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Today's Topics:

- **Electric Driveline Fluid Testing Update**
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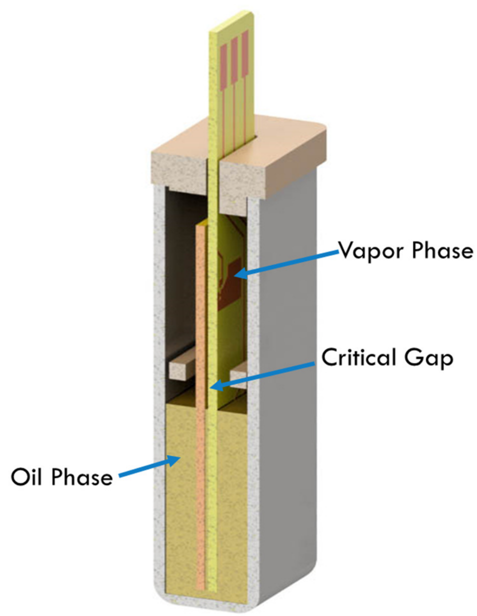
Electric Driveline Fluid Testing Update

Conductive Deposit Test (CDT) and Wire Corrosion Test (WCT)

The automotive lubricant industry has been *charged* on the buzz around electric vehicles for the last few years. In the 2021 Q4 On the Horizon, Savant shared news about new methods developed specifically to test fluids for compatibility with electric vehicles and the then-in-progress SAE document listing these tests. Last fall the awaited SAE J3200_202210 Information Report was published. As expected, it includes a discussion of the benefits and uses of the Conductive Deposit Test (CDT) and the Wire Corrosion Test (WCT) that Savant Labs now offers, along with several other tests. More action regarding these tests is ongoing within the ASTM D02 Committee. Last December the ASTM D02 Subcommittee 9 on Oxidation of Lubricants presented plans to complete a full Interlaboratory Study (ILS) to determine a precision statement for the Conductive Deposit Test and make it an official ASTM Standard Test Method. The Subcommittee also presented plans for a pilot study on the Wire Corrosion Test to determine how many labs will need to participate in an upcoming full ILS.

With industry standardization groups showing so much interest in electric driveline fluid tests, it’s clear that they are important to the industry. Why are they so important? In the last two years, many lubricant manufacturers have been developing special-purpose lubricants to meet the needs of electric vehicles. This follows a period when axle oils, manual transmission fluids, or ATFs were used to lubricate the electric vehicle driveline and even to provide cooling to the electric motor. Corrosion to an electric motor exposed to a lubricant has been known to cause catastrophic failures [1], [2], [3]. Perhaps the recent interest in dedicated fluids results from knowledge of such instances and the needs outlined in SAE J3200_202210. Whether producing a lubricant tailored to the specific needs of an electric vehicle or verifying the compatibility of a pre-existing fluid with an EV application, it has become necessary to use tests that can reveal critical failures, such as the CDT and WCT.

Conductive Deposit Test



The Conductive Deposit Test is specifically designed to detect conductive deposits that could create a short in an electric motor or other critical circuitry. A printed circuit board with copper traces is used to stand in for relevant copper-containing electrical components, such as motor windings, in the electric vehicle. The circuit board is exposed to the test fluid under controlled temperature with minimal fluid flow and closed, but not sealed, headspace. This simulates the conditions in EVs where components are tightly spaced and may not see much fluid circulation or are exposed to vapors from the lubricant during normal use. As copper from the circuit is corroded, it can combine with components of the fluid and stick to the circuit board as deposits. If these deposits can conduct electricity, a problem occurs when they bridge the gap between two otherwise unconnected circuit components. In a real-life application, this could cause unintended currents to flow between circuit components, quickly overheating the components, and causing deformation or even welding [3]. In the CDT, the resistance measured on the test drops to a low value. The speed with which this happens and the final resistance are used to infer the suitability of a fluid for the application. Limits are currently set by each manufacturer, but industry-wide limits may eventually be established by standardization groups. The test may run for up to 1000 hours to build extra confidence in the long-term operation of the fluid, but the resistances drop to concerning values in less than 500 hours for fluids with problematic results in the field. In addition, as the deposits form, the variability of the resistance increases dramatically due to the intermittent nature of the electrical connection formed by the deposit. This is measured with the Conductive Deposit Index (CDI). Either the CDI or the resistance value can be used to identify a fluid with poor performance in the field. Both the resistance limit indicating a failure and the Conductive Deposit Index limit indicating a failure may be adjusted to correspond with particular applications.

