellent sealing and conformability
- High ductility for easier installation of small rings
- Molded-in joint geometries provide cost savings
- Excellent wear properties in dry and lubricated environments

## Thrust Washers, Thrust Bearings, Needle Bearing Replacements

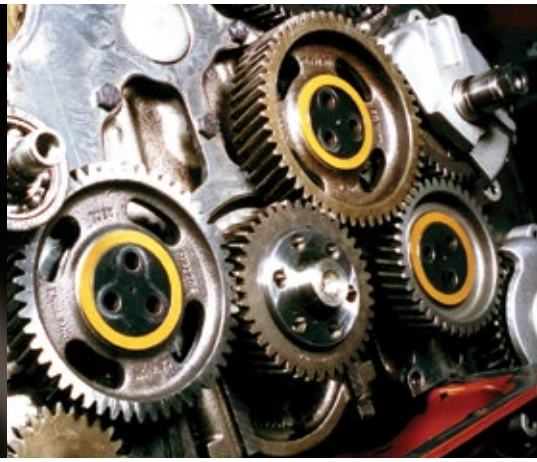
- Low creep
- High compressive strength
- Low coefficient of friction
- Excellent wear properties in dry and lubricated environments
- Suitable for very high pressures and velocities
- Molded-in oil grooves eliminate secondary machining costs

## Check Balls

- Excellent sealing and conformability
- High compressive strength
- Low creep
- Lighter than metal for quicker response
- Non-destructive to metal seat
- Noise reduction

# Wear-Resistant Grades for Drivetrain Systems

| | | Dry | Lubricated | Seal Rings | Thrust Washers | Check Balls |
|---|---|---|---|---|---|---|
| **Torlon® PAI** | | | | | | |
| 4203L | Unfilled, high elongation | | √ | √ *Small rings, high elongation* | √ *High lubrication* | √ *Compressive properties* |
| 4301 | High compressive strength | √ | √ | √ | √ | |
| 4275 | Designed for high speeds | √ | √ | √ *Best balance* | √ | |
| 4630 | Excellent wear resistance | √ *Best performance at high velocity low pressure* | √ | √ | √ | |
| 4645 | Excellent wear resistance | | √ *Best performance at high velocity low pressure* | √ | √ | |
| **KetaSpire® PEEK** | | | | | | |
| KT-820 SL30 | Very good wear resistance | √ | √ | √ | √ | |
| KT-820 SL45 | Very good wear resistance | | √ | √ | √ | |
| **AvaSpire® PAEK** | | | | | | |
| AV-755 SL45 | Very good wear resistance, more cost effective than PEEK | | √ | √ | √ *Large rings* | |
| **Amodel® PPA** | | | | | | |
| AT-6130 HS | Good wear resistance, most cost effective | | √ | | √ | |

# Typical Properties

| Property [1] | Units | Torlon® 4203L | Torlon® 4301 G/PTFE [2] | Torlon® 4275 G/PTFE | Torlon® 4630 G/PTFE | Torlon® 4645 CF/PTFE | ASTM Test Method |
|---|---|---|---|---|---|---|---|
| Tensile strength | MPa | 152 | 113 | 117 | 81 | 114 | D638 |
| | ksi | 22.0 | 16.4 | 16.9 | 11.8 | 16.6 | |
| Tensile modulus | GPa | 4.5 | 6.8 | 8.8 | 7.4 | 18.6 | D638 |
| | ksi | 4,000 | 990 | 1,280 | 1,080 | 2,700 | |
| Tensile elongation | % | 7.6 | 3.3 | 2.6 | 1.9 | 0.8 | |
| Flexural strength | MPa | 241 | 215 | 208 | 131 | 154 | D790 |
| | ksi | 34.9 | 31.2 | 30.2 | 19.0 | 22.4 | |
| Flexural modulus | GPa | 5.0 | 6.9 | 7.3 | 6.8 | 12.4 | D790 |
| | ksi | 730 | 1,000 | 1,060 | 990 | 1,800 | |
| Compressive strength | MPa | 221 | 166 | 123 | 99 | 157 | D695 |
| | ksi | 32.1 | 24.1 | 17.8 | 14.4 | 22.8 | |
| Shear strength | MPa | 128 | 111 | 77 | | 85 | D732 |
| | ksi | 18.5 | 16.1 | 11.1 | | 12.4 | |
| Izod impact strength, notched | J/m | 144 | 64 | 85 | 48 | 37 | D256 |
| | ft-lb/in | 2.7 | 1.2 | 1.6 | 0.9 | 0.7 | |
| Izod impact strength, unnotched | J/m | 1070 | 430 | 270 | 160 | 110 | D4812 |
| | ft-lb/in | 20 | 8 | 5 | 3 | 2 | |
| CLTE [3] | ppm/°C | 31 | 25 | 25 | 16 | 5 | D696 |
| | ppm/°F | 17 | 14 | 14 | 9 | 3 | |
| Heat deflection temperature | °C | 278 | 279 | 280 | 280 | 281 | D648 |
| | °F | 532 | 534 | 536 | 535 | 538 | |
| Specific gravity | | 1.42 | 1.46 | 1.51 | 1.56 | 1.57 | D792 |
| Water absorption, 24 hours | % | 0.33 | 0.28 | 0.33 | 0.18 | 0.25 | D570 |
| Coefficient of friction, dry | | | | | | | |
| 50 fpm and 500 psi (0.254 m/s and 3447 kPa) | | | 0.30 | 0.30 | 0.31 | | D3702 |
| 800 fpm and 31.25 psi (4.064 m/s and 215 kPa) | | | 0.39 | 0.29 | 0.31 | | D3702 |
| Wear factor, dry | | | | | | | |
| 0.254 m/s and 3447 kPa (50 fpm and 500 psi) | $10^{-8}$ $m^3/Nm$ | [4] NR | 27 | 26 | 12 | NR | D3702 |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | NR | 14 | 13 | 6 | NR | |
| 4.064 m/s and 215 kPa (800 fpm and 31.25 psi) | $10^{-8}$ $mm^3/Nm$ | NR | 34 | 36 | 27 | NR | |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | NR | 17 | 18 | 14 | NR | D3702 |
| Wear factor, lubricated [5] | $10^{-8}$ $mm^3/Nm$ | 55 | 18 | 14.1 | 22 | 3.2 | D3702 |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | 27 | 9 | 7.0 | 11 | 1.6 | |

