# EVs Need Different Lubes

**The wave of vehicle electrification is coming and lubricant and additive companies must take into account the new technological challenges posed by the changing demands on fluids. Nick Augusteijn pops the hood and pokes around what those challenges are.**

The number of hybrid electric and electrically chargeable vehicles on the roads is steadily increasing, particularly in the European Union, and this will begin to affect the development of lubricant technology, according to one major additive supplier.

In Germany, the continent's largest car market, registrations of hybrids and electric vehicles grew by 54.8 percent and 39 percent, respectively in 2017. Across the EU bloc, 431,504 hybrids and 216,566 electric vehicles joined the car parc, according to the European Automobile Manufacturers' Association.

Alternatively powered vehicles, including cars running on liquefied petroleum gas and natural gas vehicles, only accounted for 5.7 percent of new car sales in the region. Market research firm IHS Markit, however, predicts vehicles using some form of electrification will hold a market share of roughly 40 percent by 2028.

The implications for lubricant technology will mean improved corrosion protection of metal parts in contact with the oil, especially at higher temperatures, and the oil's thermal stability, Lubrizol's global manager for transmission lubricants, Michael Gahagan, told *Lubes'n'Greases*.

"We are seeing more focus now on characterizing the electrical and heat transfer properties of lubricating oils. It is possible that a new range of lubricating fluids may be used in the drivetrain to enable these advancements in vehicle electrification," he said.

**Read-across Technology**

The way original equipment manufacturers seem to be currently specifying lubricants is for them to be compatible across the board, Gahagan said to an industry conference earlier this year. This means that, because of modular construction – for example, where a gearbox of a particular model may or may not have an e-motor attached – then that fluid has to lubricate both engine variants.

While current hybrids can, and often do, use traditional driveline fluids, manufacturers would do well to adopt new, dedicated fluids that are better able to protect and ensure the smooth functioning of the electrified drivetrain parts.

The drivetrain of the Toyota Prius – arguably the world's best-known hybrid EV, with global sales of almost 100,000 units of all variants in the first quarter of 2018 – uses what is known as a power split unit. This unit is a planetary-type gearbox that links the internal combustion engine, the generator, oil pump and electric motor together, allowing the ICE to operate independently of the car's speed.

**Charge Ahead**

At the same conference, Gahagan highlighted another main consideration for developing novel EV fluids – the electrical conductivity of fluids and the related safety concerns. EVs have higher system voltage of up to 48 volts in a typical hybrid EV compared with 12 V in a conventional ICE car.

A major concern among OEMs surrounding lubricants in hybrid EVs is electrical charge in the lubrication fluid, especially at the power split, where the oil is in contact with the electric motor itself, Gahagan said. (See figure 1)

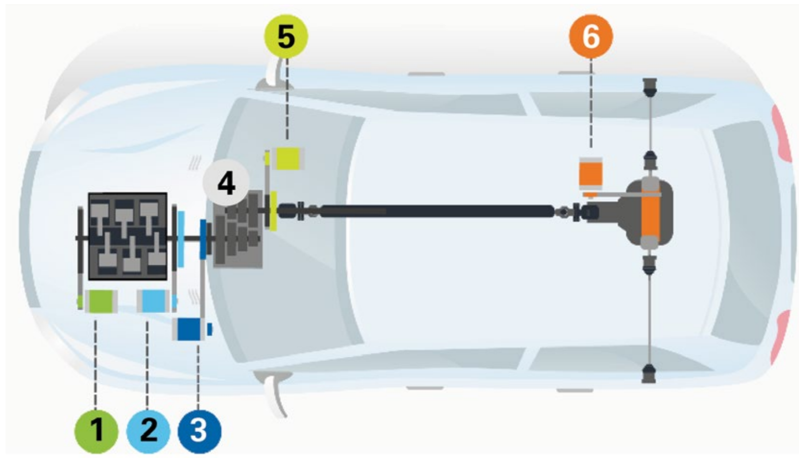
"Once you start looking at the transmission … when you have e-motors involved, then you're looking at the hybridization of the transmission itself, and the lubricant in many cases is in contact with that motor and that has lead to many questions about lubricant properties in the presence of electric fields."

Fluids tailored to hybrids and EVs would, therefore, have to have the right electrical properties and be compatible with insulating materials.

There are two considerations Gahagan highlighted when it comes to the electrical conductivity of fluids. First, if the conductivity is too high, there is a risk of current leaking, which could be fatal for any passenger who came into contact with charged parts.

