NLGI SPOKESMAN

Serving the Grease Industry Since 1933 - VOL. 84, NO. 5, NOV./DEC. 2020

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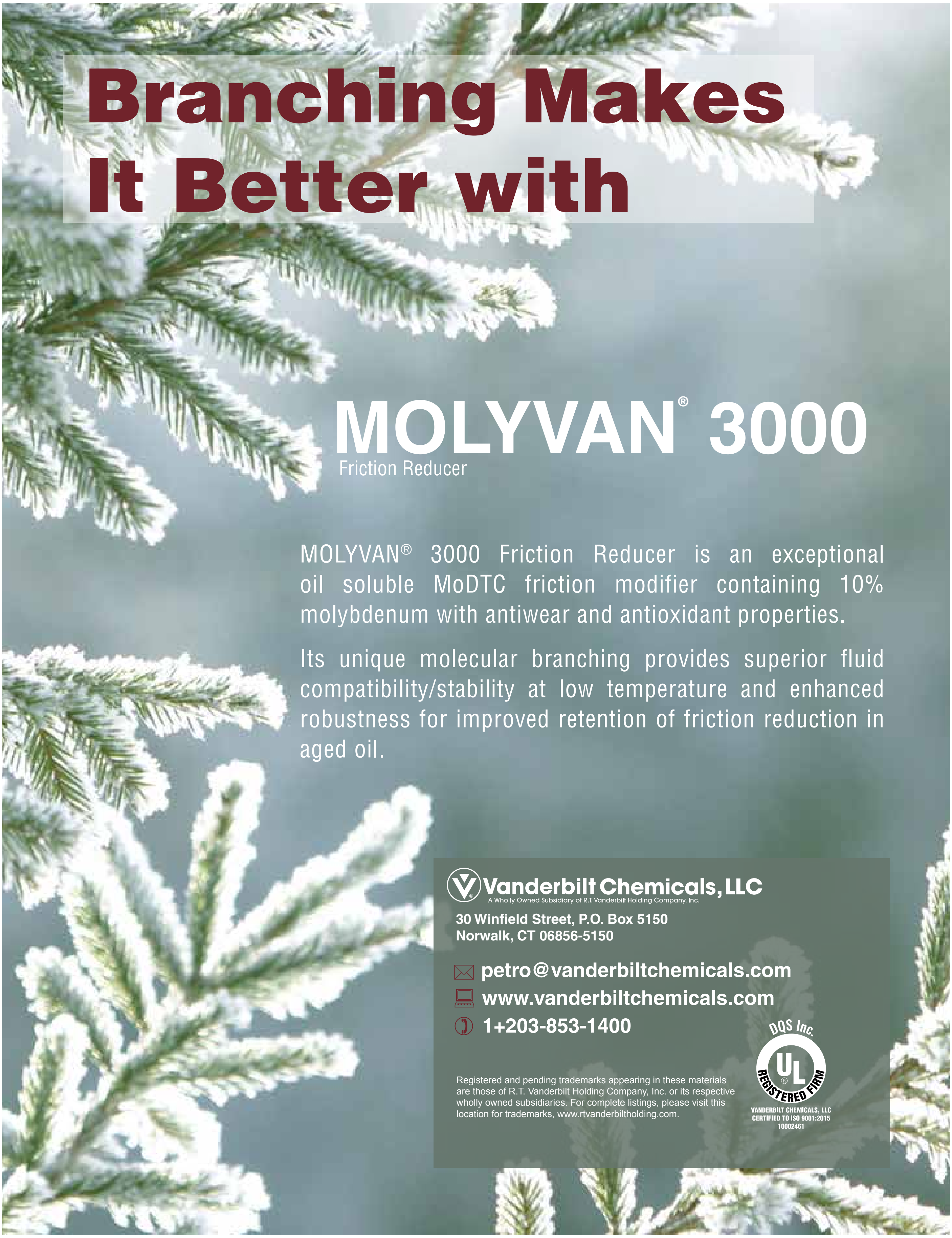

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ON THE COVER
Happy Holidays!

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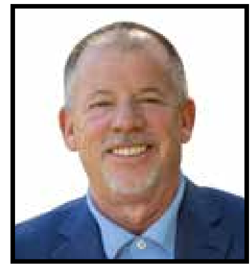
PRESIDENT'S PODIUM



Jim Hunt
NLGI President
2020 – 2022

Once again, we sincerely hope all of you and your families remain safe and healthy during this pandemic. This has truly been a year to remember and one a lot of us would like to forget. This message should truly be an opportunity to review some of the amazing things the NLGI has accomplishment in the most challenging times. Trust me, we accomplished so much this year.

First, we had a very successful virtual Technical Week. We were able to deliver all the education and technical content that is typically received at our in-person meeting. Second, NLGI remains financially healthy. In fact, we are projecting over budgeted revenue for 2020. Additionally, we awarded the 2020 research grant to the University of Akron for their research proposal titled "*Strategies for Optimizing Greases to Mitigate Fretting Wear.*" This research project will be concluded in Fall 2021. Finally, the HPM certification is moving full speed ahead. We plan to launch this new certification in the coming weeks. Once an application and product is submitted, the testing/approval process can take 6-8 weeks, so we encourage you to start formulating your products now. Please refer to the specification details on the NLGI website.

Now, please allow me this opportunity to focus some of this podium to truly provide a yearly review. Like to start with a famous quote from Charles Dickens, A Tale of Two Cities. "It was the best of times, it was the worst of times". Now I am sure that everyone is scratching their heads to understand how this applies to us during one of the most challenging and difficult years of our lifetimes.

Let's start with the obvious. 2020 has been a year of the deadliest pandemic most of us have ever experienced. It has negatively impacted someone we know in so many ways in many countries. Precious lives lost, millions of jobs gone, possibly forever, lives changed in ways we never could ever comprehend. I have personally lost cherished family members and I still grieve for them and their immediate families every day. All of us at the NLGI offer our condolences and blessings to all our NLGI members that have lost loved ones.

We also have witnessed a country politically, racially, and spiritually divided. In a time where a message of hope and optimism is needed more than ever, we are experiencing riots and despair. Anger and violence are at an all-time high in many major cities that were truly the crown jewels of the United States. In fact, we are more the Divided States and not the United States at a time were unification is need most.

So, you ask how this could ever be the best of times with all the global despair. Let's review some of the positive aspects of what has happen this year. Most of us that travel often as part of our job requirements have been given the opportunity to spend more quality time with our families and loved ones than ever before. These renewed family bonds are truly a blessing for all of us. All of us have taken much care and responsibility to protect the most vulnerable at all cost. Some of the most unlikely heroes have emerged including all the brave doctors and nurses on the front lines. They have never stopped making sacrifices while providing love, hope and inspiration to ones that need it the most. Knowing the we are all potentially vulnerable at any given time, some of us have discovered that we can truly love harder than ever before.

continued on next page…

Has this pandemic changed us for now or forever? If it hasn't, it should. Let's all try to be more tolerant of people that don't share our views. Let's continue to unselfishly provide the extra care to the ones we cherish and everyone that needs our help. Love stronger and longer. Pray for the ones that need our prayers. Be willing to give a little more to the ones that truly could use a helping hand. Offer an optimistic and inspiring message everywhere you go with a smile that truly drives the message home. We are all in this together and we will all get through this together. Hopefully, we will all be better and more grateful than we were before the pandemic.

We all should remain grateful for all that we have been given. I am sure when the day comes and I see my NLGI global colleagues and friends, if it is allowed, we will go back to showing our care for each other with hopefully a strong hug and not just a elbow rub. The NLGI members are truly a family that may be isolated for now by a life-threatening pandemic but, can never be separated for long.

All of us at the NLGI remain tremendously grateful for the continuous loyalty, dedication and support to keep us healthy and viable during this challenging year. You have our long-term commitment that we will continue to work even harder for all of you to ensure this Institute is the very best it can be. We also would like to continue to extend our invitation for all volunteers to participate in the NLGI committees.

I would like to reconfirm the NLGI's key strategic priorities for next year. We will continue to focus tremendous efforts to ensure we retain our current memberships and grow our global memberships in the future. Achieving our 2021 membership goals is a high priority. We also plan to continue partnering with other strategic global organizations to build awareness for NLGI. We plan to continue to provide unparalleled educational offerings. NLGI will continue to fund the Research Grant next year. We are committed to grow our level of academic and outside agency interest. Additionally, NLGI will continue its educational offerings, including extending the HPM webinar series into next year. Finally, NLGI will continue to improve our governance structure and leadership.

With the highest level of care and consideration, we thank all of you for all you have done and continue to do for the NLGI. Please take the time to enjoy the blessings we have and hope to see you all next year. Truly looking forward to next year.

Jim Hunt
NLGI President
2020 - 2022

Grease Evaluation for Continuous Caster Bearings

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Keywords: bearing, lubrication, bearing tests, field trials, greases, surface analyses, moisture effects

INTRODUCTION

The overall efficiency and performance of a steel rolling mill depends critically on the work roll bearings that support the rollers used to press steel and form slabs. These work roll bearings (Figure 1) are subjected to high loads and high temperatures along with large amounts of water ingress in the grease and bearings [1], which can affect the bearing life due to lubricant starvation and corrosion damage [2-4]. Poor grease selection for work roll bearings accelerates bearing damage, shortens bearing life, and increases grease consumption.

This study will discuss experimental results related to grease selection for continuous caster bearings, notably effects of water, which are crucial for the service life of the bearings and are very much dependent on the grease formulation [5].

Water contamination plays a key role in this application. It is important to accurately measure the water within grease, understand its impact, and establish the user guidelines accordingly. Thus, another goal of this study was to develop an accurate procedure to measure the water content of lubricating grease. A method was established to mix between 0.1 and 10% water with grease. The water content was measured for typical calcium sulfonate and aluminum complex greases. Both aged and oxidized greases, along with fresh greases, were tested.