*[1] Actual properties of individual batches will vary within specification limits.*
*[2] Abbreviations for additives: G=graphite, CF=carbon fiber, GF=glass fiber*
*[3] Coefficient of Linear Thermal Expansion reported as average for flow direction from 0 °C–150 °C*
*[4] NR=Not Recommended*
*[5] In automotive transmission fluid at 150 °C, 75 fpm and 1000 psi (0.38 m/s and 6896 kPa)*

# Typical Properties

| Property [1] | Units | KetaSpire® KT-820 SL30 CF/G/PTFE [2] | KetaSpire® KT-820 SL45 CF/PTFE | AvaSpire® AV-755 SL 45 CF/G | Amodel® AT-6130 HS GF | ASTM Test Method |
|---|---|---|---|---|---|---|
| Tensile strength | MPa | 133 | 161 | 169 | 167 | D638 |
| | ksi | 19.3 | 23.4 | 24.5 | 24.2 | |
| Tensile modulus | GPa | 11.0 | 18.3 | 33.6 | 8.6 | D638 |
| | ksi | 1,590 | 2,660 | 4,870 | 1,250 | |
| Tensile elongation | % | 2.8 | 1.5 | 0.9 | 3.2 | |
| Flexural strength | MPa | 221 | 265 | 250 | 236 | D790 |
| | ksi | 32.0 | 38.5 | 36.2 | 34.2 | |
| Flexural modulus | GPa | 10.5 | 16.6 | 25.9 | 7.9 | D790 |
| | ksi | 1,530 | 2,410 | 3,760 | 1,140 | |
| Compressive strength | MPa | 105 | 132 | 97 | 114 | D695 |
| | ksi | 15.3 | 19.2 | 14.1 | 16.5 | |
| Shear strength | MPa | 67 | 79 | 70 | 65 | D732 |
| | ksi | 9.7 | 11.5 | 10.1 | 9.4 | |
| Izod impact strength, notched | J/m | 69 | 69 | 37 | 133 | D256 |
| | ft-lb/in | 1.3 | 1.3 | 0.7 | 2.5 | |
| Izod impact strength, unnotched | J/m | 530 | 530 | 320 | 1,390 | D4812 |
| | ft-lb/in | 10 | 10 | 6 | 26 | |
| CLTE [3] | ppm/°C | 22 | 16 | 7 | 24 | D696 |
| | ppm/°F | 12 | 9 | 4 | 13 | |
| Heat deflection temperature | °C | 291 | 299 | 278 | 276 | D648 |
| | °F | 556 | 571 | 532 | 529 | |
| Specific gravity | | 1.45 | 1.5 | 1.53 | 1.34 | D792 |
| Water absorption, 24 hours | % | 0.14 | 0.03 | 0.01 | 0.24 | D570 |
| Coefficient of friction, dry | | | | | | |
| 50 fpm and 500 psi (0.254 m/s and 3447 kPa) | | 0.27 | | 0.23 | | D3702 |
| 800 fpm and 31.25 psi (4.064 m/s and 215 kPa) | | 0.33 | | 0.34 | 0.29 | D3702 |
| Wear factor, dry | | | | | | |
| 0.254 m/s and 3447 kPa (50 fpm and 500 psi) | $10^{-8}$ $m^3/Nm$ | 151 | [4] NR | NR | NR | D3702 |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | 75 | NR | NR | NR | |
| 4.064 m/s and 215 kPa (800 fpm and 31.25 psi) | $10^{-8}$ $mm^3/Nm$ | 63 | NR | NR | 424 | |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | 32 | NR | NR | 211 | D3702 |
| Wear factor, lubricated [5] | $10^{-8}$ $mm^3/Nm$ | 11 | 5.8 | 5.4 | 15.8 | D3702 |
| | $10^{-10}$ $in.^3min/ft\text{-}lb\text{-}hr$ | 5.5 | 2.9 | 2.7 | 8 | |

[1] *Actual properties of individual batches will vary within specification limits.*
[2] *Abbreviations for additives: G = graphite, CF = carbon fiber, GF = glass fiber*
[3] *Coefficient of Linear Thermal Expansion reported as average for flow direction from 0 °C – 150 °C*
[4] *NR = Not Recommended*
[5] *In automotive transmission fluid at 150 °C, 75 fpm and 1000 psi (0.38 m/s and 6896 kPa)*

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