"There is a concern that in some cases the lubricant could allow a leakage of electrical current from the high-voltage terminals at the e-motor to the external case of the transmission and hence the vehicle," he told *Lubes'n'Greases*. Although drivers need not worry too much. "Our research testing currently shows any such leakage to be low risk."

**Figure 1: Typical Hybrid EV Architecture**




1 E-motor in front of engine
2 E-motor behind engine
3 E-motor at transmission input
4 Power split unit
5 E-motor at back of transmission
6 E-motor at rear axle

*Source: Lubrizol*

Second, if conductivity is too low, electrostatic charge can build up, resulting in electrical arcing in the oil. This leads to the degradation of the fluid, compromising its protective features, and also to arcing that can damage bearings and seals.

Fortunately, lubricants are poor electrical conductors, which is good news in an e-motor, but they are static dissipative, i.e., they allow charge to pass through them slowly.

"In layman's terms, many oils, such as transmission fluids, are electrical insulators in that they do not conduct electricity well. There is some scope to lower the conductivity of a transmission fluid by additive package selection and design. This may seem desirable if there is a concern about electrical conductivity being too high."

In fuels, however, if electrical conductivity is too low, electrostatic charge can build up and lead to sparks, which is extremely hazardous for highly flammable fuels, but can also can damage sensitive electrical equipment, Gahagan explained.

"Raising the electrical conductivity a little by means of additive technology prevents the risk of such charge build-up. The best way to describe this property is to call transmission fluids 'static-dissipative insulators'."

Other factors such as oxidation, which causes oil to deteriorate, can also increase conductivity. Oxidized oils have higher electrical conductivity than the non-oxidized.

"From a conductivity perspective to date, in our testing, used oils remain within the normal expected bounds for lubricating oils," he said.

Gahagan used the example of a solenoid that had been exposed to a transmission fluid that was susceptible to oxidation. Tests found that sludge build up can impede the ability of the lubricating oil to remove heat from the coil windings in the solenoid and can affect the effective operation of the electrical unit, he said.

However, insulators can suffer from dielectric breakdown, when an insulator effectively becomes a conductor if the applied voltage is high enough. This phenomenon is observed in lightning, when air becomes a conductor. This can also be the case with lubricants, yet the voltages have to be much higher than lightning in air, which is good news.

"This is a very good argument for having a lubricant in contact with the e-motor. It's better than air at suppressing dielectric discharge," Gahagan informed the conference.

**The Heat is Off**

Another challenge is temperature, as conductivity of automatic transmission fluids in a hybrid EV can increase, especially as it ages, Lubrizol found. Indeed, heat transfer is a major focus for EV fluids developers.

"There is much interest in a fluid's ability to remove heat from e-motors and electrical devices. This is not simply related to properties such as fluid thermal conductivity, but also heat capacity, fluid density and, importantly, viscosity comes in to play."

The challenge is to keep the EV fluid's viscosity low enough to provide good heat transfer but resistant enough to decomposition brought about by the heat it has to manage. This, said Gahagan, is achieved by a combination of suitable base fluid, performance polymer and the design of performance additives to aid the fluidity and longevity of the fluid.

**Testing Time**

According to Lubrizol, it is not just the lubricant that needs to adapt to hybrid and electric vehicles; the same applies to lubricant test methods. Given the presence of electrical components and wires in the hybrid architecture, and given the potential for changes in the level of conductivity and a greater variation in temperatures, corrosion deposition tests need to be made more sophisticated.

About 20 kilograms of copper are used in an average hydrocarbons-fueled vehicle, compared to as much as 80 kg for an EV, noted Gahagan. For example, he suggested, the industry should consider adopting a wire corrosion test since stray voltage or energized circuits promote corrosion that would normally not occur.

"The industry has traditionally used copper strips and used visual ratings to screen and test for corrosion. The copper wires corrosion test gives a much more reliable output in terms of degree and rate of corrosion of copper metal."

Another technological development that lubricants and fluid producers must take note of is the introduction of the electric dual clutch transmission, or eDCT, a multiple-speed automatic gearbox for EVs that draws on the example of the DCT. The eDCT uses an e-motor in addition to the twin clutch for seamless shifting. Because of the electrical components and wiring involved, a gearbox fluid would have to offer copper corrosion protection while at the same time being compatible with the insulation and other materials of construction.

Some tests can be adapted easily, said Gahagan. For example, oxidation tests can be run hotter or longer than standard to reflect the high heat output. In other cases, a newer approach is needed, as with the wire test. And corrosion tests could use actual parts rather than materials.

"Testing of actual component parts is very useful. We are also seeing more interest in plastics compatibility and electrical insulator compatibility with oils." □