The Importance of Lubricant Performance Under Extreme Low Temperatures

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Introduction

The formulation of a lubricant ultimately determines how said lubricant will respond to extremely low temperatures. Greases need to perform well in these conditions to prevent components of the machine from becoming starved of lubrication. Tests such as the Kesternich Method have been used to gain a better understanding of the cold flow properties of greases while requiring smaller test samples. New technology such as the K95300 Low-Temperature Grease Flow Tester has developed to follow the Kesternich Method, yielding promising results.

The K95300 Low Temperature Grease Flow Tester

The K95300 is a fully automatic test system that can achieve temperatures of -50°C without external cooling devices. The Kesternich Test Method can be easily programmed into the instrument as well as other custom configurations. The K95300 has numerous advantages over other instruments that test following the Kesternich Method. Some of those advantages are shown below.

	K95300 Tester	Others
Temp. Range	<-50°C	<-30°C
User Interface	Guided Touch	Cursor-Based
Precool Time t0 -30°C	<10 minutes	<60 minutes
Data Storage	Standard USB	Not Available
Support Function	Embedded Support	Handbook
Remote Monitoring	Mobile App	Not Available

Figure 3/4. Advantages of K95300 Tester (above) and Image of K95300 Tester (below). Stanley Zhang, *Koehler Co.*, Evaluation of the Cold Flow Properties of Lubricating Greases Under Extreme Negative Temperatures.

How the Instrument Works

1. **Cooling:** The instrument will cool down the nozzle to the selected test temperature using a cascaded Peltier system.
2. **Stabilizing:** This begins once the desired temperature has been reached, takes from 15-500 minutes to complete.
3. **Pressure:** The instrument will increase pressure to the sample in intervals of time for the test.
4. **Data Collection:** If the system recognizes a rapid pressure decrease, the system will store the maximum pressure value as the test result.

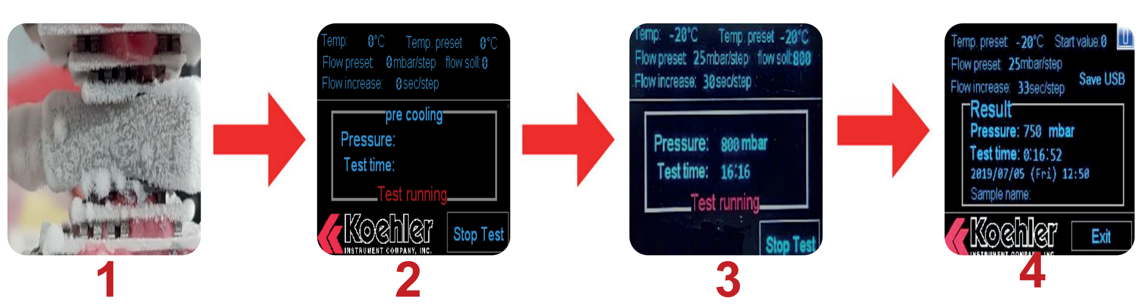

Figure 5. Simple Depiction of How the Instrument Works. Koehler Co. , *Low Temperature Grease Flow Tester*
https://koehlerinstrument.com/products/category/lubricating-greases/?product_id=278

Why Cold Flow is Important

While the primary concern of lubricant formulations may be the upper threshold of heat the lubricant can take before combusting, it is also vital to account for the other extreme. At critically low temperatures, the lubrication will reach a point where it solidifies and will no longer flow, known as the pour point. The congealed lubricant prevents certain parts of the machine from receiving lubrication which is shown below. The lack of lubrication causes metal-on-metal grinding, which heats the metal to the point where they weld together then tear apart. This causes shrapnel/debris to break off, which damages the machine resulting in its overall death. Oftentimes this results in needing to completely replace the machinery, which can cost hundreds of thousands of dollars depending on the type of machine. For this reason, it is vital to invest in lubricants that can withstand extremely low temperatures to avoid this situation.