STEEL INDUSTRY LUBRICATION

In the modern steel industry, lubrication of continuous caster bearings has been critical to the performance of the steel plant. Greases formulated for low-speed applications have been applied predominantly to lubricate the caster bearings. The most critical challenge for the grease is to handle water that is sprayed to cool the steel slabs. The intrusion of water into the grease affects the rheological properties of the grease. The grease that can overcome the impact of water is the best candidate for lubricating and improving the operational life of the caster roll bearings, which comprise 40% of the bearing cost in any integrated steel plant.

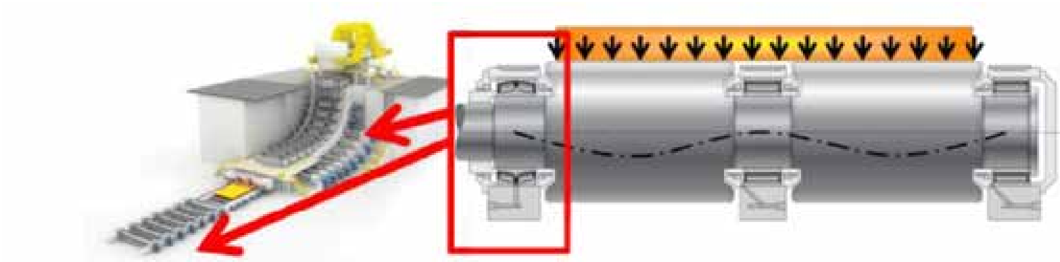


Figure 1. Work roll bearings in a continuous caster

The operational life of bearings is often determined by the performance of the lubricating grease. The consistency of the grease prevents it from leaking out of the bearing and provides good sealing properties. The possible ingress of water into the bearing can have a considerable impact not only on this consistency but also on the lubricating ability of the grease. Some greases are less sensitive to water than others. The goal of the paper is to contribute to the development of such guidelines for the development and selection of greases for application where they are subjected to water ingress. The approach is to study the impact of water on grease and discuss implications for grease selection for continuous caster bearings.

According to prior studies published in the literature,

Calcium sulfonate greases have some advantages over aluminum complex greases [6-9]:
- Calcium sulfonate greases are very water-resistant compared to aluminum complex greases.
- Aluminum complex greases have low thermal resistance and, when heated, can form stringy gels causing sharp increases in torque and additional work to turn a bearing. Moreover, aluminum complex greases have relatively low shear stability. The grease may break down and not retain consistency if worked repeatedly.

Molybdenum disulfide or MoS_2 is typically observed within steel mill greases [10-14]:
- MoS_2 is a solid lubricant additive that increases the load-carrying capability of grease.
- Even after oxidation, grease formulated with MoS_2 can still deliver an acceptable lubricant performance.

SELECTION OF GREASES BASED ON EFFECT OF WATER

In the steel industry, many EP greases are being used currently in critical applications where high-pressure water is sprayed on the working area, which affects the grease performance. The focus for this investigation was the effect of water on Grease D (Timken recommendation) and Grease E (baseline, existing grease used by end-users). Grease D is a calcium sulfonate grease with MoS_2, NLGI #2, formulated with mineral oil (460 cSt @ 40 C); whereas Grease E is an aluminum complex grease with MoS_2, NLGI #2, formulated with mineral oil (460 cSt @ 40 C).

BEARING TEST EXPERIMENTAL

An FAG Roller Bearing Test Apparatus FE8 was used to test greases under simulated application conditions. A few key tooling and design modifications were made to better simulate the application conditions: bearing speed was 15 rpm with a high slide-to-roll ratio or SRR (30%) for accelerated testing of axial cylindrical roller bearings - 81212TV bearings with 81212 cage assembly. The test load was 100 kN to attain 2.5 GPa contact stress, and the test temperature was 80 C.

Figure 2. Bearings Used In Testing

Figure 3. Bearing Setup Inside Test Rig

Figure 4. FE8 Test Rig Setup

Figure 5. Inner Shaft

The test was conducted to compare the effects of different grease formulations on wear after 500 h test duration. The washer's surface finish was 11 μin (275 nm), and the composite surface roughness parameter Rq was 283 nm. Thus, the film thickness at 80 C was 32 nm, and the film thickness ratio was 0.11 for Grease D and Grease E. Figures 2-5 shows key pictures from the bearing test procedures.

BEARING TEST RESULTS AND LUBRICANT ANALYSES

Figure 6 and Table 1 show test results for Grease D (calcium sulfonate) mixed with 10% water, Grease E (aluminum complex) with 10% water, and post-test grease samples that were collected for analysis. For Grease D (calcium sulfonate), the initial water percentage was 10% and fell to less than 6% after testing; significant wear was observed (~1000 ppm Fe). Whereas, for Grease E (aluminum complex), the water percentage started at 6.7% and fell to less than 1% after testing. Grease E could not handle all the water that was added (10%). The water accelerated the oil separation from Grease E, and the grease dried out on the rollers and raceways. The wear with Greases E was higher (>1500 ppm Fe) than with Grease D, and oil separation reduced due to grease work hardening.

First, it was learned that Grease E (aluminum complex) was not compatible with water. It was very difficult to mix this grease and water using an ASTM D1831 Roll Stability Tester. Only 6.7% water could be mixed with Grease E. Second, water mixed with Grease E was detrimental to bearing lubrication and, consequently, to bearing life. The FE8 test rig with Grease E ran only 172 h instead of the expected 500 h, and the rollers of the bearings broke due to grease starvation. Also, during the test, water migrated out of the grease along with the base oil, so the grease dried up and the bearings were unable to run. For both Grease D and E with water, there was wear on the rollers. Third, water should be avoided in bearing applications. But if water is unavoidable, then grease selection should take into consideration grease compatibility with water. Thus, in this study, bearing test results suggested that calcium sulfonate grease with a molybdenum disulfide additive outperformed aluminum complex-based grease under conditions with water contamination.

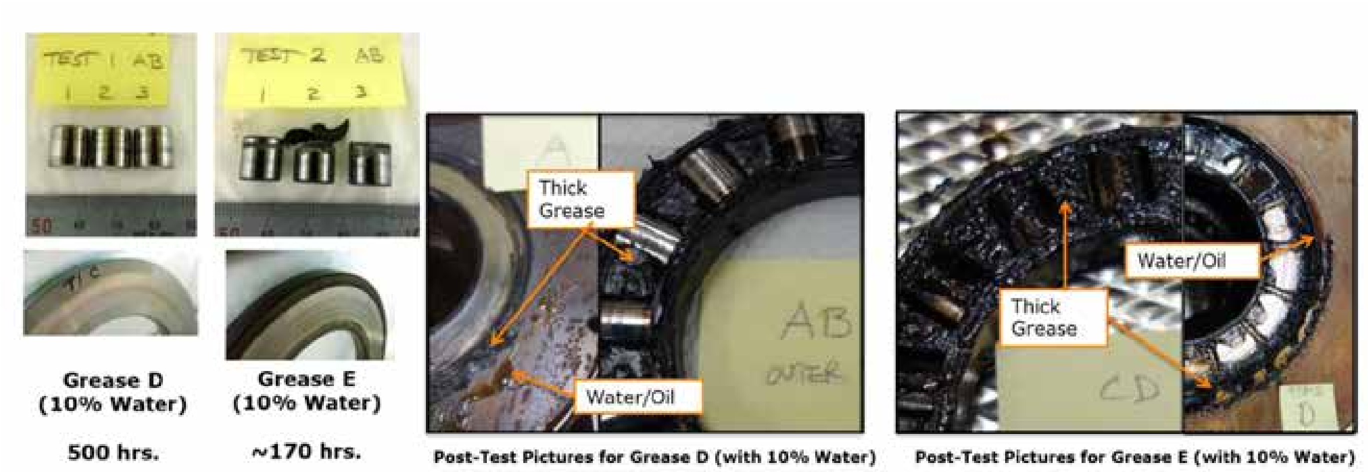


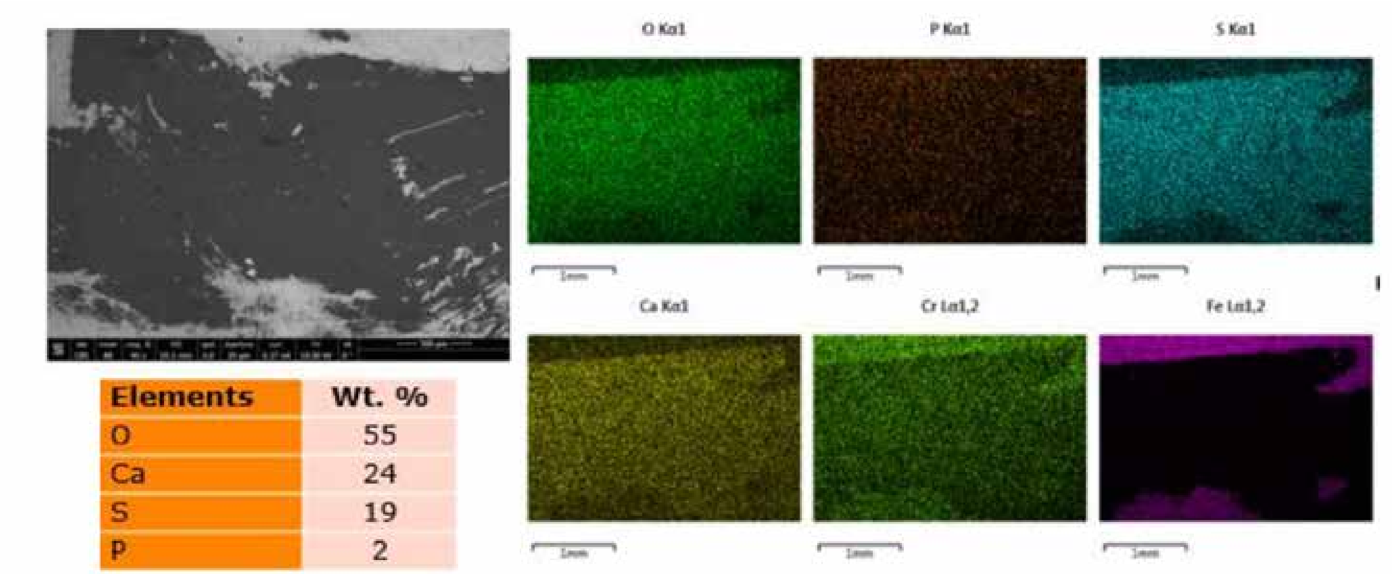
Figure 6. Roller and raceway conditions of post-test bearings and bearing test duration

