Exploring plastics in electrical applications

When using plastics for electrical applications, including automotive electricals, apart from their mechanical properties, their electrical behaviour is a decisive factor.

In these applications, it is mainly their insulation properties that are of importance, and certain other requirements connected with them. Most engineering plastics are good to excellent insulators. Their specific resistance (volume resistivity) is around $10^{13}\Omega\cdot\text{m}$.

Specific resistance is usually measured according to DIN 53482, with surface electrodes placed on opposite sides of a thin plaque. An additional ring electrode ensures surface currents do not distort the measurements.

At very high tensions (or more precisely, at very high field strengths) insulation strength may suddenly break down; the current then forms sparks, which tunnel their way through the plastic. The ability to withstand this phenomenon is known as dielectric strength; it is of special importance for plastics in high-tension applications, such as automotive ignition systems.

Typical dielectric strength values for engineering plastics are in the magnitude of 30,000V/m; in the case of nylon, it may drop by 10-20% due to humidity absorption. Particularly in connection with static charges, surface resistivity (or its inverse, surface conductivity) is the determining factor.

Humidity of the air and contamination or dirt on the surface affect this property much more than they affect volume resistivity. Typical values are above $10^{12}\Omega$; with nylon, conditioning may cause it to drop by a factor of about 10.

**Tracking and arcing**

Electrical tension may cause a tracking current to flow on plastics surfaces, especially if they are contaminated with humidity, dirt or chemicals. Irregular interruptions occur along this current path, which may be caused by evaporating liquids.

At these points, small arcs are generated, whose thermo-mechanical effect erodes the material’s surface. Tracking resistance indicates how well the surface of a plastic material resists damage caused this way.

Tracking resistance, or Proof Tracking Index (PTI), measured according to DIN IEC 112, is the numerical value of the maximum test voltage at which there is no tracking between two electrodes while a test fluid is dripped onto the surface.

Arc resistance is closely connected with tracking resistance. Under the influence of an arc (which in practice may be generated by a short circuit) the plastic should not form a conductive bridge and should, if possible vaporise, so as to extinguish the arc.

Similarly, a glow-wire simulates a source of ignition. The glow-wire test according to VDE 0471 provides information about whether an object, such as an overheating conductor, could be a fire hazard in an electrical apparatus.

Dielectric properties must be taken into account when working in AC and high-frequency applications, such as data-processing and information technology. They are important because the charges and dipoles of a plastic material change orientation in time with the alternating current’s cycles. This has two results.

First, the electric field strength is greater in the plastic than in vacuum: the dielectric constant describes this parameter, whose value is mostly between 2.5 and 4, and may rise to 8-10 in conditioned nylon.

Second, the change of orientation requires energy: the dielectric loss factor describes this material feature, which with many engineering plastics, lies in...
the range of $0.1 - 1.1 \times 10^{-3}$, but whose value varies with frequency, temperature and humidity content.

**Miniaturisation**

Miniaturisation and continuous improvement of safety and user protection are driving forces for development in the electrical and electronic industry. The many different connectors used in data technology and telecommunications are examples of miniaturisation.

Due to the closeness of the contact pins and sockets, these parts must have good tracking resistance, as may be found in two thermoplastic polyesters, Crastin® PBT and Rynite® PET. Both of these resins also offer good flow characteristics, so high-quality thin parts can be moulded without displacing the pins and sockets.

Injection moulded interconnect devices, or MIDs with their closely spaced circuits, have been miniaturised even more. Apart from tracking resistance, the choice of material for these devices must take further factors into consideration, depending on the manufacturing process to be employed.

The factors include either the plastic material's suitability for hot-stamping the conductor tracks (for this process Zytel® HTN high-performance polyamide should be considered), or, in the case of reflow soldering, short-term thermal resistance up to 250°C without warpage, a property which Zytel® HTN, Zenite® liquid crystal polymer and Therms® high-performance polymer offer. A third example is furnished by completely encapsulated electric motors, in which coil holders and encapsulation are made of Zytel® HTN.

The reasons for choosing this material are its very good insulating properties, measured according to UL 1446 Class B up to 130°C, its good chemical resistance and its suitability for overmoulding.

**Fire protection**

Switches and similar functional parts must meet high safety requirements, to ensure even in the event of a fault, there is no danger of a short circuit or fire, even when the apparatus is working unsupervised.

For such cases, Rynite® PET offers a combination of good tracking resistance and fire safety, as shown in a glow-wire test at 850°C. An over-voltage protection device made of Delrin® acetal exploits the fact that, in the event of arcing, this material out-gasses with a pressure-wave, thereby extinguishing the arc.
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