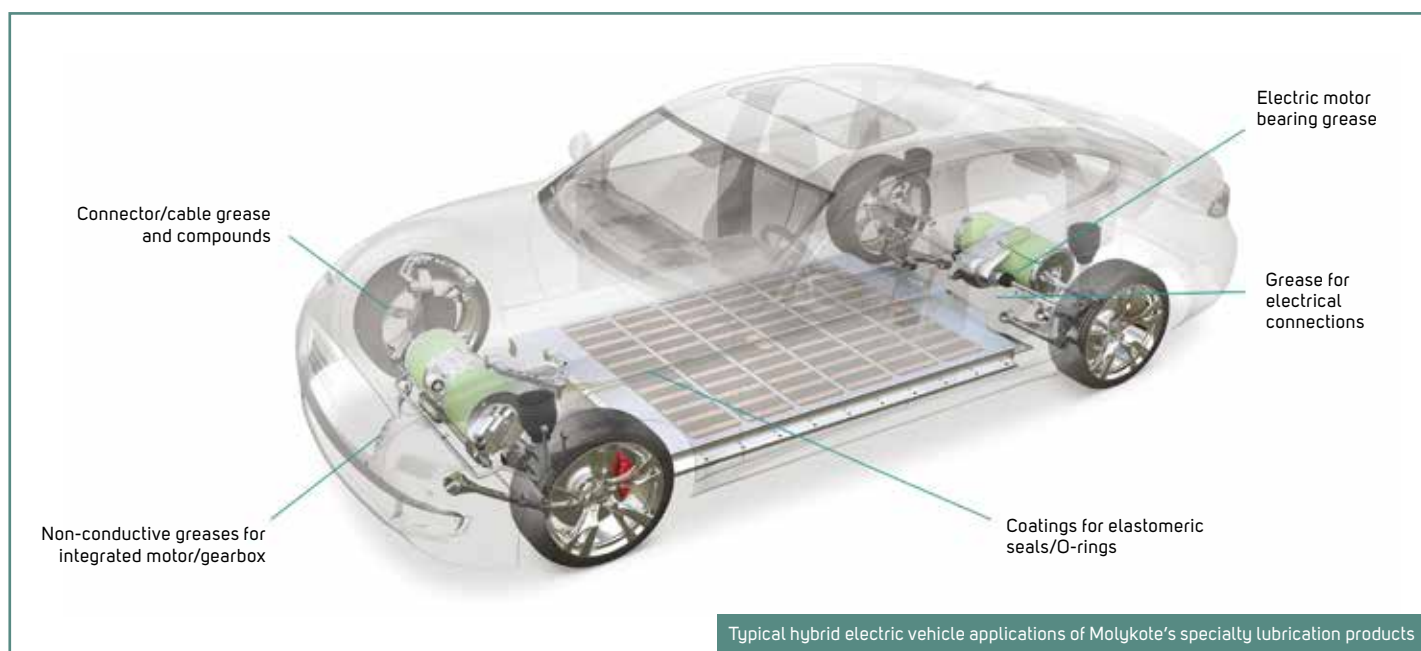


Tribological technology

Extensive R&D in greases, anti-friction coatings, pastes, compounds, dispersions and oils is helping to meet complex technical design and lubrication challenges



▶ Many challenges in automotive powertrain systems historically have been tied to achieving fuel economy and reduced emissions. With increasingly stringent fuel efficiency, emissions and safety regulations – as well as evolving consumer demands – there is even greater emphasis on lightweighting, electrification, hybridization, NVH reduction and durability, while enhancing the overall driver experience. Designers of future vehicle propulsion systems will continue to push the limits in attaining fuel economy and emission requirements, as well as in creating a unique vehicle experience for the occupants.

With 70 years of experience in the industry and a multifaceted product offering, Molykote Specialty Lubricants works closely with global customers to help solve complex technical design and lubrication

challenges and is investing in materials and application engineering capabilities for advanced propulsion systems.

Molykote's six technology families – greases, anti-friction coatings, pastes, compounds, oils and dispersions – address a wide range of performance requirements and enable design flexibility. Specialty greases and anti-friction coatings, in particular, have found extensive use within powertrain lubrication applications.