Test methods/ Samples		Grease E (Fresh)	Grease E + 10% water (Post-test)	Grease D (Fresh)	Grease D + 10% water (Post-test)	Grease D + 0% water (Post-test)
Grease thickener		Aluminum Complex		Calcium Sulfonate		
Elemental Spectroscopy ASTM D5185 (PPM) / XRF	Fe	74	1,500	5	960	459
	Al	>1,000	>1,000			
	Ca			44,900	44,800	45,100
	Mg			841	848	605
	P	1,220	1,200	23	23	28
	Zn			28	24	24
	Mo	123	128	1,326	1,300	1,226
	Si	563	550	18	18	18
	B			570	575	580
	S	250	260	7,600	7,640	7,390
Water Content (ppm) ASTM D6304		729	9,000	3,009	60,000	2,500
Oil Bleed % ASTM D6184		3	0	0	0.6	1
NLGI Grade		2	3.5	2	1	1

Table 1. Lubricant analyses of post-test grease samples from bearing test

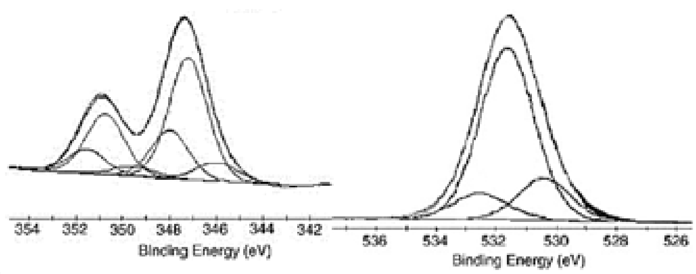
BEARING TEST – SURFACE ANALYSES

Scanning electron microscopy (SEM) was used to analyze the surfaces of rollers and raceways of bearings tested with Grease D mixed with 10% water. As shown in Figure 7, the elemental mapping of rollers and raceways confirmed the tribochemical film formation (calcium, sulfur) and presence of thickener in films formed on the mating surfaces of the bearings. Moreover, X-ray photoelectron spectroscopy (XPS) confirmed the presence of various calcium and oxygen compounds as presented in Figure 8. Thus, surface analysis confirmed the tribochemical film formation, and the contribution of the thickener to film formation, that contributed to excellent performance of Grease D under the influence of water.



Elements	Wt. %
O	55
Ca	24
S	19
P	2

Figure 7. SEM analysis of a bearing surface



Calcium:	Calcium (346), Calcium Carbonate (347) and Calcium Sulfonate (348)
Oxygen:	Iron oxides: Fe2O3 (530.5), hydroxides (531.75) and sulfates, sulfonate (532.5)

Figure 8. XPS data for a bearing surface

BENCH TEST

A bench test was conducted to evaluate wear and tribochemical films per ASTM D5707-18 “Standard Test Method for Measuring Friction and Wear Properties of Lubricating Grease Using a High Frequency, Linear-Oscillation (SRV) Test Machine”. The test parameters were: normal load 200 N (Max Hertz ~ 2.7 GPa), stroke length 1 mm, frequency 20 Hz, temperature 80 C, test duration five h (360,000 cycles), contact geometry 10 mm ball diameter (52100 steel) on flat disk (52100 steel), lubricant 0.1 ml of grease, and number of tests repeats four times for each grease type.

The wear was determined by measuring the diameter of the wear scar on the ball in the direction of sliding and perpendicular to the sliding direction. An elliptical wear area was calculated from the measured wear scar diameters. The wear was compared using the normalized wear area, which equals the measured elliptical wear area divided by the calculated Hertzian contact area.

Figure 9 shows that in the absence of water, the normalized wear for Grease D was less than half of the wear for Grease E. Thus, this result suggested that Grease D (calcium sulfonate) had better load carrying capability as well as higher wear-resistance than Grease E (aluminum complex).

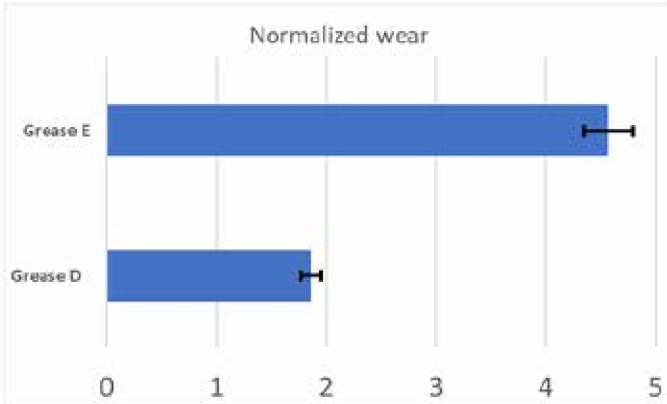
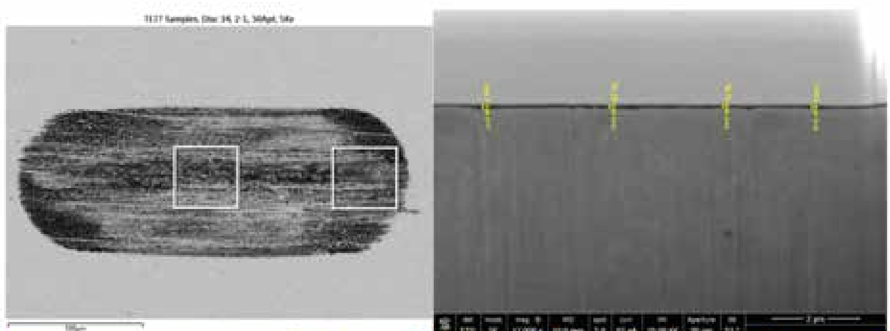


Figure 9. Normalized wear area of Grease D and Grease E

The SEM-EDS (energy dispersive spectroscopy) and FIB-SEM (focused ion beam) were conducted on Grease D. As presented in Figure 10; the tribochemical film had a contribution of thickener (calcium and sulfur). Moreover, a robust tribochemical film between 80 and 160 nm thick contributed to the excellent wear performance of Grease D.



	Fe	Ca	O	C	S
Grease D	60.7	17.1	13.8	5.7	2.8

Figure 10. SEM-EDS results for a bearing surface

FIELD TRIALS

The calcium sulfonate Grease D was evaluated in a field trial. Prior to this field trial, the customer reported scuffing and other damage on raceways. During this trial, Grease D, along with the correct selection of bearings and seals, provided many advantages over the former grease.

Figure 11. Grease D resulted in mild wear in a field trial

Correct selection of bearings, seals, and lubricant (Grease D) led to significant cost savings due to the following:

- Reduced the unplanned downtime;
- Only mild wear was observed on the raceways (Figure 11) instead of scuffing and other damage observed previously with Grease E.
- Increased the roll service life;
- Increased in the reclaim rate >3 times;
- Less corrosion occurrence;
- Lower operating temperatures, and thus, reduced power consumption;
- Lower bearing costs and lower cost of ownership;

Moreover, Table 2 shows that at the end of the field trial, Grease D had very similar elemental composition, water content, oil bleed properties, and NLGI grade to Grease D that was mixed with 10% water and tested with the FE8 rig. This shows the value of going beyond only reading the technical data sheets for a grease and evaluating the grease by running a test that simulates the application conditions.

Test methods/ Samples		Grease D (Fresh)	Grease D + 10% water (Post-test)	Grease D + 0% water (Post-test)	Grease D + Field trial (Post-trial)
Grease thickener		Calcium Sulfonate			
Elemental Spectroscopy ASTM D5185 (PPM) / XRF	Fe	5	960	459	1,160
	Al				
	Ca	44,900	44,800	45,100	45,000
	Mg	841	848	605	800
	P	23	23	28	28
	Zn	28	24	24	26
	Mo	1,326	1,300	1,226	1,200
	Si	18	18	18	18
	B	570	575	580	585
	S	7,600	7,640	7,390	7,870
Water Content (ppm) ASTM D6304		3,009	60,000	2,500	54,000
Oil Bleed % ASTM D6184		0	0.6	1	0.5
NLGI Grade		2	1	1	1

Table 2. Lubricant analyses of post-test grease samples from bearing test and field trial

TECHNIQUE TO ACCURATELY MEASURE WATER CONTENT IN GREASES

For this study, it was necessary to measure the moisture content of grease samples. The grease samples all had similar viscosity, texture, and thickness, but varied in color from bright red to dark grey and black. The water content varied significantly among the grease samples. The goals were:

- Develop a routine procedure for measuring moisture content, ranging from a few hundred ppm to over 10%, in grease samples;
- The procedure must produce accurate and repeatable results.
- The procedure needs to be efficient and easy to perform in the lab.

To reach these goals, it was determined that ppm accuracy was needed, and that the use of Karl Fischer moisture testing would be required. Volumetric Karl Fischer methodology was considered initially, but it was determined that the moisture levels below 2% would be difficult to measure with accuracy and repeatability. Because most grease samples contained well below 2% moisture, and only a few had higher moisture content (between 8 and 10%), it was decided that a coulometric Karl Fischer titration system with a correct configuration could work.

First attempt using volumetric Karl Fischer and direct injection into the titration cell

The first set of attempts at using the volumetric Karl Fischer method were limited. It was difficult to measure low-level moisture content (under 1%) with accuracy and with good repeatability. Moreover, changing the composition of the Karl Fischer reagent to address samples with various moisture contents, which ranged from under 1% to over 10%, was time-consuming and not very efficient.

