Material Specifications and Connection of Aluminum Conductors at WAGO

For our products, we use materials that have been proven in practice, some over decades. Nonetheless, we are constantly doing further research and testing new materials. This is also true of the contact paste that must be used to connect aluminum conductors to WAGO spring clamps.

WAGO information:

- Insulation Materials
- Table: Standard Insulation Materials
- Polyamide (PA 66)
- Glass fiber-reinforced polyamide (PA°66°GF)
- Polyphthalamide (PPA GF)
- Polyamide (PA 46)
- Polycarbonate (PC)
- Plastics polybutylene terephthalate (PBT)
- Glass-fiber-reinforced polybutylene terephthalate (PBT GF)
- Contact materials
- Terminating aluminum conductors

Overview of Material Specifications

Insulation Materials

WAGO primarily uses polyamide (PA 66 and PA 46) for housing current-conducting parts, as well as polyphthalamide (PPA) and polycarbonate (PC) for insulation material (see table). For more than 40 years, these materials have been proven in practice in WAGO products, and they all are approved by certified third-party agencies. The polymer materials listed are technically halogen-free and flame-retardant in accordance with IEC 61249-2-21 and do not contain any heavy metals, silicone, asbestos or formaldehyde as formulation components.

Material	**PA66**	**PA66 GF**	**PPA GF**	**PA46**	**PC**	**PC**	**PBT**	**PBT GF**
Flammability class to UL 94 flammability test ratings	V0	V0	V0	V2	V2	V0	V0	V0
Oxygen Index (OI) per EN ISO 4589-2	>32%	>33%	>37%	>27%	>26%	>35%	>32%	>32%
Glow wire test per IEC 60695-2-12 GWFI IEC 60695-2-13 GWIT	850°C 775°C	850°C 775°C	960°C 775°C	750°C 725°C	800°C 850°C	960°C 850°C	960°C 775°C	960°C 775°C

Temperature of the ball indentation hardness test per IEC 60695-10-2	≥ 125°C	≥ 175°C	≥ 225°C	k.A.*	≥ 125°C	≥ 125°C	≥ 200°C	≥ 200°C
Comparative Tracking Index (CTI) per IEC 60112	600 V	600 V	600 V	375 V	225 V	225 V	600 V	600 V
RTI impact per UL 746B	105°C	100°C	130°C	115°C	125°C	120°C	120°C	115°C
Heat deflection temperature HDT/B (A) per ISO 75 (with a bending stress of 0.45 MPa by default or 1.8 MPa)	215°C (0.45 MPa)	235°C (0.45 MPa)	285°C (0.45 MPa)	280°C (0.45 MPa)	130°C (1.8 MPa)	130°C (1.8 MPa)	160°C (0.45 MPa)	203°C (1.8 MPa)
Surface resistivity per IEC 60093	10^{12} Ω	10^{12} Ω	10^{15} Ω	10^{13} Ω	10^{15} Ω	10^{15} Ω	10^{15} Ω	10^{15} Ω
Specific contact resistance per IEC 60093	10^{15} Ω/ cm	10^{15} Ω/ cm	10^{13} Ω/ cm	10^{13} Ω/ cm	10^{11} Ω/ cm	10^{13} Ω/ cm	10^{13} Ω/ cm	10^{13} Ω/ cm
Dielectric strength per IEC 60243-1	30 kV/mm	40 kV/MM	25 kV/mm	25 kV/mm	25 kV/mm	29 kV/mm	17 kV/mm	27 kV/mm