Greases, composed of a base oil, thickener and additives, are used in the driveline, e-motors, gearboxes, spindles, and high- and low-temperature bearings.

The base oil contributes greatly to the grease's overall performance. Traditional mineral oil bases can provide an economical starting point, but more demanding powertrain applications require higher-performance materials,

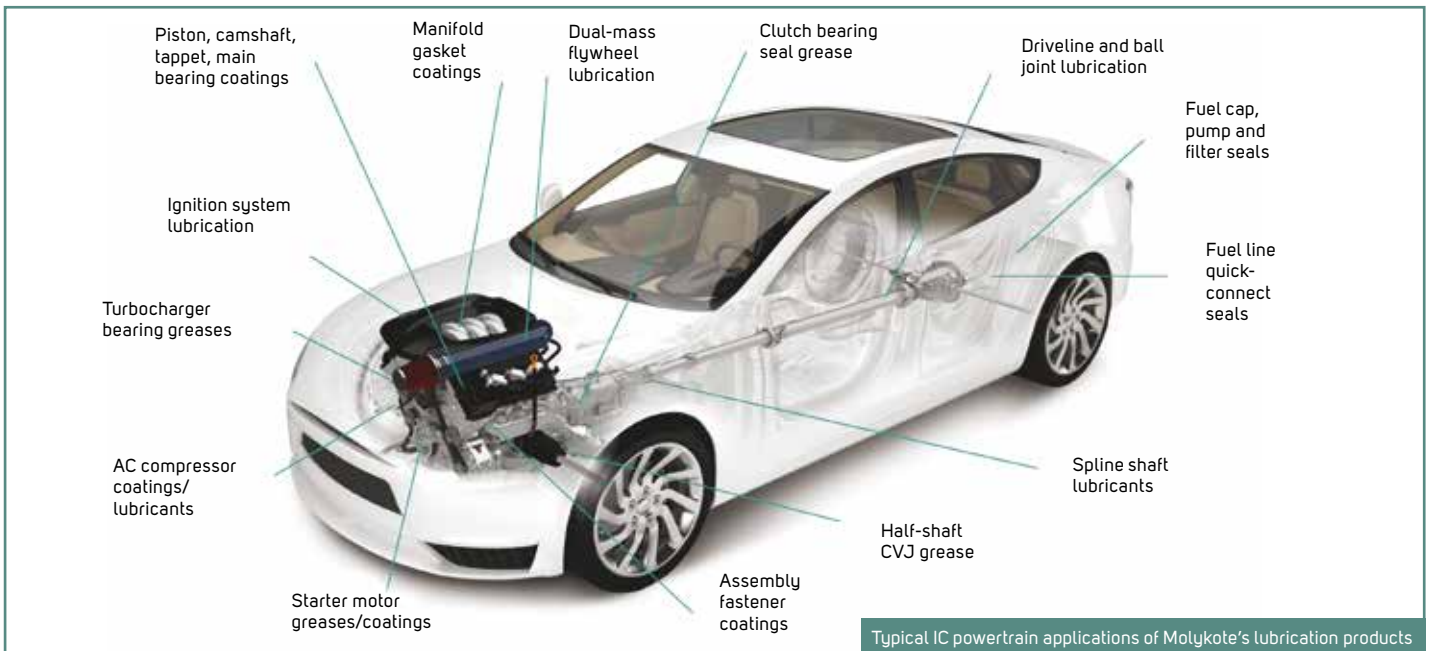
such as polyalphaolefin (PAO), polyalkylene glycol (PAG), silicone or perfluoropolyether (PFPE).

Today, there are more than 200 Molykote grease formulations available to minimize wear and enhance powertrain efficiency. However, the company continues to lead in application-matched lubricant development, with new thickener and additive chemistries enabling customized performance that balances loads, temperatures, speeds and other environmental conditions as demanded by OEMs and component suppliers.

With increased electrification, demands on stop/start motor reliability have more than doubled in the past few years. Molykote G-5025 grease is formulated to lubricate and protect the over-running clutch within the starter motor unit. The grease is ideal for the long life expectancy and extreme conditions typical of

under-the-hood environments. It has a high-shear-stable silicone base oil and proprietary anti-oxidative additives that provide high cycle stop/start capability and controlled low-temperature friction to ensure durable protection for the starter-motor application.