Second attempt using coulometric Karl Fischer and direct injection into the titration cell

The second set of attempts used the coulometric Karl Fischer method via direct injection of the sample. This approach required filling a syringe with a grease sample and then injecting the sample through a 16-gauge needle into the titration cell. The titration cell configuration included a 2-component setup using Coulomat AG as the anolyte and Coulomat CG as the catholyte. It quickly became apparent that keeping the titration cell clean would be problematic due to small, medium, and large pieces of grease floating in the titration cell. Some grease clogged the inner burette and coated the detector electrode; this was a messy problem. Results were inconsistent and, in most cases, caused over titration. Using a cosolvent such as xylene did not prove to be a feasible option due to the various sample types and moisture content ranges.

- A simple solubility solution did not work uniformly for all the samples.
- Reducing the amount of anolyte in the titration cell to make room for a cosolvent limited the ability to test samples with higher moisture content.

Sample	Grease A	Grease B	Grease C	Grease D	Grease E
Thickener	Lithium Complex	Lithium Complex	Calcium Sulfonate	Calcium Sulfonate	Calcium Sulfonate
Test 1	878	58	3345	9010	Over Titration
Test 2	Over Titration	2234	Over Titration	5930	8998
Test 3	1976	Over Titration	Over Titration	Over Titration	4438

Table 3. Water content in the greases (ppm)

After repeated attempts to standardize a procedure using the direct injection method, it was determined that test procedures varied from sample to sample. The variability of the samples' moisture content and solubility made it difficult to maintain the titration cell for conducting tests on different samples.

Third attempt using a coulombic Karl Fischer titrator and an evaporator oven

The third set of attempts used a solids evaporator oven, which heats a sample to evaporate moisture that is carried by nitrogen gas into the Karl Fischer titrator. There are several advantages to this method:

- The nitrogen gas flow from the evaporator carries over the moisture from the sample via heated tubing, through a bubbler tube, and into the titration cell.
- No grease sample debris gets into the titration cell. This keeps the titration cell clean and ready for repeated tests.
- Only introducing small amounts of moisture into the titration cell helps maximize the finite measurability of the reagents themselves. The titration cell does not get filled up with sample material and, therefore, this reduces the waste of the reagents.

Two conditions that needed to be determined were the required temperature for the evaporator oven and the grease sample size.

Temperature

When using the evaporator, it is important to set the oven to the correct temperature in order to ensure that all the moisture is released from the grease sample. A temperature that is too high will ensure that the moisture is released, but it will also produce unnecessary heat and cause the sample to burn and bubble excessively. At lower temperatures, the sample may not release all of its moisture, producing an erroneously low moisture reading. To determine the correct temperature, an evaluation of the moisture curves was conducted. In general, results are most accurate when the curve shows that the evaporator drives off moisture quickly and there is a sloping moisture curve with a long tail—watching how the temperature affects the sample and analyzing the moisture curve assists in choosing the appropriate temperature. It was determined that a temperature of 165 C produced good results for the greases in this study.

Sample size

An estimated sample size of approximately 1 g produced good accuracy and repeatability. Smaller sample sizes produced more variability, regardless of moisture content. Larger sample sizes increased the accuracy and repeatability, but increased the test duration and used more of the reagent's useful life.

Once the temperature and sample size were determined, a procedure was established. To increase throughput and reduce time cleaning equipment, disposable aluminum foil inserts were used in conjunction with the glass sample boats.

In this study, the procedure began with taring the mass of the glass sample boat with an aluminum foil insert. Adding the sticky grease sample into the sample boat while on the analytical balance using a cotton-tipped swab worked effectively. Once the added sample was added to the sample boat, the mass was recorded or transmitted, if the analytical balance was directly connected with the Karl Fischer titrator.

The sample boat with the grease sample was transferred into the heater tube in the evaporator. The evaporator oven heated the grease sample to the point where the moisture evaporated from the sample and was carried by flowing nitrogen gas through a heated tube into the reagent inside the titration cell. Since only moisture was delivered, the titration cell stayed clean. The detector electrode recognized the water molecules and performed the normal coulometric Karl Fischer process.

Results

The evaporator oven, in conjunction with the coulometric Karl Fischer titrator, provided a uniform method for testing grease samples that had wide-ranging moisture content and solubility requirements. Repeated testing showed that tests could be performed one after another with good accuracy and repeatability. Using disposable aluminum sample boats made it easy to load new samples and dispose of messy grease samples after testing was completed.

CONCLUSIONS

An investigation was conducted on grease selection for work roll bearings. The conducted studies went beyond the information contained in the technical data sheets for two greases. The customer was given a correct grease recommendation that led to significant cost savings.

Key technical lessons were learned:

- An aluminum complex grease was not compatible with water.
    - It was very difficult to mix an aluminum complex grease and water. It was possible to only mix 6.7% water with this grease instead of the target 10% water.
    - Mixing water with this aluminum complex grease was detrimental to bearing lubrication, and thus, bearing life.
    - The FE8 test rig with aluminum complex greases ran ~170 h instead of the expected 500 h because the bearing rollers broke. During testing, water migrated out of the aluminum complex grease along with the base oil, so the grease dried up and the bearings were unable to run.
- Both a calcium sulfonate grease (with 10% water) and the aluminum complex grease (with 6.7% water) allowed wear on the rollers in FE8 testing. Water should be avoided in bearing applications, but if unavoidable, grease selection should take into consideration the grease compatibility with water.
- Calcium sulfonate grease with a molybdenum disulfide additive outperformed an aluminum-based grease under water-contamination conditions. Calcium sulfonate grease formed a tribochemical film that contained thickener (calcium and sulfur) and was between 80 and 160 nm thick. This tribochemical film contributed to the excellent wear performance of the calcium sulfonate grease. This, calcium sulfonate thickener-based grease with molybdenum disulfide is recommended for use in caster bearings.
- The selection of grease for an application should involve more than reading the technical datasheets. It is important to run a relevant test that simulates the application conditions before selecting a grease.
- A methodical process was developed to accurately measure water content in greases. The evaporator oven in conjunction with the coulometric Karl Fischer titrator, provided a uniform method for testing samples that had wide-ranging moisture content and solubility requirements with good accuracy and repeatability.

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Tribological Performance of a Novel Molybdenum Dithiocarbamate Compound in Greases Studied by Four-Ball, SRV and MTM Methods

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ABSTRACT

Four-ball wear and extreme pressure (EP), oscillating friction and wear (SRV) and Mini-Traction Machine (MTM) methods were employed to evaluate the tribological performance of a molybdenum dithiocarbamate (MoDTC) compound in lithium complex, polyurea and calcium sulfonate complex greases. This MoDTC compound is a novel liquid with highly-branched alkyl groups and a highly-sulfurized core (HBHS-MoDTC). The experimental data indicated that HBHS-MoDTC exhibited friction-reducing properties in greases tested by all three methods, especially at higher temperatures. Tests were performed by running an MTM at different speeds, slide-to-roll ratios (SRR) and temperatures to observe the friction behavior of HBHS-MoDTC in lithium complex grease. MTM data indicated that higher speeds, higher SRRs and higher temperatures activated HBHS-MoDTC's friction-reducing function. This meant that HBHS-MoDTC showed potential as an additive to improve grease's tribological performance under relatively severe operational conditions.

KEYWORDS: Grease, Molybdenum Dithiocarbamate, Friction, Wear, Friction Modifier, Mini-Traction Machine

1 INTRODUCTION

Environmental protection, energy savings and high efficiency are key drivers for upgrading lubricants. Molybdenum dithiocarbamate (MoDTC) is a well-established phosphorus-free additive technology used in lubricating oils and greases to reduce friction, improve energy efficiency and prevent wear. In the mixed to boundary lubrication regimes, use of MoDTC additives can result in a very low friction coefficient, around 0.05, making it a very effective friction modifier and an essential component of current lubricants such as engine oils and CVJ greases [1-9] (additional references cited by Fish [8] and Ward [9]). Its effectiveness in friction reduction comes primarily from forming an MoS_2-containing tribofilm on the rubbing surfaces. The layered-lattice structure of MoS_2 contributes to low friction. In MoS_2, there is powerful covalent bonding between atomic species, but only very weak Van der Waals attractions between layers in the lattice. The weak Van der Waals forces between MoS_2 layers allow for easy shearing to occur within the tribofilm, which is responsible for the low-friction properties [10].

MoDTC compounds can vary chemically due to differences in the degree of sulfurization and types of amines used in their preparation. These subtle chemical differences can affect the tribological performance of MoDTC compounds and their compatibility with base oils. In 2015, Patel et al. [11] reported that a novel MoDTC with highly-branched alkyl groups and a highly-sulfurized core showed performance advantages over a typical MoDTC (no branching, lower S/Mo ratio) as a lubricant additive:

(1) Improved low-temperature solubility in highly hydro-treated mineral oil and polyalphaolefin (PAO) oil;
(2) Better friction-reducing (FR) performance at low treat level and lower activation temperature; and
(3) Better FR retention capability and the formation of a stronger tribochemical film.

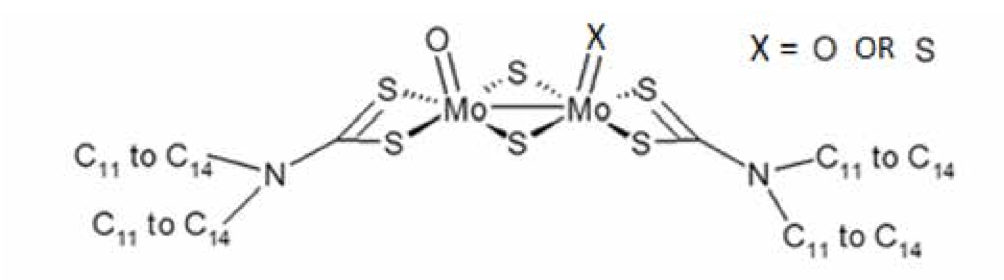
The present study evaluated this novel MoDTC with highly branched alkyl groups and a highly sulfurized core, here abbreviated as HBHS-MoDTC, in one base oil and several greases. The friction performance and the favorable tribological conditions for this additive are discussed in this paper.

2 EXPERIMENTAL MATERIALS AND METHODS

2.1 Base Oil, Greases and Additives

The lubricating oil used in this study was 150N Group II. The lubricating base greases included a lithium complex grease, a polyurea grease and a complex calcium sulfonate grease. All three base greases were obtained from real production batches.

