Genestar™
High Performance Polyamide: PA9T
for reliably efficient automotive parts
Properties of GENESTAR™ for automotive applications

- The lowest water absorption rate among high heat-resistant polyamides.
- Retains both dimensional stability and strength due to its low water absorption.
- Superb chemical and hydrolysis resistance.
- Excellent mechanical properties at high temperature and long term heat resistance. (Tg: PA9T > PA46 > PA66)
- Outstanding fuel barrier properties.

Terephthalic Acid

C9-diamine

Long Hydrocarbon Chain

Aromatic Core

(Tm=300°C (Injection) 264°C (Extrusion) Tg=125°C)
Water absorption

23°C, in water

**PA9T**

Long-chain diamine structure (C9)

**PA46**

Number of carbon atoms per 1 amide group in recurring units

Water Absorption Rate (%)

- PA46
- PA6
- PA66
- PA610
- PA6T
- PA9T
- PA612
- PA11
- PA12

Kuraray
# Chemical resistance

Retention (%) of strength after dipping in solvent at 23°C for 7 days

<table>
<thead>
<tr>
<th></th>
<th>PA9T</th>
<th>PA6T</th>
<th>PA46</th>
<th>PA66</th>
<th>PPS</th>
</tr>
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<tbody>
<tr>
<td>Gasoline</td>
<td>86</td>
<td>86</td>
<td>71</td>
<td>86</td>
<td>98</td>
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<tr>
<td>Engine oil</td>
<td>89</td>
<td>88</td>
<td>67</td>
<td>81</td>
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<tr>
<td>Methanol</td>
<td>72</td>
<td>35</td>
<td>54</td>
<td>39</td>
<td>98</td>
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<tr>
<td>Toluene</td>
<td>82</td>
<td>77</td>
<td>74</td>
<td>68</td>
<td>95</td>
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<tr>
<td>Chloroform</td>
<td>87</td>
<td>85</td>
<td>71</td>
<td>68</td>
<td>87</td>
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<tr>
<td>Hot water (80°C)</td>
<td>90</td>
<td>63</td>
<td>40</td>
<td>44</td>
<td>96</td>
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<tr>
<td>Sulphuric acid (10%aq.)</td>
<td>81</td>
<td>52</td>
<td>42</td>
<td>39</td>
<td>98</td>
</tr>
<tr>
<td>NaOH (50%aq.)</td>
<td>85</td>
<td>62</td>
<td>59</td>
<td>71</td>
<td>92</td>
</tr>
<tr>
<td>CaCl₂ (50%aq.)</td>
<td>92</td>
<td>64</td>
<td>52</td>
<td>73</td>
<td>97</td>
</tr>
</tbody>
</table>

Retention (%) of strength after dipping in solvent at 23°C for 7 days

Thickness of specimen : 0.2mm

*Yellow cells show that maintains 80% of initial property
Mechanical properties at elevated temperature

Flexural Modulus of Unreinforced Grade

Tg: PA9T ≡ PA6T > PA46
Crystallinity: PA9T ≡ PA46 > PA6T
Long term heat resistance (GF30%)
Fuel CE10: isoctane/toluene/ethanol = 45/45/10 vol.%
Applications

- Heat resistance
- Dimensional stability
- Chemical resistance
- Fuel barrier

Genestar™

- Sliding
- Cooling
- Fuel
- Air Intake

- EGR Valve Motor Insulator
- ETB Gear
- Thermostat Housing
- HVAC gear
- Window Wiper Motor Gear
- Quick Connector
- Fuel Tube
- Fuel Cell Stack Parts
- Lock Nut

- Bearing Retainer
- CAC Tank
- Wire Harness
- Cable Tie

Applications

- AFS system Gear
HVAC actuator gear: Low water absorption, strength at high temp.

Grade: G1300A, N1000A

Downsizing

Advantages
- Low water absorption
- Low friction and wear
- Strength at high temp.

【Conventional Materials】POM, PA66

【Problems】Decrease in strength and dimensional stability due to water absorption and high heat conditions

【Requirements】Low water absorption, low friction, strength at high temp.

Gear: 60% weight reduction Actuator: 40% size reduction
ETB Gear: Low water absorption, low friction, strength at high temp.

