Technology

New materials technology and coiled cable meet tough demands for tomorrow's EV charging

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Electric vehicles (EVs) bring low emission or even emission-free motoring, and sales are on the rise. In turn, that has increased the focus on charging infrastructure; a greater number of EVs will require more charging stations and those stations will need to offer fast battery charges in a safe and efficient fashion. Consequently, this places new demands on the cables carrying the current from the charger to the vehicle.

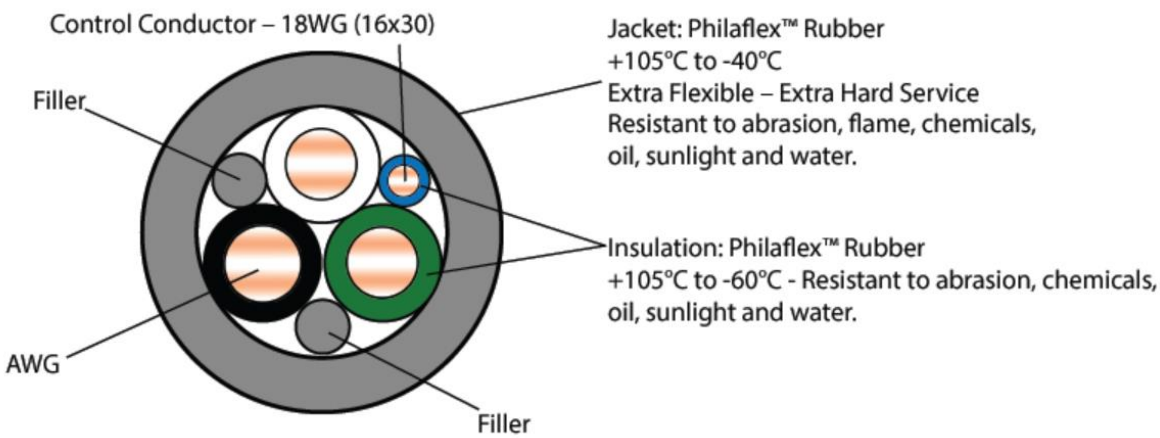


Figure 1: Cross section of Philatron Philaflex EV charging cable. Source: Philatron

EV pioneer Tesla, for example, has already outfitted around 7,600 "supercharger" stations in the U.S. at 1,100 sites. These top-level EV chargers operate at 480 V and up to 250 kW. The charging cables — the critical link between the charger and the EV — must be able to handle these high currents for extended durations. And there are already plans for superchargers that can supply up to 350 kW, further increasing the current carrying requirement of the cables.

But the challenge for EV charging cables goes well beyond high voltage and current capability. The cables also need to withstand external temperature extremes, UV radiation, water, automotive chemicals and more without degrading. Further, in a world where many charging stations are gathered close together, cables must be extra flexible for compact and safe extension and retraction to ensure a safe environment for the public and avoid cable damage from vehicles.

This article explains how Philatron's innovative new Philaflex™ brand of EV cables use new materials and coiling techniques to address the unique challenges of cable charging.

Recharging an EV

EVs use electricity to replace or supplement the fossil fuels used to power conventional vehicles. According to the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), EVs come in three main types.

All-electric vehicles (AEVs)

AEVs plug into the grid to recharge the batteries, which are then used to power one or more electric motors driving the wheels. Additional charging comes from regenerative braking. AEVs produce no emissions.

Plug-in hybrid electric vehicles (PHEVs)

PHEVs use batteries to power one or more electric motors driving the wheels. The batteries can be charged by plugging into the grid, but they are also topped-up when the car is being driven by an internal combustion engine (ICE). There are some emissions, but these are typically lower than a comparable size/power conventional ICE vehicle.

Hybrid electric vehicles (HEVs)

HEVs use an ICE to charge batteries, which then drive electric motors to power the vehicle, directly drive a generator that then drives the electric motors, or charges the batteries and directly drives the wheels to supplement the electric motors when power demand is high.

AEV and PHEV batteries are charged using a DC voltage. To facilitate charging from an AC grid supply, most vehicles include an internal AC-to-DC converter. If the charger can supply a DC voltage, the inverter is bypassed and the supply feeds the batteries directly. Chargers are categorized at three levels:

- Level 1 — AC portable devices, which offer a low level of charging and are mainly designed for topping up the batteries of PHEVs for an in-town range boost;
- Level 2 — AC wall chargers, commonly used in the home and for some public charging. Level 2 enables charging up to 19.2 kW, or about 115 km of range per hour of charging;
- Level 3 — DC fast chargers that offer up to 250 kW (and 350 kW in the near future) and can add 115 km of range for every 10 minutes of charging. DC fast charge stations are too expensive for home use and are instead placed at conventional fuel stations and dedicated freeway sites.

EV batteries are charged at different rates depending on their current charge status. If the batteries are near empty or near full, charging is slowed to prevent damage, but if the battery charge is between about 10% and 80%, charging can occur much more rapidly. For this reason, manufacturers advise stopping to recharge well before the battery charge is exhausted.