The HBHS-MoDTC was synthesized from a highly-branched and symmetrical amine and has a highly-sulfurized core. This liquid HBHS-MoDTC additive contained 10.2% molybdenum and 11.4% sulfur with the atomic ratio of S/Mo 3.35 (compared to S/M 3.00 in traditional MoDTC compounds). The chemical structure of HBHS-MoDTC can be described as follows:



2.2 Four-Ball Wear Tests

The standard four-ball wear test methods ASTM D2266 for grease and D4172 for oil were used to evaluate additive performance. Experimental conditions were: 20, 30 and 40 kgf loads, 1200 r/min speed, 60 min and 75 C. Real-time recording of the coefficient of friction during the test was performed with the frictional force sensor on the specific four-ball test machine used, in addition to the measurement of wear scar diameters.

2.3 Four-Ball EP test

The standard ASTM D2596 four-ball extreme pressure (EP) test method was used to evaluate additive EP performance in greases. Experimental conditions were 1770 r/min speed and 10 sec time duration. Both last non-seizure load (LNSL) and weld point were measured.

2.4 MTM Stribeck Curve

A Mini Traction Machine (MTM) was used to evaluate frictional characteristics of lubricants in boundary and mixed lubrication regimes (Stribeck Curve) with a ball-on-disc configuration. A rotating 52100 steel ball was pressed against an independently rotating 52100 steel disc immersed in the grease. The operating conditions were set by independently controlling the rotational velocities of the shafts that drove the ball and the disc, in order to obtain a particular combination of rolling speed and SRR, as well as by controlling the contact force and the oil bath temperature. The test conditions were 35 N load (equivalent to 1 GPa Hertzian point contact load) and 50% SRR. Stribeck Curves were generated at 40, 60, 80, 100, 120 and 140 C. Mean speed was started at 1000 mm/s, then decreased in steps of 100 mm/s down to 100 mm/s, and finally, decreased in steps of 10 mm/s down to 10 mm/s. The operation scheme of the MTM is illustrated in Figure 1.

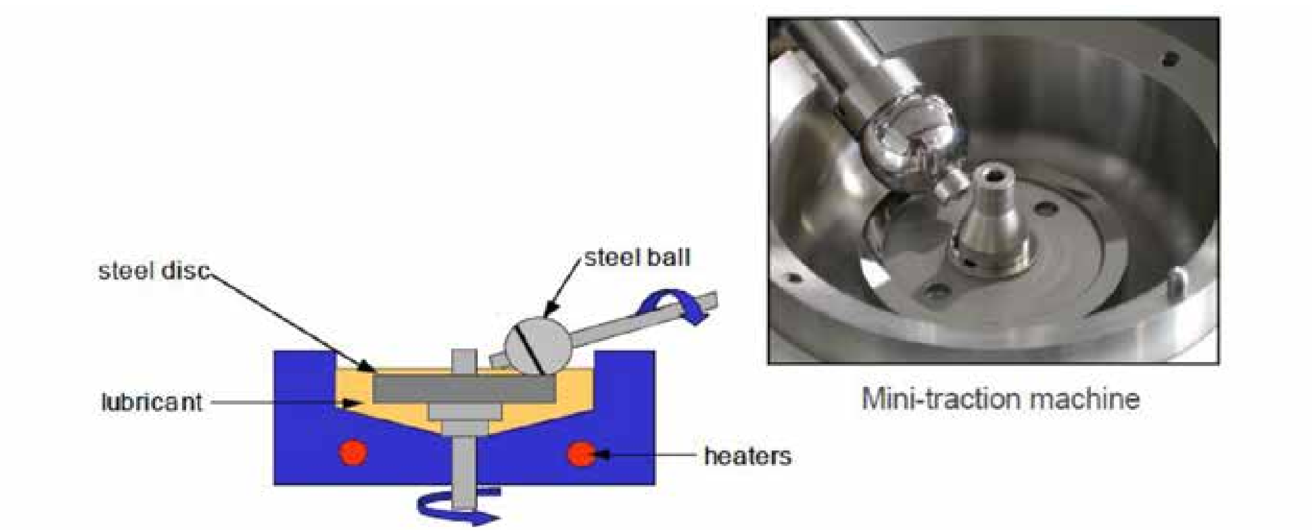


Figure 1. MTM work scheme

2.5 MTM Step Test

High speeds can help lubricating oil to wedge effectively into tribological contacts and, therefore, improve the lubrication status, even to reach fluid film lubrication. But for highly viscous, semi-solid greases, there is always a great challenge in tribological design whether or not the grease can effectively wedge into the frictional contacts, especially at high speeds. In this study, the above test profile for oil was used to test greases. But the grease tests failed due to sudden increases in high friction caused by starvation of the grease between the ball and the disc at high speeds. Obviously, it is very difficult for the MTM to run the grease Stribeck test for short-time contact and continuously changing speed. Thus, in this study, an MTM step test was run to evaluate grease's friction properties with and without HBHS-MoDTC under specific tribological conditions, such as different temperatures, speeds and SRRs.

The MTM step test conditions were: 35 N load, temperatures of 60 and 120 C, 50% SRR (half sliding and half rolling) and 200% SRR (pure sliding), speeds of 100, 500, 650 and 800 mm/s and test duration of 60 min.

2.6 SRV Test

According to the ASTM D5707 test method, the lubricating grease's coefficient of friction under high frequency and linear oscillation motion was determined using an oscillating friction and wear (SRV) test machine at a test load of 200 N, frequency of 50 Hz, stroke amplitude of 1.00 mm, duration of 60 min and temperatures of 50 and 80 C.

3 RESULTS AND DISCUSSION

3.1 Tribological Performance in Base Oil by Four-Ball Tests

First, 0.8% HBHS-MoDTC (800 ppm Mo) was added to the 150N Group II base oil, and the tribological performance was evaluated by four-ball tests. The experimental results are given in Table 1.

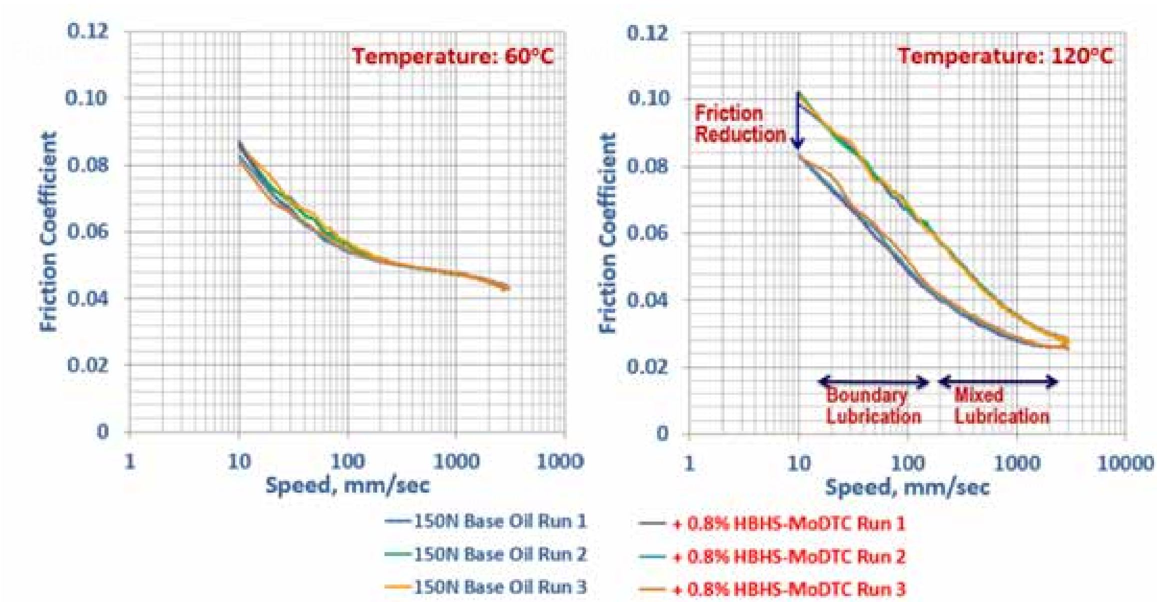
Table 1. The EP, AW and FR Performance of HBHS-MoDTC in Group II Base Oil by Four-Ball Tests

	Wear scar diameter, mm			Average friction coefficient			Last non-seizure load, kgf
	20 kgf	30 kgf	40 kgf	20 kgf	30 kgf	40 kgf	
150N Group II base oil	0.599	0.666	fail	0.117	0.108	fail	32
+ 0.8% HBHS-MoDTC	0.469	0.504	0.514	0.074	0.079	0.073	80

It can be seen from Table 1 that HBHS-MoDTC reduced friction and wear scar diameters in the base oil. It also increased the last non-seizure load of the oil,, which implied that stronger tribochemical films were produced on the rubbing surfaces.

3.2 Tribological Performance in Base Oil by MTM

Second, 0.8% HBHS-MoDTC was added to the 150N Group II base oil, and the frictional properties under slide-roll conditions were evaluated using an MTM at 40, 60, 80, 100, 120 and 140 C. The Stribeck Curves at 60 and 120 C are given in Figure 2 as the representatives at low and high temperatures, respectively.



From Figure 2, it can be seen that the temperature was a key factor for HBHS-MoDTC to develop its

FR performance in the oil. At the lower temperature (60 C), an obvious FR characteristic by HBHS-MoDTC was not visible, but at the higher temperature (120 C), HBHS-MoDTC exhibited excellent FR properties under both mixed lubrication and boundary lubrication conditions. Judging from the friction coefficients, it seems that the mixed lubrication regime of the oil containing 800 ppm Mo was from 1000 to 100 mm/ under these MTM conditions.

3.3 Tribological Performance by Greases in Four-Ball Tests

In the next part of this study, 1.0 or 2.0% of HBHS-MoDTC was added to lithium complex, polyurea and calcium sulfonate complex base greases, and the tribological performance was evaluated by four-ball tests. The experimental results are given in Table 2.