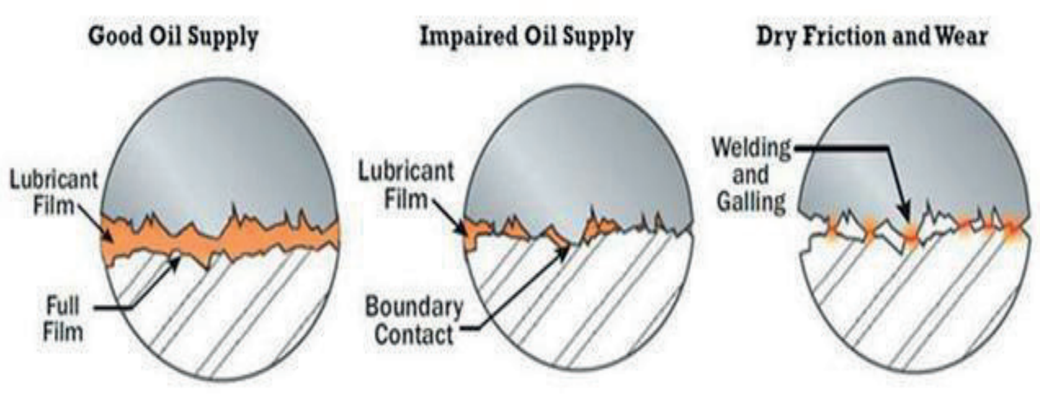

Figure 1. Depiction of Lubrication Starvation. Jim Fitch, *Machinery Lubrication*, 2012, Signs of Lubricant Starvation

Projecting Forward

As the lubricant market steadily shifts towards a green future with environmentally friendly lubricants (EAL's) at its forefront, there has been some concern on how these EAL's would perform in the extreme cold. Fortunately, EAL's such as synthetic esters and perfluoropolyethers (PFPEs) have proven there's no need to sacrifice low-temperature operability for being environmentally friendly. Both types of EAL's have a high viscosity index, with PFPEs being the best in class with a viscosity index ranging from 50-350. This makes PFPEs a likely candidate for use in both extremely high and low temperatures. PFPEs also have been proven to last significantly longer than other competitive EAL's, up to 64 times longer. Furthermore, despite their extreme capabilities, PFPEs are completely safe to handle and are also recyclable. For the reasons mentioned above, more R&D should go into finding cheaper methods of producing this lubricant to lower its cost.

Figure 6. Truck in Extreme Cold. International Lubrication and Fuel Consultants Inc., http://www.ilfcinc.com/

Kesternich Method (DIN 51805)

Tests such as the U.S. Steel Grease Mobility Method or the Lincoln Ventmeter Test are good at predicting the pumpability of greases at low temperatures, but they have always had a hard time being applied due to their lack of standardization. The Kesternich Method, originally developed to test the cold resistance of vulcanized rubber, has been modified to test grease flow at low temperatures. The test is typically performed by first packing the grease into the nozzle by repeatedly pressing the nozzle against the sample. Then the grease sample in the nozzle is cooled to the desired test temperature. Finally, pressure is applied to the grease sample, forcing it out of the nozzle. This pressure begins low and increases over time until the grease is forced out of the nozzle. One clear advantage of the Kesternich Method is the small sample size it requires. While other low-temperature tests require a minimum sample size of 220 g of grease, the Kesternich method only needs 1.6485 mL of grease, the equivalent of less than 2 g of water. A comparison is shown below.

	ASTM D1092	Lincoln Ventmeter	US Steel Mobility	Kesternich Method
Minimum Temperature	-54°C	-29°C	-34.4°C	-50°C
Method to Move Sample	Piston	Air Pressure	Piston	Air Pressure
Sample Size	223 g	400 g	220 g	2 g

Figure 2. Comparison of low-temperature grease tests. Stanley Zhang, *Koehler Co.*, Evaluation of the Cold Flow Properties of Lubricating Greases Under Extreme Negative Temperatures.

Conclusion

It has always been necessary for lubricants to be able to perform under a wide range of temperatures. As industrial operations continue to expand into extremely cold environments like the arctic, it is becoming more important to have a reliable way to test the performance of lubricants in these conditions. The K95300 Low Temperature Grease Flow Tester adhering to the Kesternich Method offers a simple, quick, and standardized method to do so while requiring less grease to test than other methods. Furthermore, the future of lubricants as the market shifts towards EAL's is not in danger of losing low-temperature operability as the high viscosity index of PFPEs makes them ideal for wide temperature ranges.

References

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