Charging an EV battery from empty to full can take up to 75 minutes for a vehicle with an 85 kW hour battery even when using the most powerful (250 kW) superchargers. However, charging from 20% to 50% can be achieved in around 20 minutes and to 80% in just another 10 minutes more. EV suppliers are planning charger networks such that the greatest distance between stations equals the range powered by a battery charged to 80% rather than full. This encourages consumers to make shorter duration charging stops and then top-up fully overnight while at home.

Custom-designed cables for EV charging

The critical connection between the charger and the car is the charging cable and connector. DC fast charging stations place heavy demands on cables and connectors and require reliable and robust solutions. This type of public charger typically uses a combined charging system (CCS) connector, which is capable of charging up to 350 kW. The cable comprises heavy-gauge live, neutral and Earth wires and a lighter-gauge control conductor.

There are many off-the-shelf cable offerings for DC fast chargers, but most fall short of ideal performance in practical usage. In most cable designs, the heavy-gauge coarse stranded wire used to carry the high currents during fast charging makes the cables stiff. The problem is compounded because conventional products are made with inflexible insulating and jacketing materials — composed of thermoset materials such as Neoprene, Hypalon, styrene-butadiene rubber or ethylene propylene rubber — that become even more rigid as the temperature drops. When these cables are bent at low temperatures, the stiffness of the insulation and jacketing causes it to permanently deform into ridges. The problem quickly gets worse when thicker gauge conductors are used because for every doubling of the cable radius, the (rigid) surface area of the cable insulation and jacketing trebles.

However, Philatron, a cable manufacturer that has spent years creating EV custom cable and wire solutions for a variety of different companies, is now offering a new generation of thermoplastics as the foundation for its Philaflex™ insulation. Philaflex not only supports cable insulation and jacketing that is electrically superior to older thermoset materials, but it is also more flexible than any other standard EV charging cable. Moreover, Philaflex thermoplastic materials extend the service life and bolster the performance of custom cables, prevent ridging and offer recyclability.

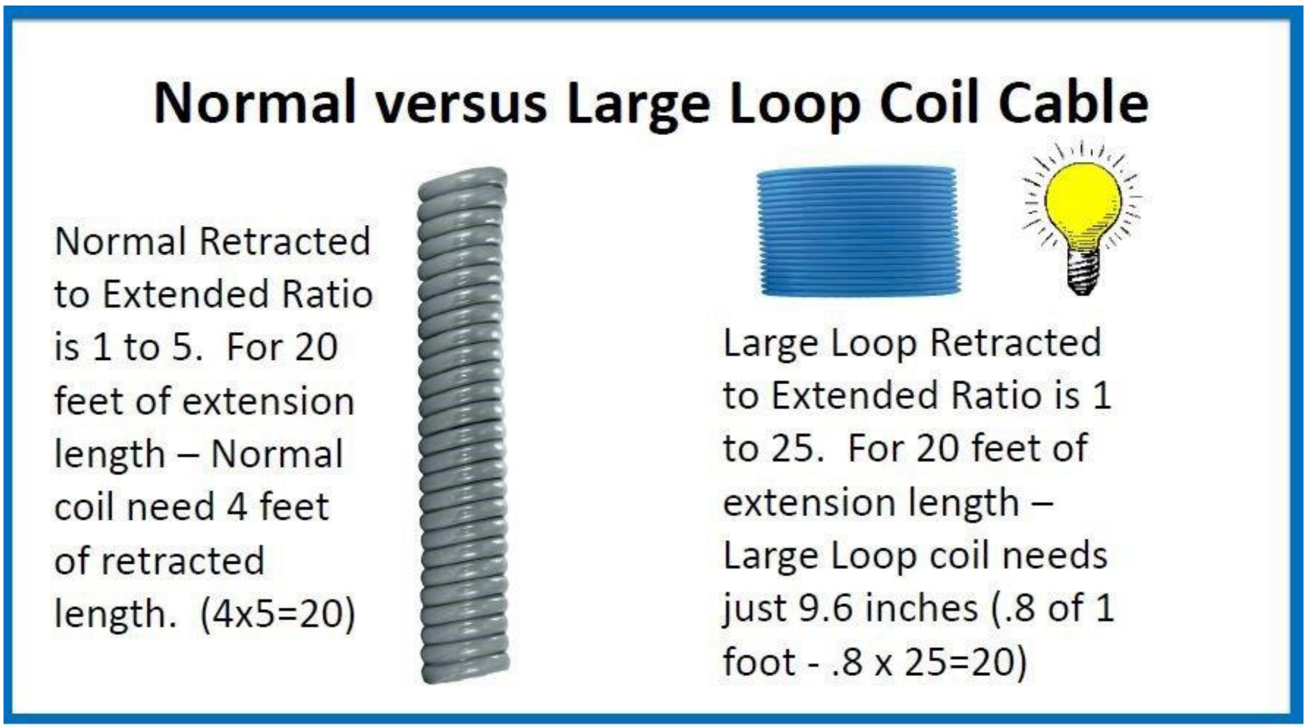
Philatron offers a range of Philaflex insulated and jacketed materials for EV charging with power conductor gauges from 16 AWG all the way up to 500 kcmil (and 18 AWG or 16 AWG control conductor or a group of shielded multi-control conductors 18 AWG or 16 AWG). The cables are designed for outdoor extra heavy-duty use, can handle from 300 V to 1,000 V and feature ampacities of 18 to 600 amps (conductor at 90˚ C, ambient temperature 40˚ C). Ampacity is the current that a conductor, its jacket and insulation can carry without compromising safety at ambient temperatures. The key to a cable’s ampacity is how fast it can dissipate power at high currents to prevent overheating and a potential fire hazard. Philaflex EV charging cables meet the UL-62 standard, comply with European Union Directive RoHS, are temperature rated from -40° C to 105˚ C and are resistant to abrasion, flame, chemicals, oil, sunlight and water (Figure 1).