Table 2. The EP, AW and FR Performance of HBHS-MoDTC in Greases by Four-Ball Tests

	Wear Test (40 kgf, 1200 rpm, 75 C, 60 min)		EP Test	
	Wear Scar, mm	Average Friction Coefficient	LNSL, kgf	Weld load, kgf
Lithium Complex Base Grease	0.588	0.099	80	250
+ 1.0% HBHS-MoDTC	**0.469**	0.081	100	250
+ 2.0% HBHS-MoDTC	**0.445**	**0.074**	100	250
Polyurea Base Grease	0.647	0.094	100	200
+ 1.0% HBHS-MoDTC	**0.524**	**0.072**	100	200
+ 2.0% HBHS-MoDTC	**0.515**	**0.071**	100	200
Calcium Sulfonate Complex Base Grease	0.375	0.098	100	315
+ 1.0% HBHS-MoDTC	0.348	**0.076**	100	400
+ 2.0% HBHS-MoDTC	0.367	0.082	126	400

The stated repeatability for ASTM D2266 is 0.2 mm. According to this criterion, HBHS-MoDTC did not have a statistically significant effect on wear scar diameters for the three greases in Table 2. Figure 3 shows the wear scars and the topography of the ball surfaces for the lithium complex greases, with and without HBHS-MoDTC. According to criteria from ASTM D5183, differences in the average friction coefficients in Table 2 do not guarantee that HBHS-MoDTC significantly reduced friction in this study. The friction curves for the lithium complex greases and the polyurea greases, with and without HBHS-MoDTC, are illustrated in Figures 4 and 5, where the friction fluctuations can be observed.

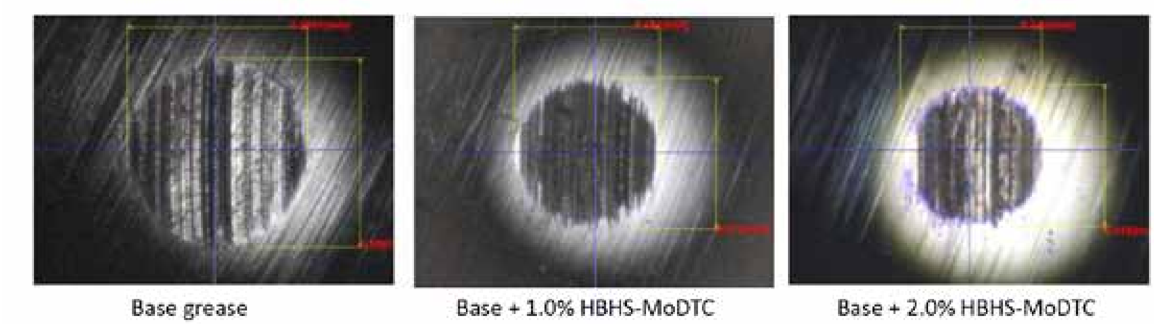


Figure 3. Wear scars for lithium complex greases from four-ball tests

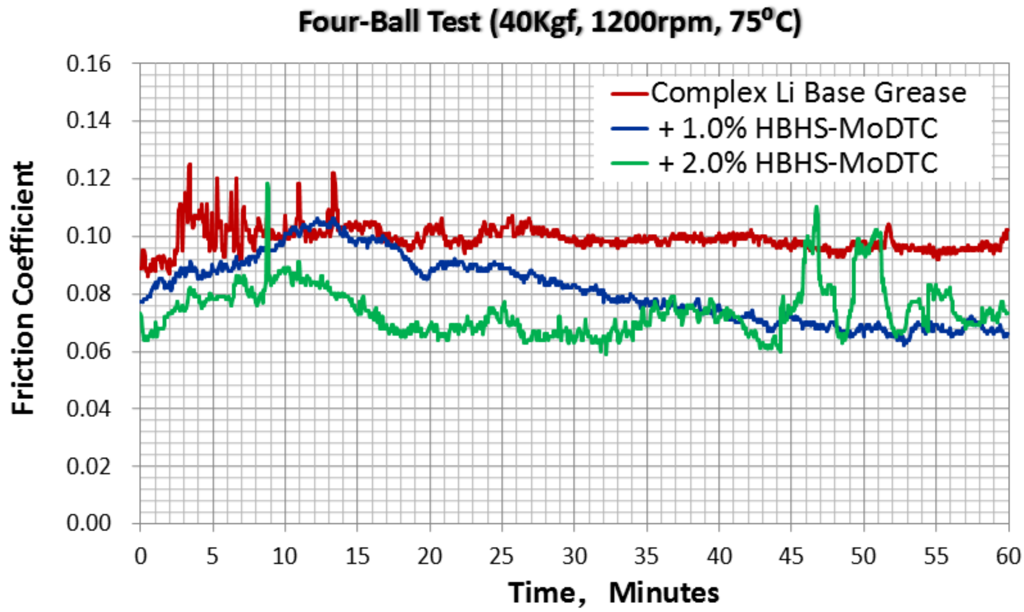


Figure 4. Friction data for the lithium complex grease, with and without HBHS-MoDTC, by four-ball tests

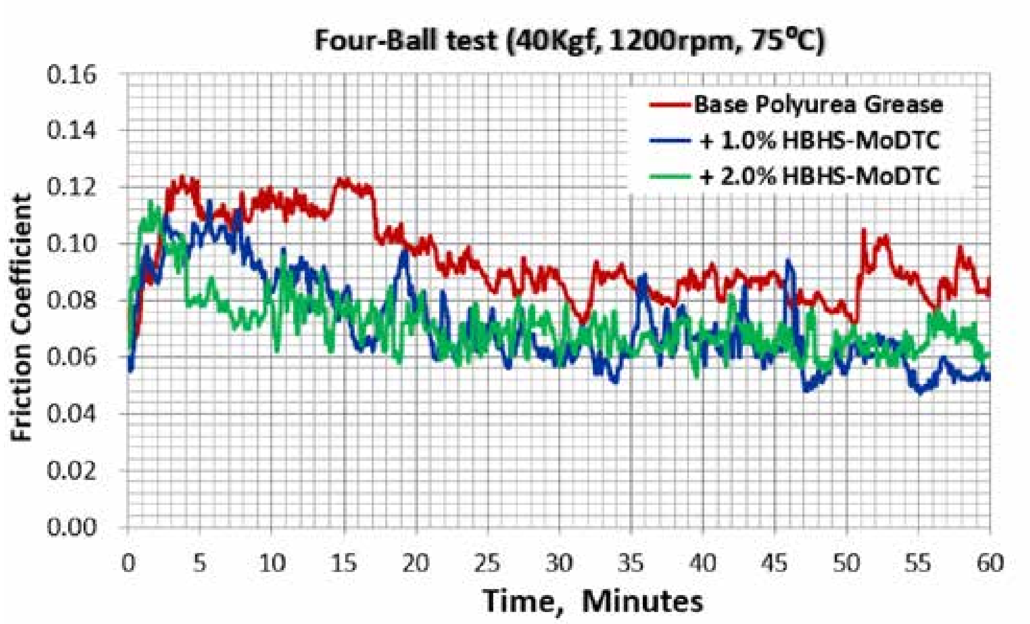


Figure 5. The FR performance of the polyurea grease, with and without HBHS-MoDTC, by four-ball tests

Considering the experimental data given in Table 2 and Figures 3, 4 and 5, the HBHS-MoDTC may have somewhat improved the overall tribological performances of the lithium complex and polyurea greases.

3.4 SRV Grease Test

Next, 1.0 or 2.0% HBHS-MoDTC was added to lithium complex, polyurea and calcium sulfonate complex base greases, and the friction behaviors were evaluated by the SRV test at 50 and 80 C. The friction curves of the lithium complex grease, with and without HBHS-MoDTC, are illustrated in Figure 6.

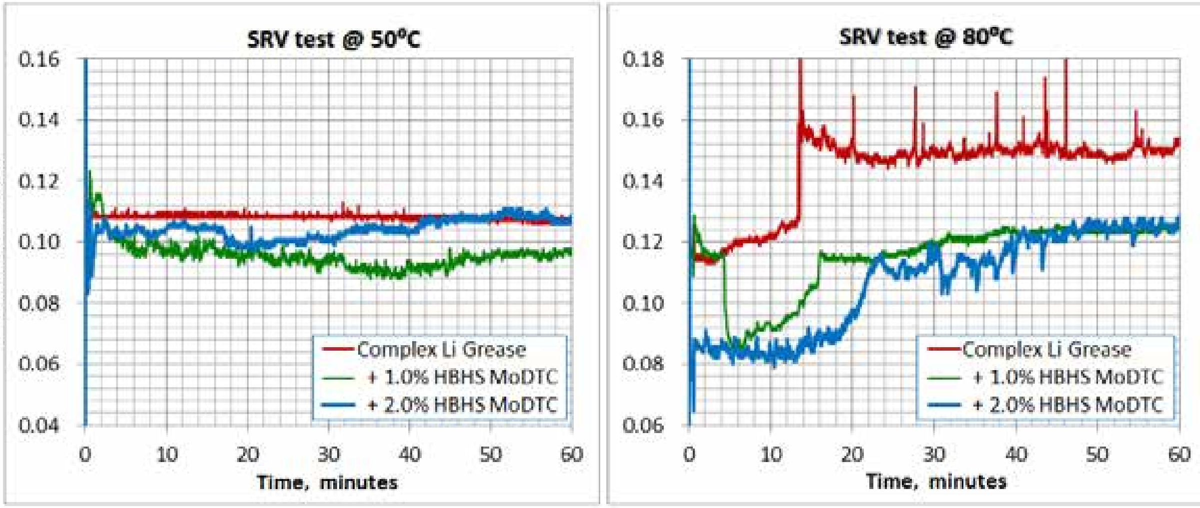


Figure 6. The friction curves of the lithium complex grease, with and without HBHS-MoDTC, by SRV tests

From Figure 6, it was found that, in the lithium complex grease at the lower temperature, i.e., 50 C, HBHS-MoDTC did not exhibit obvious friction-reducing properties. However, at the higher temperature, i.e., 80 C, HBHS-MoDTC demonstrated somewhat better friction-reducing capacity than at 50 C.

