NOVEMBER/DECEMBER 2025

# Wire & Cable Technology International

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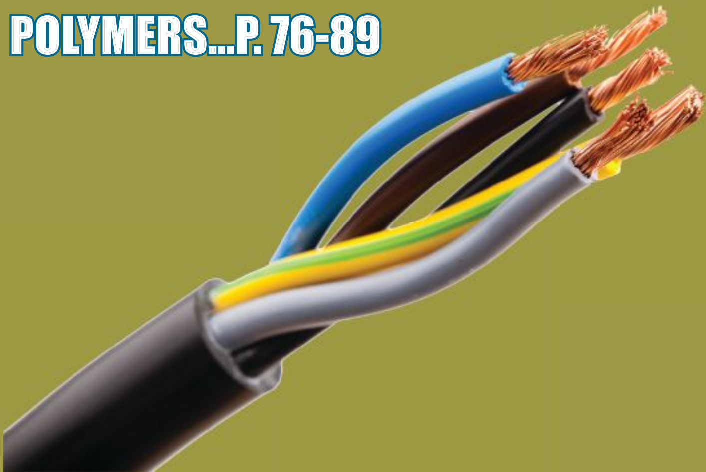
Serving manufacturers, processors, distributors and users of wire and cable

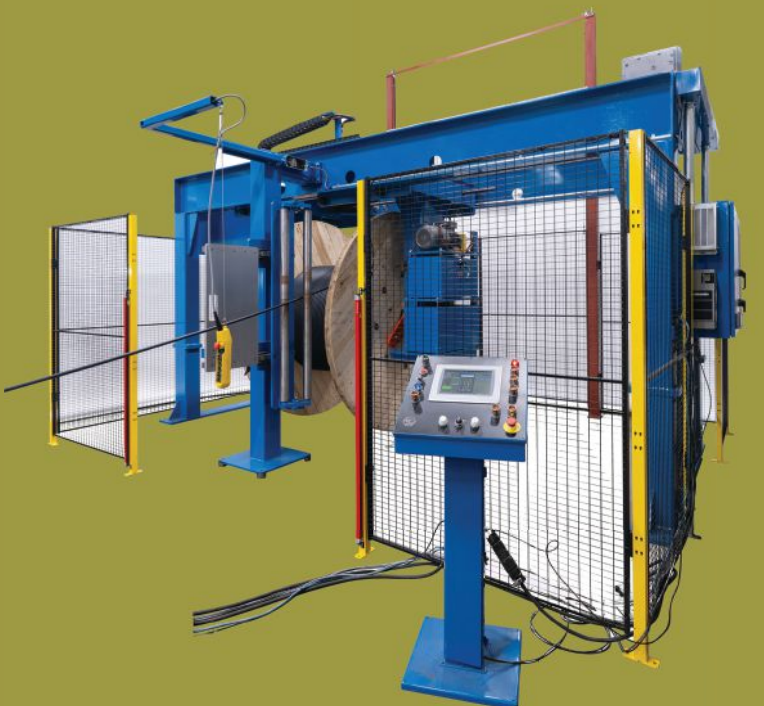












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## Wire Harness & Cable Connector

Focused News, Information and Products for Wire & Cable Processors, Distributors and End Users.

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November/December 2025

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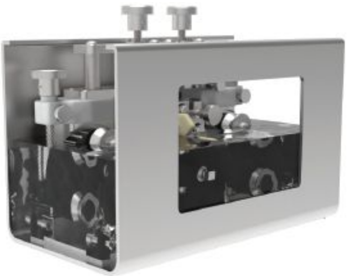

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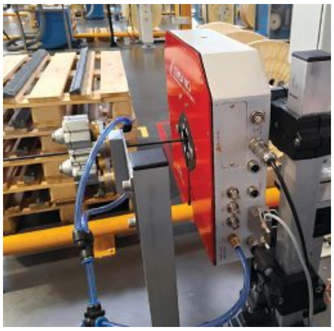

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## Industry Events



## Tech Briefs



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## January/February 2026 Issue

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# Fluoropolymer Breakthroughs in EV Motor Wire Insulation

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**www.agcchem.com**

**The future of e-mobility depends not only on batteries and semiconductors but also on the polymers that make high-voltage operation possible.**

The growth of the EV industry is transforming powertrain design. To meet rising expectations for higher power density, faster charging and greater efficiency, EV manufacturers are pushing motor systems from today's 400-volt architectures toward 800 volts and beyond. While this evolution enables significant performance gains, it also introduces new engineering challenges.