【Conventional Material】PA46
【Problem】Dimensional stability
【Requirements】Low water absorption, low friction, strength at high temp.

Advantages
- Low water absorption
- Low friction and wear
- Strength at high temp.

Grade: G1352A
 Cooling module for fuel cell stack:
Low water absorption, electrical insulation

【Conventional Material】New part

【Requirements】Insulation property after water absorption, acid & LLC resistance

Advantages
- Better insulation property retention after water absorption

Grade: G1301A
Thermostat housing: Chemical resistance

Grade: G1350A

- **Conventional Material**: PPS
- **Problems**: Heavy, low impact resistance
- **Requirements**: LLR resistance, low specific gravity, ductility

**Advantages**
- Low specific gravity
- Less brittle
- Forced extraction

20% weight reduction (vs. PPS)
Cable tie: Chemical resistance, long term heat resistance

- **Conventional Material**: PA46
- **Problem**: Degenerated by calcium chloride
- **Requirements**: Calcium chloride resistance, long term heat resistance

**Advantages**
- Calcium chloride resistance
- Retention of strength due to its low water absorption rate

Grade: N1001A, N1006A
Wire harness tube: Chemical resistance, long term heat resistance

【Conventional Material】PA46
【Problem】Degenerated by calcium chloride
【Requirements】Calcium chloride resistance, long term heat resistance

Advantages
- Calcium chloride resistance

Grade: N1006D
Adaptive Front Lighting System
Grade: G1300A

【Conventional Material】New part
【Requirements】Low friction and retention of strength under high Temp.

Advantages
- Low friction and wear
- Strength at high temp.
CAC Tank:
Strength at high temp., long term heat resistance, chemical resistance

Grade: G1300A, G1500A, GX1500A

【Conventional Material】 Aluminum die-cast, PA46, PA66
【Problems】 Heavy, lack of chemical resistance, Long-term high-heat resistance, Acid resistance (LPL-EGR)
【Requirements】 Chemical resistance, long-term high heat resistance, acid resistance (LPL-EGR)

Advantages
• Heat resistance
• Thermal fatigue property
• Chemical resistance

40% weight reduction (vs. Aluminum die-cast)
Parts around Fuel: Fuel resistance, fuel barrier property

**Fuel tank**
- Grade: N1001A
  - Conventional material: POM
  - Requirements: Acid resistance, creep resistance
  - 30% weight reduction (vs. POM)

**Fuel tube**
- Grade: N1001D
  - Conventional material: PA12, ETFE
  - Requirements: Resistance, barrier property and low oligomer extraction against fuel
  - 30% weight reduction (vs. ETFE)

**Quick connector**
- Grade: G1300A, G1301A, GC1201A
  - Conventional material: PA12
  - Requirements: Resistance and low oligomer extraction against fuel
Typical properties of unreinforced grades

*Table shows typical values, which are not specified values.

