# Lab Test Methods for Lubes & Greases Used in EV's


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## Introduction

The heightening awareness of climate change and greenhouse gases has made people think about ways of lowering their carbon emissions. This has led to the rise in EVs and the materials needed to help them run smoothly. This includes lubes and greases that need to be specifically designed for EVs. Scientists need to make sure that these lubes and greases fit the different specifications needed for the EVs' needs. Thus there is a need for different test methods for examining these different specifications that are needed. There are certain lab test methods that are crucial for specifications needed in EVs.

## Qualifications and Purpose

There are many different qualifications that are used to determine if the greases may be a good fit for EVs which are different from the conventional ICE (internal combustion engine) vehicles. These qualifications include, but are not limited to noise, efficiency, and the presence of electrical current and electromagnetic fields from electric modules, sensors and circuits. Engineers must either select or develop new greases with the different qualifications in mind when designing EVs. The noise is an important criteria for EVs as it has the potential to cause annoyance to the driver and more importantly affect sensors that are increasingly used in the vehicle's safety and guidance according to Chad Chichester, a member of STLE (Society of Tribologists and Lubricant Engineers). The energy efficiency of a vehicle must be raised in order to compensate for the range anxiety, the fear of not being near a charging station, that may be caused by EVs. This could result in a reluctance from people to transition to EVs from ICE vehicles. The presence of electrical currents and electromagnetic fields calls for engineers to test the corrosion and material compatibility of these different greases and lubricants in order for the EV to function properly]. Test methods are thus necessary for determining if certain greases and lubes meet the qualifications needed for EVs. As seen in figure 1, there are a variety of existing test methods that examine different aspects of a greases' properties. Test Methods such ASTM D-6138 and ASTM 2265 examine properties such as corrosion resistance and high operating temperature of the lubricating greases respectively.

**Table 1.** Selected Test Specifications Relevant to Wheel Bearing Lubrication in Electric Vehicles

| Required characteristics | Test specifications |
|---|---|
| Superior wear properties under accelerated rolling contact fatigue | DIN 51819 - FAG FE8 (Wear of Rollers) |
| High-operating temperature | ASTM D2265 - Dropping Point |
| Excellent oil release properties | IP 121, ASTM D1742, ASTM D6184 |
| Fretting resistance | ASTM D4170 - Fafnir Fretting Test, SNR FEB 2 |
| Corrosion resistance | ASTM D6138 - Anti-Rust Test |
| Low-temperature torque | ASTM D1478 - Cold Start Torque |
| Consistency | ASTM D217 - NLGI Grade |
| Mechanical/work stability | ASM D217 - Worked Cone Penetration (100Kx) |
| Resistance to physical degradation | ASTM D1831 - Grease Roll Stability |
| EP properties | ASTM D2266, ASTM D2596 - 4 Ball Welding Test |
| Water resistance | ASTM D1264 - Water Washout Test |
| Grease life/oxidation stability | DIN 51821 - FAG FE9 |
| Seal compatibility | ASTM D4289: Elastomer Compatibility |

*Courtesy of Kuldeep Mistry and The Timken Co.*

Figure 1: Table of Select Test Methods used for Lubricants in EVs

## Corrosion Resistance

Tarunendr Singh of the Bharat Petroleum Corporation Limited conducted a study on Tribochemistry and EP Activity Assessment of Mo-S Complexes in Lithium-Base Greases. He ran lots of different tests on both the normal version of his grease and the greases with the Mo-S complex additives. The greases that were tested were a Lithium-base grease without any additives (Grease A), Grease A + bis(1,5-di-p-methoxyphenyl-2,4- dithiomalonamido)-dioxomolybdenum(VI) (Grease B), and Grease A + bis(1,5-di-p-chlorophenyl-2,4- dithiomalonamido)-dioxomolybdenum(VI) (Grease C). Within these different tests was a rust test using the ASTM D-6138 test method. This test method is used to assess the ability of grease to prevent corrosion in rolling bearings operated in the presence of distilled water, sodium chloride solution, or synthetic sea water.