The friction curves of the polyurea grease, with and without HBHS-MoDTC, at both 50 and 80 C, are illustrated in Figure 7.

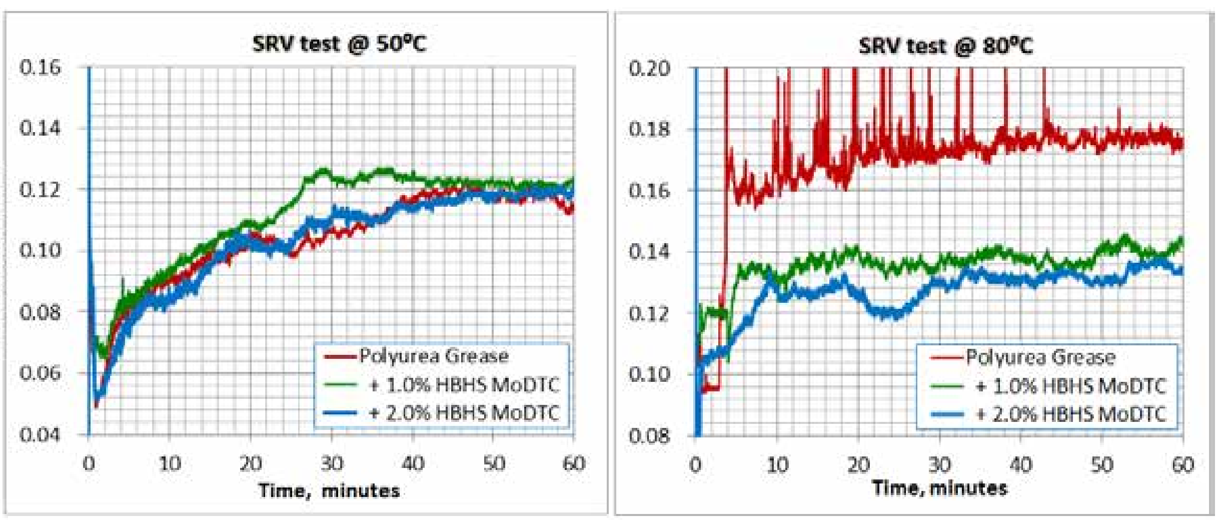


Figure 7. The friction curves of the polyurea grease, with and without HBHS-MoDTC, by SRV tests

It was found from Figure 7 that for the polyurea grease at the lower temperature, i.e., 50 C, HBHS-MoDTC did not exhibit obvious friction-reducing properties. However, at the higher temperature, i.e., 80 C, HBHS-MoDTC demonstrated better friction-reducing capacity than at 50 C.

The friction curves of the calcium sulfonate complex grease, with and without HBHS-MoDTC, at both 50 and 80 C are illustrated in Figure 8.

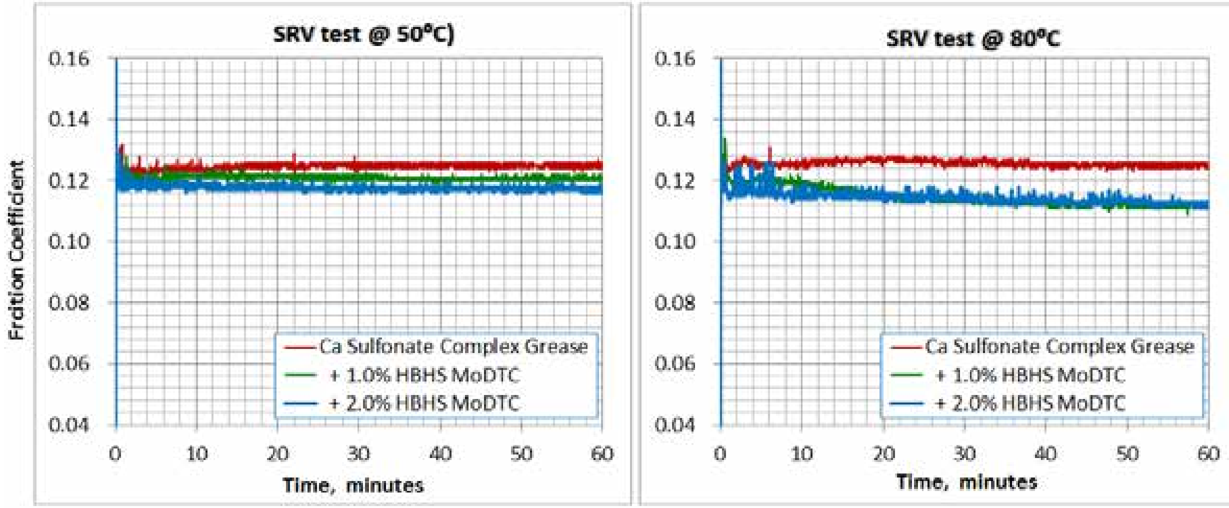


Figure 8. The friction curves of the calcium sulfonate complex grease, with and without HBHS-MoDTC, by SRV tests

In Figure 8, it appeared that HBHS-MoDTC slightly reduced the friction of the calcium sulfonate complex grease at 80 C and had a smaller effect at 50 C.

From all the SRV friction data, it was concluded that the higher temperature (80 C) made it possible for HBHS-MoDTC to reduce friction in greases under boundary lubrication conditions.

3.5 MTM Step Test for Grease

In this study, grease starvation occurred between the ball and the disc due to short-time contacts and continuously changing speed with the test profile used for oil. As a result, there were sudden increases in friction, so it was almost impossible to use that profile to run grease Stribeck tests with the MTM. Therefore, a series of timed step tests at different temperatures, speeds and SRR conditions was used instead to measure friction. The effects of temperature, speed and SRR on the performance of the lithium complex grease, with and without 2.0% HSHB-MoDTC, were evaluated. The effect of temperature under the given contact conditions is illustrated in Figure 9.

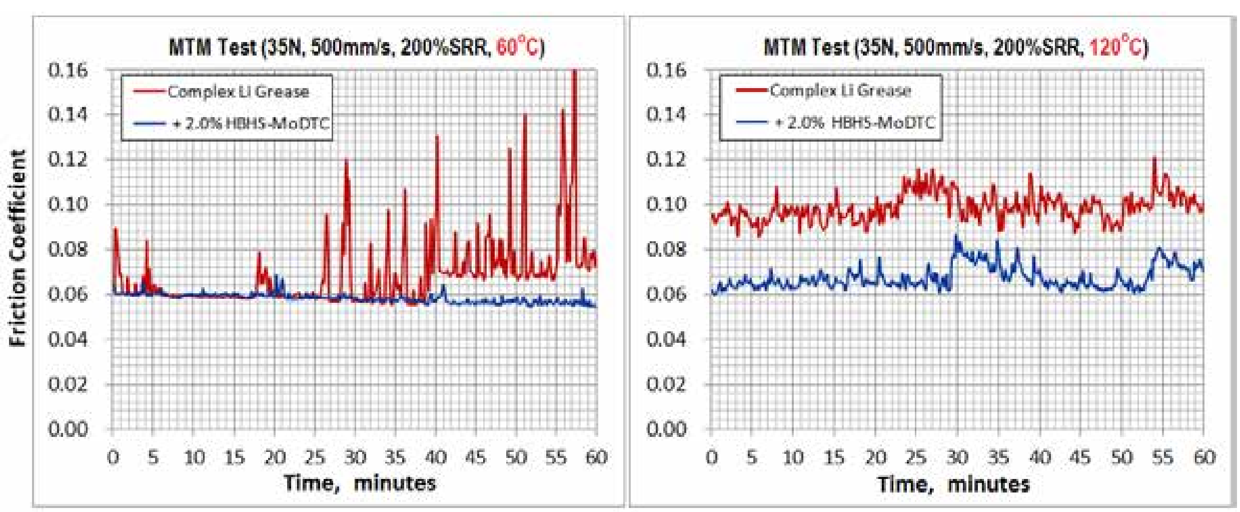


Figure 9. The effect of temperature on the FR performance of the lithium complex grease, with and without HBHS-MoDTC, in MTM step tests

From Figure 9, it can be seen that HBHS-MoDTC did not reduce the friction at the lower temperature (60 C), although it did eliminate the very sharp spikes in friction. At the higher temperature (120 C), HBHS-MoDTC reduced the friction significantly. Thus, as in Figures 3 and 6, the temperature played a crucial role for HBHS-MoDTC to develop its FR performance in lubricants.

The effect of speed is illustrated in Figures 9 and 10. For the given contact conditions, at the lower speed (100 mm/s, Figure 10, left), HBHS-MoDTC did not reduce the friction in the lithium complex grease. But at the higher speeds (500 mm/s, Figure 9, right and 800 mm/s, Figure 10, right), HBHS-MoDTC reduced the friction relative to the base grease. Friction data at 500 mm/s (Figure 9, right) and 800 mm/s (Figure 10, right), all at 120 C, appeared relatively similar, possibly because fluid film lubrication took place. At 100 mm/s (Figure 10, left), the grease may have been in mixed lubrication mode.