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Test method</th>
<th>Genestar N1000A</th>
<th>Genestar N1001A</th>
<th>Genestar N1002A</th>
<th>Genestar N1006A</th>
<th>Unreinforced Grades</th>
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</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
<td>(ISO)</td>
<td>Standard</td>
<td>Abrasion resistance</td>
<td>Toughened</td>
<td>Extrusion</td>
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<tr>
<td>Glass fiber content</td>
<td>%</td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Physical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific gravity</td>
<td>g/cm³</td>
<td>118A</td>
<td>1.14</td>
<td>1.11</td>
<td>1.17</td>
<td>1.06</td>
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<td>Water absorption (23°C in water, 24hrs)</td>
<td>%</td>
<td>62</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
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<td>Mechanical properties</td>
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<td></td>
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<tr>
<td>Tensile strength</td>
<td>MPa</td>
<td>527</td>
<td>85</td>
<td>80</td>
<td>80</td>
<td>50</td>
<td>50</td>
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<tr>
<td>Tensile elongation</td>
<td>%</td>
<td>527</td>
<td>4</td>
<td>12</td>
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<td>Flexural strength</td>
<td>MPa</td>
<td>178</td>
<td>115</td>
<td>105</td>
<td>115</td>
<td>70</td>
<td>60</td>
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<td>Flexural modules</td>
<td>GPa</td>
<td>178</td>
<td>2.5</td>
<td>2.3</td>
<td>2.5</td>
<td>1.5</td>
<td>1.4</td>
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<td>Charpy impact strength (notched)</td>
<td>kJ/m²</td>
<td>179/1eA</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>65</td>
<td>NB</td>
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<td>Thermal properties</td>
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<tr>
<td>Melting point</td>
<td>°C</td>
<td>11357-3</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>264</td>
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<tr>
<td>Glass transition</td>
<td>°C</td>
<td>—</td>
<td>125</td>
<td>125</td>
<td>125</td>
<td>125</td>
<td>125</td>
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<tr>
<td>DTUL (1.82 MPa)</td>
<td>°C</td>
<td>75Af</td>
<td>125</td>
<td>120</td>
<td>125</td>
<td>110</td>
<td>105</td>
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<tr>
<td>Dimensional characteristics</td>
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<td></td>
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<tr>
<td>Molding shrinkage (in direction of flow) (2mm)</td>
<td>%</td>
<td>294-4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
<td>1.7</td>
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<tr>
<td>Molding shrinkage (at right angles to flow)</td>
<td>%</td>
<td>294-4</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.7</td>
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<tr>
<td>Abrasion properties</td>
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<td></td>
<td></td>
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<tr>
<td>Critical PV value</td>
<td>kg/cm²·cm/sec</td>
<td>JIS K7218-A</td>
<td>850</td>
<td>1000</td>
<td>1150</td>
<td>1000</td>
<td>750</td>
</tr>
<tr>
<td>Coefficient of friction, P=10kgf/cm²</td>
<td>—</td>
<td>JIS K7218-A</td>
<td>0.45</td>
<td>0.15</td>
<td>0.25</td>
<td>0.25</td>
<td>0.15</td>
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<tr>
<td>Wear, P=10kgf/cm²</td>
<td>mg</td>
<td></td>
<td>200</td>
<td>20</td>
<td>5</td>
<td>50</td>
<td>180</td>
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</table>
Typical properties of reinforced grade

*Table shows typical values, which are not specified values.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Unit</th>
<th>Test method</th>
<th>Genestar</th>
<th>Reinforced Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ISO)</td>
<td>G1300A</td>
<td>G1500A</td>
</tr>
<tr>
<td>Glass fiber content</td>
<td>%</td>
<td>—</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>

Physical properties

| Specific gravity       | g/cm³ | 118A | 1.37 | 1.58 | 1.58 | 1.40 | 1.50 | 1.34 | 1.22 |
| Water absorption       | %     | 62   | 0.19 | 0.13 | 0.13 | 0.19 | 0.14 | 0.19 | 0.19 |

Mechanical properties

| Tensile strength       | MPa  | 527  | 190  | 250  | 250  | 200  | 200  | 175  | 170  |
| Tensile elongation     | %    | 527  | 2.5  | 2.0  | 2.0  | 2.5  | 2.5  | 3.0  | 3.0  |
| Flexural strength      | MPa  | 178  | 270  | 370  | 370  | 285  | 290  | 250  | 260  |
| Flexural modulus       | GPa  | 178  | 8.8  | 15.3 | 15.5 | 10.0 | 10.7 | 8.2  | 9.4  |
| Charpy impact strength | kJ/m²| 179/1eA | 10  | 17  | 17  | 12  | 13  | 17  | 12  |

Thermal properties

| Melting point       | ºC   | 11357-3 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Glass transition    | ºC   | —       | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 |
| DTUL(1.82MPa)       | ºC   | 75Af    | 270 | 275 | 280 | 270 | 270 | 270 | 270 | 265 |

Dimensional characteristics

| Molding shrinkage : in direction of flow (2mm/t) | %    | 294-4 | 0.3 | 0.2 | 0.1 | 0.3 | 0.2 | 0.3 | 0.2 |
| : at right angles to flow                        | %    | 294-4 | 0.9 | 0.8 | 0.5 | 0.9 | 0.8 | 0.9 | 0.7 |