The test begins when new, cleaned, and lubricated bearings are partially immersed in water (distilled, synthetic sea water, or sodium chloride solution) under no applied load at a speed of 83 ± 5 rpm in a predetermined sequence of running and stopping for a period of approximately one week. After cleaning, the bearing rings are examined and rated according to the degree of corrosion.

In order to perform this test, a corrosion tester is needed. For this, Koehler Instrument Company has created their own corrosion tester. The Corrosion Tester K9445X has been developed for testing lubricating greases on their corrosion inhibiting characteristics in rolling bearings in the presence of either distilled or demineralized water, or salt water or synthetic sea water and under no applied load. It can also be used to test the corrosion inhibiting characteristics of lubricating oils.

Figure 2: K9445X Koehler Corrosion Tester

## High Operating Temperature

Xiaoqiang Fan and a group of researchers in China wanted to find the probing effect of thickener on tribological properties of lubricating greases. They mixed their thickeners within a lubricant known as MACs. One of the many test methods that were done on the lubricating greases is known as the ASTM D-2265 Dropping Point. The dropping point is useful to assist in identifying the grease as to type and for establishing and maintaining benchmarks for quality control.

This test begins when a grease sample in a grease test cup is supported in a test tube placed in an aluminum block oven at a preset constant temperature. A sample thermometer is placed in the tube and so positioned that it measures the temperature in the sample cup without coming in contact with the grease. As the temperature increases, at some point a drop of material will fall from the cup to the bottom of the test tube. The reading on the sample thermometer and temperature of the aluminum block oven is recorded to the nearest degree as the observed dropping point.

In order to produce this test method, a high temperature dropping point apparatus is needed in order to determine the dropping point of a grease or lubricant. For this, Koehler Instrument Company has created their own High Temperature Dropping Point Apparatus. This apparatus tests dropping points of lubricating greases at temperatures of up to 400°C (752°F). It also includes a thermostatically controlled aluminum block oven and six complete dropping point assemblies. A six-place oven has large viewing ports with fluorescent backlighting for excellent visibility. The microprocessor PID control provides quick temperature stabilization without overshoot and the bath is protected by an over-temperature control circuit that interrupts power should the block temperature exceed a programmed cut-off point. The dual LED displays provide actual and setpoint temperature values in °C/°F format [6].

Figure 3: Koehler High Temperature Dropping Point Apparatus

## Results and Discussion

TABLE 3: Typical test results recorded for the prepared Grease A, Grease B, and Grease C.

| Sl. No. | Test | Results GREASE A | Results GREASE B | Results GREASE C | Methods ASTM |
|---|---|---|---|---|---|
| (1) | NLGI grade | 2 | 2 | 2 | NLGI |
| (2) | Penetration, 60 X | 274 | 272 | 272 | D 217 |
| | Penetration, 100,000 X | 299 | 294 | 295 | |
| (3) | Drop point, °C | 198 | 198 | 199 | D 2265 |
| (4) | Oil separation, % by wt at 100°C, 30 h | 1.4 | 1.5 | 1.8 | D 6184 |
| (5) | Oil separation on storage, % by wt | Nil | Nil | Nil | D 1742 |
| (6) | Oxidation stab. at 99 ± 1°C, 100 h pressure drop, psi | 15 | 2 | 1.5 | D 942 |
| (7) | Water washout at 80°C, % loss by wt | 4.0 | 4.2 | 4.0 | D 1264 |
| (8) | Rust test | FAILS | 1 | 1 | D 1743 |
| (9) | EMCOR rust test | FAILS | 0,0 | 0,0 | D 6138 |
| (10) | Copper corrosion test at 100°C, 24 h | PASS | PASS | PASS | D 4048 |
| (11) | Deleterious particles, number of scratches | NIL | NIL | NIL | D 1404 |
| (12) | Wheel bearing test at 105°C for 6 h, leakage by wt, gms. | 1.2 | 1.2 | 1.3 | D 1263 |
| (13) | Four-ball wear test, Wear-scar dia., mm, ~1200 rpm, 40 kg at75°C | 0.85 | 0.45 | 0.42 | D 2266 |
| (14) | Four-ball weld load, kg | 160 | 315 | 315 | D 2596 |
| (15) | Timken Ok Load, lbs | 20 | 45 | 45 | D 2509 |