Polyamide (PA66)
WAGO uses modified, technically halogen-free, flame-retardant polyamides.
These materials do not corrode, are difficult to ignite and feature self-extinguishing properties (V0 rating per UL 94). In accordance with UL 746C, the polyamides used at WAGO have a continuous operating temperature of 105 °C (221 °F) based on the relative temperature index with impact load (RTIimp). This ensures that the necessary electrical and mechanical insulating properties are maintained at a sufficiently guaranteed level over a long period of time. The short-term upper temperature limit is 200 °C (392 °F). In lower temperature ranges, it has been determined that no damage to the insulation material occurs during usage down to −35 °C (−31 °F). After installation and wiring, WAGO products can even be used at temperatures down to −60 °C (−76 °F). Environmental humidity (up to 2.5 % in a standard atmosphere) is absorbed, providing the polyamides with optimum elasticity, strength and durability. In practical use, basic stabilization of WAGO's polyamides has been proven over many years to be sufficient to prevent damage caused by ozone or UV radiation exposure in intended applications. Polyamides have excellent resilience against the most demanding climates and have been proven in tropical applications. Insulation parts made of polyamide are resistant to insects. The material does not provide oxygen or other biogenic elements to microorganisms. The presence of anaerobic earth bacteria, mold, fungus and enzymes does not degrade the material. Polyamides are resistant to most fuels, greases and oils, as well as the most commonly used cleaners, such as alcohol, Freon, Frigen and carbon tetrachloride. Acid resistance depends on the acid type and concentration, as well as the exposure time.
Insulation materials are used during in-house production at WAGO after acceptance of factory test certificates and specified material tests.

Glass finer-Reinforced Polyamide (PA 66 GF)
WAGO uses glass-fiber-reinforced polyamides for components with increased mechanical demands, such as levers, push-buttons or housings exposed to high stress, because they have significantly better mechanical characteristic properties than non-reinforced polyamides. In general, materials are used that have excellent tracking resistance and flammability ratings and high temperature resistance.
More data can be found in the table.

Polyphthalamide (PPA GF)
Glass-fiber-reinforced high-performance polyamides are ideal for high-temperature applications, due to the material's high thermal dimensional stability, low dependence on ambient conditions and excellent strength properties. The material's outstanding tracking resistance permits short creepage distances to be incorporated into miniature components. Fire protection equipment enables classification in flammability class V0 per UL 94 – even for extremely thin walls. PPA GF absorbs minute amounts of moisture from the atmosphere, making it ideal for THR soldering applications and for thin-walled, dimensionally stable components.
More data can be found in the table.

Polyamide (PA46)
In comparison with PA 66, PA 46 has substantially higher dimensional stability under heat. The relative temperature index with impact load (RTIimp) is 115 °C (239 °F) for PA 46. The permissible short-term temperature for the type used by WAGO is 280 °C (536 °F).
More data can be found in the table.

Polycarbonate (PC)
Polycarbonate has excellent dimensional stability under heat. The electrical and mechanical properties remain intact at extremely high temperatures up to approximately 120 °C (248 °F) per UL Yellow Card. Its excellent electrical insulating properties and dimensional stability are virtually independent of environmental conditions, such as humidity and temperature. High-precision components can be created due to the low shrinkage of the material during injection molding. Polycarbonate has excellent weather resistance and is also highly resistant to high energy radiation. If the PC is not colored, then the components are glass-clear. Thanks to its desirable properties (e.g., dimensional stability, heat resistance, non-flammability, durability and transparency), PC is a proven and widely used material in the electrical industry. According to the demands on the finished product, WAGO uses polycarbonates of flammability classes V2 and V0 per UL 94. Medium-viscosity PC is used, which features excellent chemical resistance.

Plastics polybutylene terephthalate (PBT)
Polybutylene terephthalate is used due to its balanced combination of rigidity and strength alongside durability and heat deflection resistance, as well as excellent dimensional stability. It features high-level electrical and mechanical properties that are not affected ambient humidity. The fire protection equipment is technically pollutant-free as usual, and the material is classified as V0.

Glass-Fiber-Reinforced Polybutylene Terephthalate (PBT GF)
Glass-fiber-reinforced polybutylene terephthalate is also distinguished by very good mechanical and electrical properties, especially with thin walls.
Type PBT GF is also classified as V0 and, like the other WAGO plastics, technically pollutant-free.

