# Conductive PA6 (Polyamide 6)
# Material Technical Guide

## 1. Material Overview

Conductive PA6 (Polyamide 6) is an advanced engineering plastic compounded from nylon 6 resin and conductive fillers such as carbon black, graphite, or carbon fiber. While retaining the mechanical strength, wear resistance, and chemical stability of traditional PA6 materials, this material achieves controllable electrical conductivity. Conductive PA6 is widely used in plastic components requiring electrostatic control, electromagnetic shielding, and reliable structural performance.

## 2. Material Performance Characteristics

### Physical Properties

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Density | ISO 1183 / ASTM D792 | 1.20 ~ 1.36 | g/cm³ |
| Melt Flow Rate (275°C/10.0 kg) | ISO 1133 | 10 ~ 13 | g/10 min |
| Mold Shrinkage | ASTM D955 / ISO 294-4 | 0.05 ~ 2.0 | % |
| Water Absorption (23°C, 24hr) | ASTM D570 | <0.60 ~ 0.90 | % |

> Density varies by filler type and content: approximately 1.20 g/cm³ for carbon black filled grades, up to 1.36 g/cm³ for carbon fiber reinforced grades; 25% glass fiber reinforced grades are approximately 1.36 g/cm³.

### Mechanical Properties

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Tensile Strength (Yield) | ISO 527 / ASTM D638 | 55 ~ 106 | MPa |
| Tensile Strength (Break) | ISO 527 / ASTM D638 | 45 ~ 270 | MPa |
| Elongation at Break | ISO 527 / ASTM D638 | 2.0 ~ 15 | % |

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Flexural Modulus | ISO 178 / ASTM D790 | 2,700 ~ 28,000 | MPa |
| Flexural Strength | ISO 178 / ASTM D790 | 89 ~ 395 | MPa |
| Charpy Notched Impact Strength (23°C) | ISO 179 | 7 ~ 12 | $kJ/m^2$ |
| Izod Notched Impact Strength (23°C) | ISO 180 / ASTM D256 | 15 ~ 43 | $kJ/m^2$ |
| Rockwell Hardness (R Scale) | ASTM D785 | 99 ~ 123 | — |

> Tensile properties vary significantly by formulation: carbon black filled conductive PA6 has a tensile strength of approximately 55 MPa (yield); carbon fiber reinforced grades (30% carbon fiber) can reach 270 MPa; 30% glass fiber reinforced grades with conductive carbon powder have a tensile stress of approximately 106 MPa. In terms of flexural modulus, carbon black filled grades are approximately 2,700 MPa, while carbon fiber reinforced grades can reach 28,000 MPa.

## Electrical Properties

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Volume Resistivity | ASTM D257 / IEC 60093 | 1.0E+2 ~ 1.0E+4 | Ω·cm |
| Surface Resistivity | ASTM D257 / IEC 60093 | 1.0E+2 ~ 1.0E+5 | Ω |

> The volume resistivity of conductive PA6 can typically be controlled in the range of $10^2$ ~ $10^4$ Ω·cm. Specific indicators vary by grade: Cabot CA3178 has a volume resistivity of 1.0E+2 Ω·cm and surface resistivity of 1.0E+3 Ω; some grades have volume resistivity ranging from 1.0E+2 to 1.0E+4 Ω·cm; surface resistivity ranges between 1.0E+2 and 1.0E+5 Ω.

## Thermal Properties

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Heat Deflection Temperature (1.8 MPa, unannealed) | ISO 75 / ASTM D648 | 76 ~ 216 | °C |
| Heat Deflection Temperature (0.45 MPa, unannealed) | ISO 75 / ASTM D648 | 66 ~ 216 | °C |
| Vicat Softening Temperature | ISO 306 | 205 ~ 220 | °C |

| Property | Test Method | Typical Value | Unit |
|---|---|---|---|
| Melting Point | ASTM D2117 | 220 | °C |
| UL Flammability Rating | UL 94 | HB | — |

> Thermal properties improve with increasing reinforcement content: unreinforced carbon black filled grades have a heat deflection temperature (1.8 MPa) of approximately 76°C; carbon fiber reinforced grades can reach 205 ~ 216°C.