Figure 4: Test Results for Greases A, B and C tested by Tarunendr Singh

**Table 2**
Physical properties of four MACs greases.

| Sample (grease) | Abbreviation | Dropping point (°C) | Penetration (1/4 mm) | Copper corrosion (T2copper, 100 °C, 24 h) | Colloid stability (w/w%) |
|---|---|---|---|---|---|
| Lithium complex grease | LCG | 260 | 92.4 | 1a | 1.7 |
| Polyurea grease | PUG | 274 | 85.5 | 1a | 0.8 |
| Calcium sulfonate complex grease | CSCG | 290 | 80.4 | 1a | 1.8 |
| PTFE grease | PFG | 253 | 72.2 | 1a | 1.1 |

Figure 5: Physical Properties tested for four MACs Greases tested by Xiaoqiang Fan and his group of researchers

The rust tests were performed by following ASTM D 6138 method in SKF EMCOR test rig and ASTM D 1743 test rig. The prepared polyurea greases (Grease 2 and Grease 3) pass the rust tests as per ASTM D 6138 and ASTM D 1743. As evidenced by the results in Figure 4, The grease that did not have the Mo-S additive was the one that failed the EMCOR rust test. The additive fortified both Grease B and Grease C which showed better rust protection properties. Overall, the additive has seemed to improve the grease in multiple aspects and provide better performance that the grease would not produce on its own.

The greases tested by Xiaoqiang Fan and a group of researchers were Lithium complex grease, Polyurea grease, Calcium Sulfonate complex grease and PTFE grease. The dropping point of all the greases was measured using ASTM D-2265. Considering all the different complex greases had different dropping points, it can be concluded that thickeners can change the physical properties of greases.

## Conclusion

The increasing support for EVs has the potential to help reduce carbon emissions and bring awareness to different topics such as the effects of greenhouse gasses and the ever growing support for the environment. With the increasing interest and demand for EVs, the demand for effective greases and lubricants for EVs will rise as well. The test methods that are currently available and new ones that are developed in the future will help facilitate this rise in EVs and will also become more in demand. These test methods will help both scientists and engineers to help bring about a cleaner and environmentally friendly future for the world.

## References


- Andrew, J.M. The future of lubricating greases in the electric vehicle era. Tribol. Lubr. Technol. 2019, 75, 38–44. [Google Scholar]
- ASTM D2265-15 "Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range[1]"
- ASTM D6138-07 "Standard Test Method for Determination of Corrosion-Preventive Properties of Lubricating Greases Under Dynamic Wet Conditions (Emcor Test)[1]" (ASTM International)
- "Corrosion Tester." *Koehler Instrument Company Inc*, https://koehlerinstrument.com/products/lubricating-greases/corrosion-tester/.
- Fan, Xiaoqiang, et al. "Probing the Effect of Thickener on Tribological Properties of Lubricating Greases." *Tribology International*, vol. 118, Elsevier Ltd, 2018, pp. 128–39, doi:10.1016/j.triboint.2017.09.025.
- Singh, Tarunendr. "Tribochemistry and EP Activity Assessment of Mo-S Complexes in Lithium-Base Greases." Advances in Tribology, vol. 2008, Hindawi Publishing Corporation, 2008, pp. 1–6, doi:10.1155/2008/947543.
- "Products." *Koehler Instrument Company Inc*, https://koehlerinstrument.com/products/category/lubricating-greases/high-temperature-dropping-point-apparatus/.



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