Flexibility for convenience and safety

When working with large cables (4/0 AWG or greater) in the restricted spaces that surround EV charging stations, flexibility increases convenience and safety. The flexibility brought by Philaflex insulation and jacketing improves the user experience.

Large loop EV coil cable for improved cable management and safety

Straight EV cables are subject to safety and handling issues due to tangling that can cause user tripping and damage by vehicle run over when laying on the ground. This concern allowed Philatron to introduce an innovative large loop EV coil design that prevents coil sagging, excessive retracted length and ground contact.



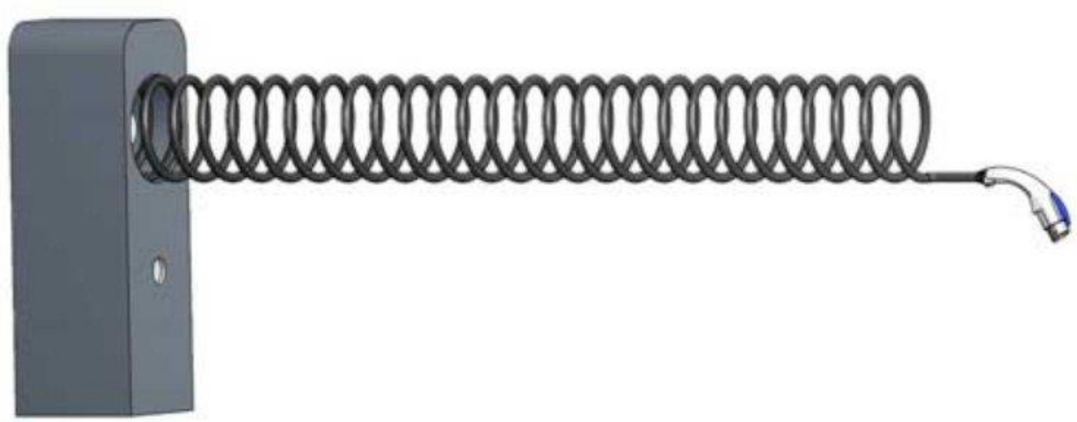


Figure 2: Philatron's coiled EV charging cable takes up less space and does not sag. Source: Philatron

Sagging is generally caused by cables that are overly long when retracted. The problem occurs when the cable is designed for a particular working length and is then coiled using a small radius coil. Upon retraction, this results in a long retracted length because the coiled cable comprises many loops. An industry “rule-of-thumb” is to aim for a retraction-to-extension ratio of one to five; so, for example, a coiled cable that extends up to 20 ft retracts into a coil measuring 4 ft. While this works well for many applications, it is unsuitable for EV charging stations because cable storage space is limited and because small radius coils encourage sagging — which turns cables into trip hazards and makes them liable to being run over by vehicles.

When a vehicle runs over a cable, the damage might not be immediately apparent. But there is a risk of internal damage that could make the cable unsafe. Cable replacement is the only way the operator can be sure the cables continue to meet electrical and safety requirements, an expensive exercise for the operator.

To address compact storage and prevent sagging, Philatron has designed the patented large loop coil with features such as a retracted-to-extension ratio of 1:25. The improvement is marked. An “industry-standard” coiled cable with 20 ft working length retracts to a 4 ft stored length. The same cable manufactured using Philatron’s large loop coil retracts to a length of just 9.6 in while eliminating sagging (Figure 2).

Electric motors drive the future

EVs are the future of personal transport. While according to USA Facts, an organization that compiles U.S. statistics, just 4.3% of vehicles purchased in the U.S. in 2019 were EVs, falling prices and increased performance of these emission-free vehicles are fostering a rapid rise in popularity. By 2025, it is estimated that there will be 6.9 million EVs on U.S. roads.

And when the owners of those vehicles come to boost their batteries at a freeway fast charger, the experience will be made simpler and safer thanks to Philatron’s innovative extra flexible Philaflex™ EV straight charging cables or Philatron’s large loop coiled EV charging cables. Contact Philatron today.