### Chemical Resistance

Conductive PA6 inherits the excellent chemical resistance of the PA6 base resin, demonstrating good tolerance to oils, chemicals, and industrial environments.

## 3. Advantages of Conductive PA6

Compared with metal materials, conductive PA6 offers the following advantages:

- **Lightweight:** Density is only 1/5 ~ 1/7 that of metal (typical density 1.20 ~ 1.36 g/cm$^3$)
- **Design Flexibility:** Complex geometries can be achieved through injection molding
- **Functional Integration:** Electrical functions integrated into plastic structures
- **Production Efficiency:** Short injection molding cycles, suitable for high-volume production

## 4. Typical Applications

Conductive PA6 is suitable for various industrial applications, including:

- Electronic equipment components
- Precision jigs and fixtures
- Automation machinery parts
- Sensor housings
- Industrial handling and processing components
- Plastic structural parts requiring electrostatic protection or conductivity
- Electromagnetic interference (EMI) shielding components

## 5. Injection Molding Process Requirements

Conductive PA6 requires strict control of process parameters during injection molding. Due to the hygroscopic nature of nylon materials, thorough drying must be performed before production to prevent surface defects and mechanical property degradation.

### Recommended Injection Molding Parameters

| Process Parameter | Recommended Range | Remarks |
|---|---|---|
| Drying Temperature | 80 ~ 130°C | Depends on material grade |
| Drying Time | 3 ~ 8 hours | Dehumidifying dryer recommended |
| Maximum Allowable Moisture Content | 0.15 ~ 0.25% | Extend drying time if exceeded |
| Barrel Temperature (Rear Zone) | 240 ~ 280°C | |
| Barrel Temperature (Middle Zone) | 265 ~ 275°C | |
| Barrel Temperature (Front Zone/ Nozzle) | 275 ~ 290°C | |
| Mold Temperature | 60 ~ 100°C | ≥80°C recommended for reinforced materials |
| Injection Pressure | 750 ~ 1,250 bar | Depends on material and product design |
| Back Pressure | 0.3 ~ 0.7 MPa | |
| Screw Speed | 30 ~ 60 rpm | |

Key process parameters include injection temperature, mold temperature, injection speed, holding pressure, and cooling time. Optimized processing conditions help achieve stable dimensional accuracy, consistent conductivity, and reliable mechanical performance.

## 6. Mold Design Considerations

Gate location, runner balancing, cooling system design, and venting structure significantly affect the quality of conductive PA6 products. Good mold design helps to:

- Maintain uniform distribution of conductive fillers
- Reduce warpage and deformation

- Improve surface quality
- Achieve stable high-volume production

## 7. Common Manufacturing Challenges and Solutions

### Warpage Control

Uneven cooling and material orientation can cause deformation. Solutions include optimizing wall thickness design, balancing cooling channel layout, and improving process parameters.

### Conductivity Variation

Improper material mixing or unstable molding conditions can affect electrical performance. Strict material control and process monitoring must be implemented.

### Surface Quality Issues

Moisture and excessive shear can cause appearance defects. Thorough drying and molding process adjustments can improve product surface quality.

## 8. Quality Inspection Requirements

Quality control for conductive PA6 components includes:

- Incoming material inspection
- Moisture content testing (recommended to control below 0.15 ~ 0.25%)
- Dimensional measurement
- Visual inspection
- Resistivity testing (volume resistivity and/or surface resistivity)
- Mechanical property verification

The above procedures ensure product quality stability during high-volume production.

## 9. Manufacturing Solutions

Techninherit provides comprehensive engineering solutions for conductive PA6 components, including:

- Material selection
- Product design optimization
- Mold development
- Precision injection molding

- Quality management

Our manufacturing capabilities support customers throughout the entire process from concept development to final mass production.

## 10. Conclusion

Conductive PA6 combines the structural advantages of engineering nylon with electrical functional properties. Through proper material selection, mold engineering, and injection molding control, this material provides reliable solutions for lightweight, durable, and functional plastic components. Typical performance parameters (density 1.20 ~ 1.36 g/cm$^3$, volume resistivity $10^2$ ~ $10^4$ Ω·cm, tensile strength 55 ~ 270 MPa) make it highly competitive in applications in electronics, automotive, automation, and other industries.