Currently, Savant has multiple customers routinely using the CDT to assess EV fluids. In addition, research efforts proceed. In a paper recently presented at the OilDoc conference, Greg Miiller of Savant Group compared failure times for two fluids with their failure times once diluted with group II base stock, an ester, and a traction reduction additive. Fluid A was considered poor performing in the vapor phase while Fluid B was considered to have poor performance in the oil phase. As can be seen in the graph below, addition of the tracking fluid greatly reduced the likelihood of conductive deposit formation for each fluid within those fluids problematic deposit forming region and outperformed the other diluents tested. Future studies are currently in the developmental stage to examine the effects of mixed lubricant systems for EV applications.

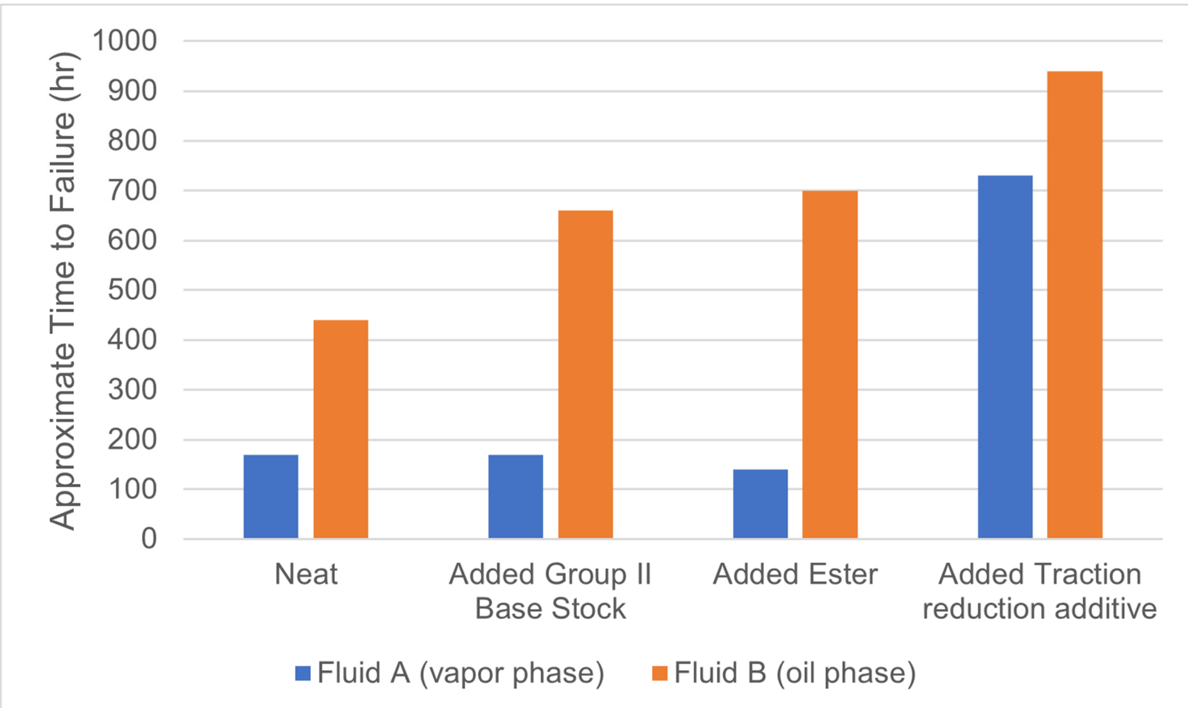
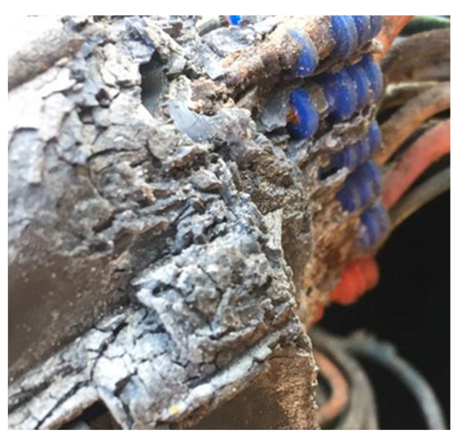


Figure 1. Summary of dilution results for Fluid A and Fluid B.