Contact materials
WAGO mainly uses high-purity copper and low-alloy copper alloys as contact materials. For each product, the material with the ideal combination of electrical conductivity, strength and relaxation stability for the specific application is used. The materials selected in this way have good chemical resistance to industrial atmospheres and sea air. Compared to brass alloys, they are insensitive to stress corrosion cracking.

Contact plating
Our conductor materials feature standard protection against oxidation and other corrosive influences in the form of a tin layer. The soft tin with a sufficient layer thickness, in combination with specific contact pressure, creates a gas-tight connection in the specified contact zone. This ensures the long-term stability of the electrical connection. With a suitable design, multiple connections are no problem. With suitable products,

the tin layer also ensures good solderability even after long periods of storage. For contacts requiring a high number of mating cycles or actuation, we use silver- or gold-based coating systems, depending on the requirements. The silver layers are provided with suitable passivation to prevent tarnishing due to reaction with sulfurous media. However, if discoloration of a contact occurs during long-term use or due to exposure to a high concentration of sulfur, this does not pose a problem for the quality of the electrical connection in most cases.

Clamping spring material
WAGO's spring pressure connection technology is based on the use of contact springs made of high-strength, high-alloy chromium-nickel steels. In cooperation with our supplies we adapt the steel grades we use to the corresponding applications in terms of their chemical composition, as well as the mechanical properties, which are adjusted in the production process. Decades of experience as inventors of spring pressure connection technology enable us to take advantage of the unique combination of strength and deformability of the materials to provide the necessary contact forces in a minimum installation space. In some of our products, we also use thermal post-treatment, which can be recognized by corresponding discoloration of the springs. Stress relaxation plays no role in the intended temperature range of the contact systems. In addition, the steels used feature high corrosive resistance, such as in sulfurous atmospheres and sea air. There is no risk of contact corrosion with copper materials when used properly. Contact with media containing chlorine must be avoided by taking suitable protective measures, as this can lead to stress corrosion cracking in chrome-nickel steels.

Connecting Aluminum Conductors ("Alu-Plus" Contact Paste)

All WAGO products are designed for connecting copper conductors, with the following possible exceptions:

Use "Alu-Plus" contact paste when connecting solid aluminum conductors to our spring clamp terminal blocks.

Due to the low conductivity of the aluminum conductors, it is also necessary to adapt the nominal currents accordingly: **2.5 mm² = 16 A und 4 mm² = 22 A.**

Syringe

Contents: 20 ml "Alu-Plus" contact paste
Item No.: 249-130
20 pieces per packing unit (4 x 5)

Application Areas

"Alu-Plus" contact paste is for safely wiring solid aluminum conductors(1) up to 4 mm² into WAGO spring clamp connections.

The following applies to spring clamp connections with PUSH WIRE® and Push-in CAGE CLAMP® connection technology:
Cleaning and greasing aluminum conductors is no longer necessary. Use WAGO "Alu-Plus" contact paste instead, which is directly injected into the conductor entry hole of WAGO terminal blocks using the handy syringe. Aluminum conductors that clearly show corrosion effects (i.e., black discoloration) require mechanical cleaning. Unprepared solid aluminum conductors can then be inserted easily.

Using terminal blocks with CAGE CLAMP® Spring Pressure Connection Technology, aluminum

conductors must first be cleaned with a blade and then immediately inserted into the clamping units filled with “Alu-Plus” contact paste.

(1)Aluminum conductors per IEC 61545 standard, Class B, “Alloy 1370” with 90–180 N/mm² tensile strength and 1–4% elongation.
Standard values: 90 … 180 MPa tensile strength, 1 … 4% elongation (per EN 615.4.1)

WAGO “Alu-Plus” Contact Paste

- Automatically destroys the oxide film during the process of insertion to in PUSH WIRE® and Push-in CAGE CLAMP® connections.
- Prevents fresh oxidation at the clamping point.
- Prevents electrolytic corrosion between aluminum and copper conductors (in the same terminal block)
- Provides long-term protection against corrosion.

It is also possible to apply WAGO “Alu-Plus” additionally on the whole surface of the aluminum conductor before termination, of course.

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