One of the most critical issues lies in the insulation of magnet wire within the motor stator. As voltage and thermal loads increase, traditional insulation systems often fail to provide sufficient reliability, leading to risks such as partial discharge, thermal degradation and chemical breakdown. To keep pace, next-generation polymers are emerging as essential materials for enabling safe, durable and efficient high-voltage motor operation.

This article examines why higher voltages are necessary, what conditions insulation materials must withstand and how advanced fluoropolymers and fluoropolymer compounds are addressing the demands of next-generation EV motors.

## Why Higher Voltage Matters in EV Motors

Key advantages of moving to higher-powered systems include improved efficiency, extended driving range and faster charging. Higher voltage also enables the development of electrified heavy-duty vehicles, commercial fleets and aircraft.

As power requirements grow, manufacturers must either increase current or voltage. Higher current generates more heat, compounding the already complex issue of motor cooling. By contrast, increasing voltage allows higher power output without proportionally increasing thermal load.

The coiled magnet wire within the stator is central to this performance. As electricity is passed through the magnet wire, an alternating magnetic field is produced, interacting with the magnets of the rotor, causing it to spin. The spinning of the rotor turns the gear shaft, rotating the wheels of the vehicle.

The insulation material on the magnet wire is critical to balancing EV power, weight and thermal performance. Higher motor power requirements, thus higher voltage requirements, are driving innovation in insulation materials. Through the use of specialty polymers, along with polymer modification and compounding, current materials can be improved to perform better in this space.

In particular, next-generation compounds with higher partial discharge inception voltage (PDIV) are needed. PDIV is the amount of voltage required to initiate a partial discharge within an insulating material. Instantaneous voltage during sudden braking and sudden acceleration is two to three times the normal voltage. For current magnet wire insulations, in a 400-volt motor, instantaneous voltage is within PDIV, so no partial discharge occurs. For the same insulation in an 800-volt motor, instantaneous voltage exceeds PDIV and the generated inverter surge invades winding wiring and parts.

## Material Requirements for High-Voltage Wire Insulation

As wiring geometries become more complex and compact, insulation materials must meet increasingly demanding criteria. Next-generation insulation materials must therefore deliver on many critical properties, including these selected few:

- ***Adhesion:*** Strong adhesion between the insulation and the wire prevents delamination and eliminates voids where partial discharges could initiate, especially at sharp bends.
- ***Thermal Resistance:*** As current density increases, higher service temperatures are required, thus wire insulation must withstand elevated heat without degradation.
- ***Flexibility:*** Stator winding requires wires to bend and wrap tightly. Flexible insulation prevents cracks or wrinkles, which otherwise become hotspots for discharge.
- ***Electrical Performance:*** The best insulation materials have a low dielectric constant, directly enhancing PDIV and supporting higher-voltage motor designs.

## Solutions: ETFE, PFA, and Compounds

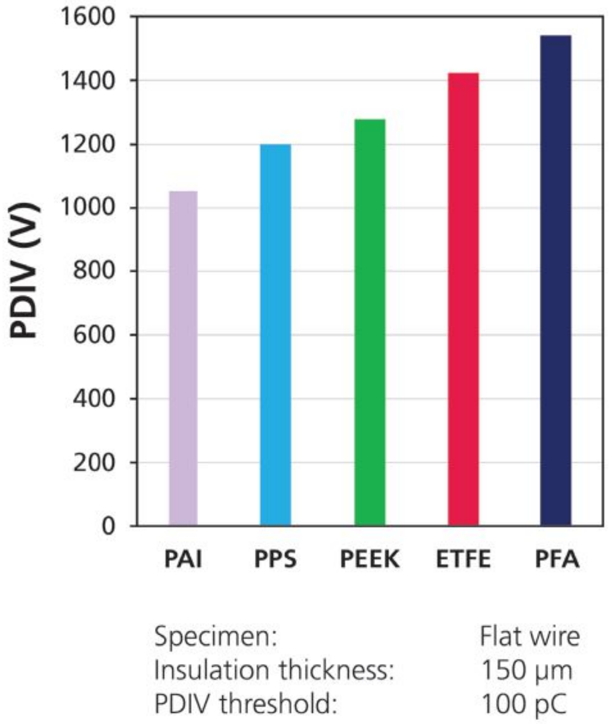
Among candidate materials, fluoropolymers and compounds based on ethylene tetrafluoroethylene (ETFE) or perfluoroalkoxy alkane (PFA) show exceptional promise. These materials offer high dielectric strength, broad operating temperature ranges and resistance to chemical and thermal degradation.