Wire Corrosion Test



While the CDT assesses the tendency of a fluid to create conductive deposits that can short a circuit, the wire corrosion test quantifies the tendency of a fluid to corrode copper. Traditional copper corrosion tests like ASTM D130 and adaptations based on it tend to be subjective and qualitative. The advantage of the wire corrosion test is that the corrosion rate can actually be determined in a given sample. A thin wire is exposed to an oil and its vapor with a separate circuit for each phase at a controlled temperature for 72 hours. In the case of the WCT, the wires are spaced sufficiently far apart that no deposits would be able to bridge the gap. Furthermore, the wires are suspended so there is no substrate on which deposits can form. As the copper is corroded the resistance of the circuit increases. Based on the known initial diameter and resistance of the wire, the diameter can be calculated at any time during the test based on the resistance, and the actual rate of corrosion can be determined. Furthermore, this test can easily be conducted at temperatures from 80 °C to 150 °C, allowing the temperature dependence of corrosion rates to be established for different fluids in both the oil and vapor phases [1]. The developers of this test found that temperature dependence varies significantly by fluid and that the hottest temperatures may not always be the most severe, particularly in the vapor phase [3]. These results underscore the importance of testing changes in formulation and testing across the full range of temperatures anticipated in the application. Savant Labs has been offering the WCT since 2021, and multiple customers have made use of the ability to test at several temperatures in order to fully characterize the copper corrosion effects of various fluids. In addition, the duration of the test can be extended to examine the corrosion rates in even very high-performing fluids.

Learning More About EV Driveline Fluid Testing

Perhaps the best way to learn more about how you might use the Conductive Deposit Test and the Wire Corrosion Test to *electrify* the development of your EV fluids is to contact us for a conversation about how Savant Labs can adapt these tests to your specific needs.

Request Quote

References

[1] Miiller, Gregory; VanBergen, William; Kurchan, Alexei; Gillespie, David; Mueller, Gunther; Pelz, Rico; Newcomb, Timothy; Hunt, Gregory, (2023, May 9 -11). Research and Development Utilizing the Conductive Layer Deposits and Wire Corrosion Bench Test Technology for Electric Vehicle Drivetrains, OilDoc Conference 2023, Rosenheim, Germany.

[2] Van Rensselar, Jeanna. (2022, November). “Rapidly expanding electric vehicle market spurs lubricant development urgency.” *Tribology & Lubrication Technology*, 78 (11), pp. 34-40.

[3] SAE 2020-01-0561 “Understanding Vapor and Solution Phase Corrosion of Lubricants Used in Electrified Transmissions” Hunt, Gregory and Prengaman, Christopher.

Savant Presents Grease Evaluation Under Oxidative Conditions and Resulting Friction and Pressure Analysis

At the recent NLGI Annual Meeting in San Diego, CA, our Canika Robinson-Owen, presented on the Evaluation of Grease under Oxidative Conditions and Resulting Friction and Pressure Analysis. The paper was co-authored by William VanBergen, Canika Owen-Robinson and Greg Miiller of Savant, and Richard Wurzbach and Sloan Healy of MRG Corp.

Abstract

As technology progresses with various improvements in the economic and ecological environment, grease is promoted as well. Wind turbines, EV, CNC machinery and an entire list of improvements require the improvement of grease technology. With that in mind, it is well understood that when different lubricating oils are mixed, any incompatibilities between the individual additive packages can result in poor performance in boundary lubrication. This can be disastrous for the industry. When evaluating the compatibility of greases, examination of both the extreme pressure and friction properties between the individual and mixed greases can be critical to insuring equipment reliability. In this presentation, we will examine the tribological performance of several binary grease blends utilizing an oscillation tribometer SRV (Schwing (oscillation), Reib (friction), Verschleiß (wear)) across a variety of aging conditions to simulate in-service mixing conditions.

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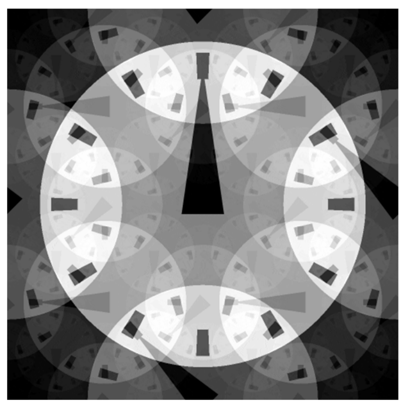

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