The combination of increased operating temperatures, aggressive fluids and electrification pose more challenges for component and system designers. To answer the call, the Molykote G-9000 grease series uses a phenyl/fluorosilicone copolymer technology that combines the high-temperature resistance of a phenylsiloxane, the fuel resistance and lubricity of a fluorosilicone, and the electrical resistance of silicone in one grease. Applications are seen in high-temperature areas throughout the powertrain, such as in proximity to batteries, charging systems or braking assemblies.



Typical IC powertrain applications of Molykote's lubrication products

In the continuing push to increase efficiency and reduce driveline drag and noise, a new low-friction Molykote grease is under development, with a unique additive package that provides a step-change reduction in the coefficient of friction compared with current competitive products.

Anti-friction coatings (AFC) are comprised of solid lubricants, a binder resin and additives in a solvent. Solid lubricants typically are MoS₂, graphite, fluoropolymers, or other white solids. While solid lubricants are the workhorse, binders must be selected carefully to ensure that the solid lubricant particles adhere to each other and to the substrate. Binder options

range from epoxies and phenolics to higher-performing resins like polyamide-imides (PAI) and are matched to the substrate and application requirements.

These engineered solutions provide durable, dry-film lubrication and wear protection, and can be ideal for demanding applications that require corrosion protection and resistance to dust and contamination while providing lubricity. Additionally, customers and their partners can benefit from Molykote AFC lab prototyping and testing capabilities, along with a network of coating partners with the expertise to ensure proper application for maximizing the coating's usable life.

Regulatory mandates, lower engine oil viscosities, and demand for longer engine life and quieter engines are driving growth of AFCs and spurring innovation. Requirements, typically described in terms of load, environment, temperature and speed, result in products that can serve a diverse set of powertrain applications.

One of the traditional powertrain AFC applications is on the pistons of an IC engine. The D-10-GBL anti-friction coating, containing graphite in a PAI binder, is screen-printed onto the piston skirt and reduces friction and wear during break-in and then during cold-start and ongoing operation, where it also reduces noise and vibration.

The D-6600 anti-friction coating offers excellent wear resistance and lower coefficient of friction for metal/metal pairings, particularly at medium and low pressures, and for metal/plastic material pairings. Besides improving service life of highly stressed components, it can assist in lightweighting efforts, NVH reduction and corrosion protection. The epoxy-based AFC with polytetrafluoroethylene (PTFE) solid lubricant is finding a home in various applications.

A next-generation coating that is especially suitable for plastic

connectors, O-rings and gasketing, the D-9100 UV-cure anti-friction coating reduces and controls friction, noise and wear on plastic, metal and rubber parts, while enabling fast processing. A water-based formulation leverages a polyurethane binder and PTFE and cures in less than one minute. Like the D-6600 anti-friction coating, it can be applied via spraying, dip-spinning or brushing.

Now celebrating its 70th anniversary, Molykote remains ready to solve lubricant challenges, whatever and wherever the need. With renowned R&D and technical support for chemistry and testing labs, along with manufacturing that spans the globe, the brand can tailor products to meet regional or global regulations and demands.

Working with professionals on current and future powertrain systems, the Molykote team continues to work hand-in-hand with customers to develop the next generation of tribological system solutions to enhance automotive and powertrain design. 🌐

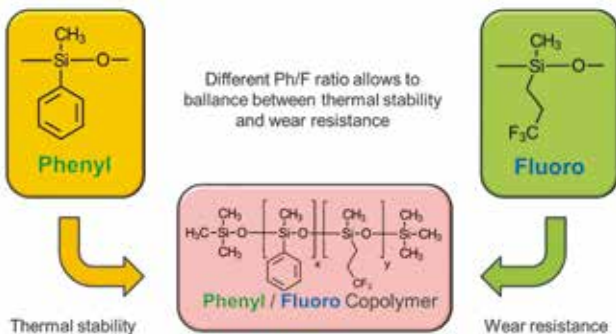
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Advanced formulations using siloxane copolymers along with specialized additives enable a wide variety of tailor-made solutions for specific challenge combinations