PFA-based compounds provide outstanding electrical insulation and thermal stability while delivering enhanced flexibility and strong adhesion to copper. This combination reduces the risk of void formation and extends motor lifetime under high-voltage stress.

ETFE-based compounds deliver a balanced performance profile, offering reliable mechanical toughness, chemical resistance and stable electrical properties across varied operating conditions.

These fluoropolymer compounds push the boundaries of what magnet wire insulation can achieve, enabling the reliable adoption of 800-volt architectures and beyond.

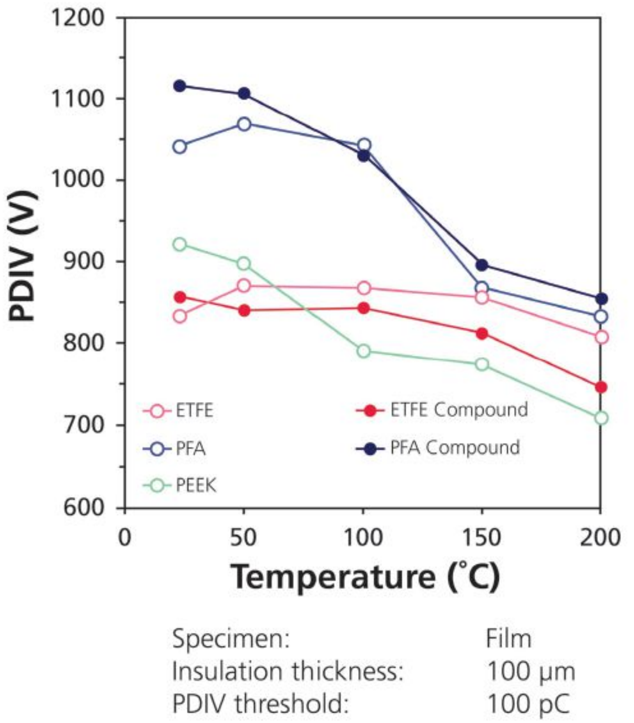
The chart below compares the PDIV of different insulation materials applied to flat wire with a thickness of 150 µm. PFA shows the highest PDIV (~1550 V), making it the strongest performer in this comparison. ETFE follows (~1420 V), also offering high resistance to partial discharge. PEEK (~1280 V) and PPS (~1200 V) form the middle tier with lower values. PAI exhibits the lowest PDIV (~1050 V), indicating weaker insulation performance under the same conditions.




Overall, PFA stands out as the most robust insulation material for flat wire applications, with ETFE close behind, while PAI provides the least margin against partial discharge.

As the chart below illustrates, PDIV decreases with temperature for all tested insulation materials. The PFA compound demonstrates the highest PDIV, starting above 1100 V at 25°C and maintaining around 850 V at 200°C. Uncompounded PFA also performs well but shows a slightly sharper decrease than the PFA compound at higher temperatures. ETFE and the ETFE compound exhibit similar PDIV values to PEEK (around 800 V to 850 V) at 25°C, but these materials show the most stability at higher temperatures, with the lowest decrease between the PDIV at 25°C and at 200°C. In contrast, PEEK starts with a high PDIV near 920 V but declines rapidly with temperature, dropping below ETFE by 100°C and reaching the lowest value at 200°C.

These results highlight PFA compounds as the most reliable choice for high-voltage insulation in elevated temperature environments, while ETFE provides a good balance for less demanding conditions. PEEK shows limited suitability for sustained high-temperature electrical applications.




## Conclusion

As the electrification of heavy-duty vehicles, light commercial fleets and aerospace applications accelerates, the need for advanced wire insulation materials will only intensify. Higher voltage systems promise greater performance but expose the limitations of conventional insulation.

By leveraging engineered fluoropolymer solutions such as ETFE and PFA and compounds based on these resins, manufacturers can deliver the thermal, electrical and mechanical resilience required for next-generation EV motors. In short, the future of e-mobility depends not only on batteries and semiconductors but also on the polymers that make high-voltage operation possible.

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***Company Profile:***
***AGC Chemicals Americas, Inc.****, Exton, PA, USA, a leading producer of fluorochemical technologies, compounds and specialty materials. The company offers the broadest range of high-performance fluoropolymers in the world including fluoroelastomers, PTFE, PFA and ETFE resins, fluoropolymer compounds, coatings and membranes.*
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