Abrasion properties

| Critical PV value | kg/cm²·cm/sec | JIS K7218-A | 1025 | 1050 | —   | —   | 1500 | 1000 | —   |
| Coefficient of Friction P=10kgf/cm² | — | 0.40 | 0.30 | 0.30 | —   | —   | 0.30 | 0.30 | —   |
| Wear P=10kgf/cm²   | mg   | 40   | 60   | 50   | —   | 10  | 15   | —   | —   |
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Melting Points of Polyterephthalamides

**PA6T homopolymer**
- Co-polymerization (ex) adipic acid, isophthalic acid, methyl pentanediame

**Modified PA6T**
- Lower chemical resistance
- Poor moldability
- Lower abrasion resistance

![Diagram showing melting points and number of carbon in diamine unit](https://example.com/diagram.png)

- Decomposition temperature
- Moldable temperature

Number of carbon in diamine unit
<table>
<thead>
<tr>
<th>Materials</th>
<th>Chemical structure</th>
<th>Thermal Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PA6-6</strong></td>
<td>$\begin{array}{c}N-(CH_2)_6-N-(CH_2)_6-C-(CH_2)_4-C_n \ C6 diamine \quad \text{adipic acid} \end{array}$</td>
<td>Tm=255°C Tg=50°C</td>
</tr>
<tr>
<td><strong>PA4-6 (Stanyl, DSM)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_4-N-(CH_2)_6-C-(CH_2)_4-C_n \ C4 diamine \quad \text{adipic acid} \end{array}$</td>
<td>Tm=290°C Tg=78°C</td>
</tr>
<tr>
<td><strong>PA6-6T (Amode A-4000, Solvay)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_6-N-(CH_2)_6-C-(CH_2)_4-C_n \ C6 diamine \quad \text{adipic acid} \quad \text{terephthalic acid} \end{array}$</td>
<td>Tm=310°C Tg=80°C</td>
</tr>
<tr>
<td><strong>PA6-1T (Grivory, HT1, EMS)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_6-N-(CH_2)_6-C-(CH_2)_4-C_n \ C6 diamine \quad \text{isophthalic acid} \quad \text{terephthalic acid} \end{array}$</td>
<td>Tm=310°C Tg=80°C</td>
</tr>
<tr>
<td><strong>PA6-6IT (Amode A-1000, Solvay)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_6-N-(CH_2)_6-C-(CH_2)_4-C_n \ C6 diamine \quad \text{adipic acid} \quad \text{isophthalic acid} \quad \text{terephthalic acid} \end{array}$</td>
<td>Tm=310°C Tg=126°C</td>
</tr>
<tr>
<td><strong>PA6M-T (Zytel HTN51, Dupont)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_6-N-(CH_2)_6-C-(CH_2)_4-C_n \ C6 diamine \quad \text{methylpentane diamine} \quad \text{terephthalic acid} \end{array}$</td>
<td>Tm=305°C Tg=135°C</td>
</tr>
<tr>
<td><strong>PA9T (Genestar, Kuraray)</strong></td>
<td>$\begin{array}{c}N-(CH_2)_9-N-(CH_2)_6-N-(CH_2)_9-C_n \ C9 diamine \quad \text{methyloctane diamine} \quad \text{terephthalic acid} \end{array}$</td>
<td>Tm=263~306°C Tg=125°C</td>
</tr>
</tbody>
</table>
**Genestar as a Thermoplastic Polymer**

**PA: PolyAmide (Nylon)**

C9-diamine + Terephthalic acid

**PA66 (66Nylon)**

C6-diamine + adipic acid

<table>
<thead>
<tr>
<th>Commodity Plastics</th>
<th>Engineering Plastics</th>
<th>High Performance Plastics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline</td>
<td></td>
<td>PA9T PA46 PA6T PPS LCP PEEK PAI</td>
</tr>
<tr>
<td>PE</td>
<td>POM</td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>PA66</td>
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<tr>
<td>PET</td>
<td>PBT</td>
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<tr>
<td>Amorphous</td>
<td>PC m-PPE</td>
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</tr>
<tr>
<td>PVC</td>
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<td>PES PSF PAR PEI</td>
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<td>PMMA</td>
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