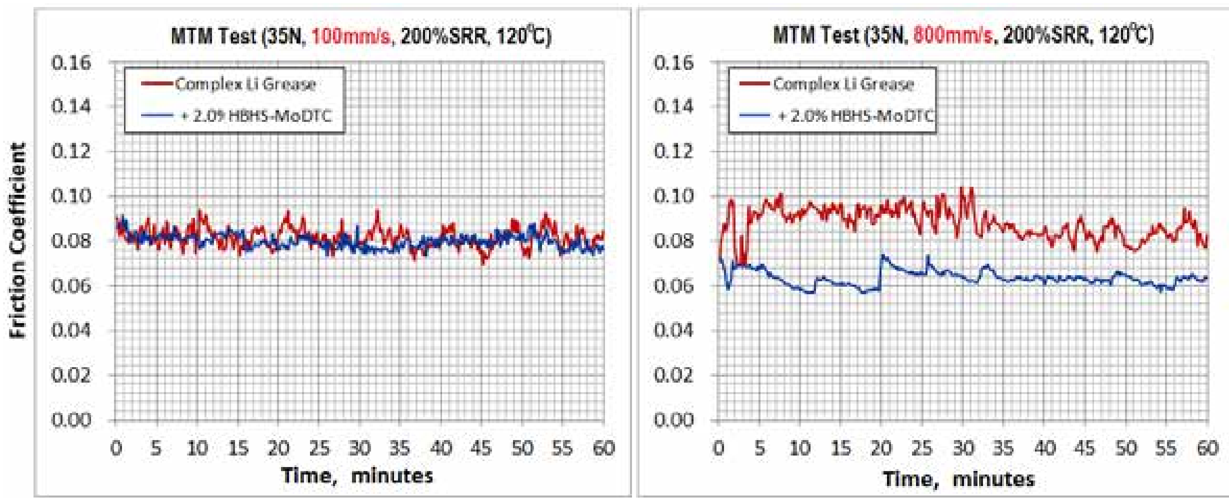


Figure 10. The effect of speed on the FR performance of the lithium complex grease, with and without HBHS-MoDTC, in MTM step tests

The effect of the SRR on the friction behavior of the greases, with and without HBHS-MoDTC, was also evaluated by the MTM step test, Figure 11. For the given contact conditions under 50% SRR (half sliding and half rolling), there was almost no evidence that HBHS-MoDTC reduced friction. But under 200% SRR (pure sliding), HBHS-MoDTC clearly decreased the friction coefficient. Thus, sliding was another favorable factor for HBHS-MoDTC to develop good friction-reducing performance in the grease. Of course, the increase in sliding caused an increase in contact temperature, which was consistent with the observation that the FR performance of the HBHS MODTC was significantly temperature dependent.

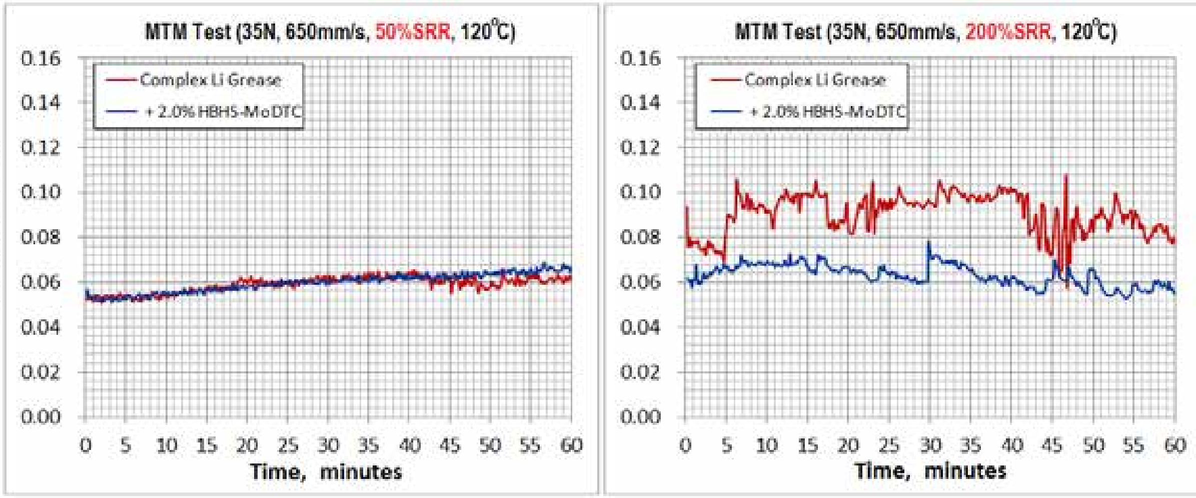


Figure 11. The effect of SRR on the FR performance of the lithium complex grease, with and without HBHS-MoDTC, in MTM step tests

Table 3 summarizes results from the series of MTM step tests for lithium complex grease, with and without HBHS-MoDTC.

Table 3. The Effect of Speed, SRR and Temperature on HBHS-MoDTC's Friction-Reducing Properties in Lithium Complex Grease by MTM Step Tests

Speed mm/s	SRR %	Temp. C	Average Friction Coefficient: Complex Li Grease	Average Friction Coefficient: +2.0% HBHS-MoDTC	Friction Reduction, %
100	50	60	0.0553	0.0588	- 6.33%
		120	0.0421	0.0427	- 0.06%
	200	60	0.0791	0.0815	- 3.03%
		120	0.0818	0.0780	4.65%
500 (Test Twice)	50	60	0.0613 (0.0592, 0.0634)	0.0644 (0.0646, 0.0641)	- 0.51%
		120	0.0552 (0.0490, 0.0613)	0.0550 (00570, 0.0531)	0.36%
	200	60	0.0646 (0.0692, 0.0600)	0.0633 (0.0581, 0.0684)	2.01%
		120	0.0961 (0.0992, 0.0929)	0.0709 (0.0678, 0.0740)	26.22%
650	50	60	0.0634	0.0668	-5.36%
		120	0.0591	0.0602	- 1.86%
	200	60	0.0583	0.0538	7.72%
		120	0.0895	0.0627	29.94%
800	50	60	0.0687	0.0594	13.54%
		120	0.0735	0.0548	25.44%
	200	60	0.0698	0.0643	7.88%
		120	0.0876	0.0640	26.94%

The data in Table 3 are illustrated in bar charts, Figure 12. The effects of speed, SRR and temperature on HBHS-MoDTC's anti-friction capabilities in grease can be concluded from Figure 12.

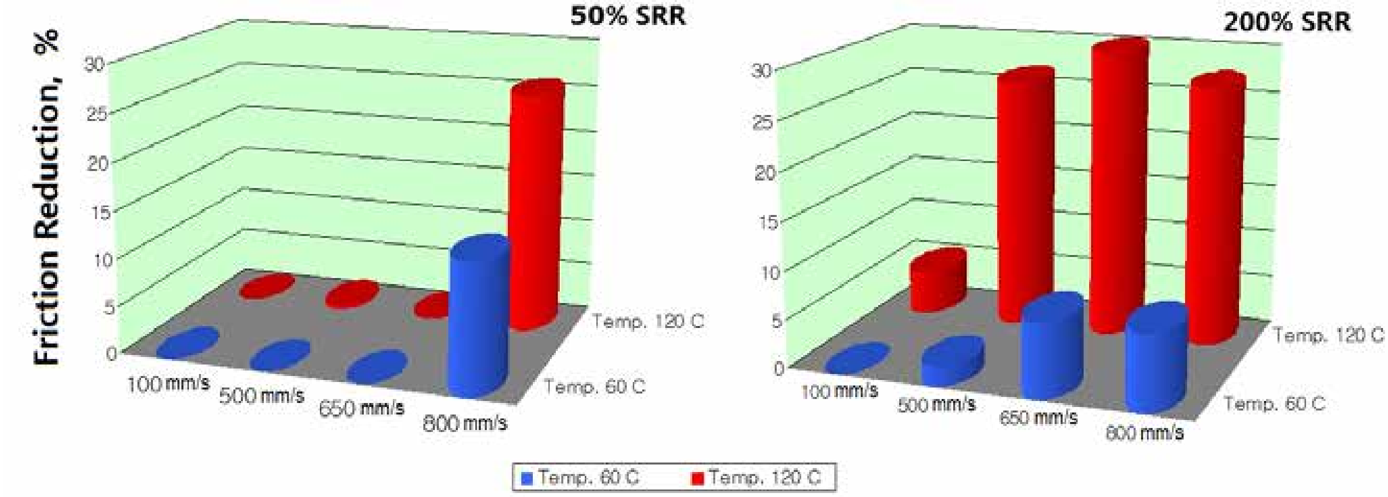


Figure 12. The effects of speed, SRR and temperature on the FR performance of the lithium complex grease containing HBHS-MoDTC in MTM step tests

It can be seen in Figure 12 that higher speed, higher SRR and higher temperature significantly promoted the FR performance of HBHS-MoDTC in the lithium complex grease. It seems that these conditions favored formation of an MoS2 film under boundary lubrication conditions. These three factors (higher speed, higher SRR and higher temperature), as individual parameters and in combination, helped MoDTC reduce friction in grease. For example, in Figure 12, even at the lower temperature (60 C), the higher speed and/or higher SRR made it possible for MoDTC to work effectively in the grease as a friction modifier.

4 CONCLUSIONS

(1) Four-ball tests indicated that HBHS-MoDTC tended to reduce friction in lithium complex and polyurea greases.
(2) MTM Stribeck Curve testing indicated that HBHS-MoDTC reduced the friction of lithium complex base grease under boundary and mixed lubrication conditions at 120 C.
(3) In MTM-step tests, higher speed, higher SRR and higher temperature significantly promoted the friction-reducing performance of HBHS-MoDTC in greases.

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Industry Calendar of Events 2020/2021

Please contact Denise if there are meetings/conventions you'd like to add to our Industry Calendar, denise@nlgi.org
(Your company does not have to be an NLGI membeer to post calendar items.)

ELGI 32nd Annual General Meeting	**Apr 24 – 27, 2021**	Hamburg, Germany	http://www.elgi.org
ELGI Working Group Meeting	**April 25, 2021**	Hamburg, Germany	http://www.elgi.org
2nd ELGI-STLE Tribology Exchange Workshop	**Apr 28 – 29, 2021**	http://www.elgi.org	http://www.stle.org
75th STLE Annual Meeting & Exhibition	**May 16 – 20, 2021**	New Orleans, LA	www.stle.org
NLGI 88th Annual Meeting	**June 13 – 16, 2021**	Napa, CA	www.nlgi.org

Warm Welcome to our New NLGI Members

Old World Industries, LLC	**Savant Labs**	**Security Oil, LLC**
Marketing Low	*Supplier*	*Marketing Low*
USA	**USA**	**USA**

Advertiser's Index

NLGI Interviews Mr. Sudhir Sachdeva
Managing Director
Siddharth Grease & Lubes Pvt. Ltd.
Gurugram (Gurgaon), India

By Mary Moon and Raj Shah
All photographs courtesy of Siddhartha Grease & Lubes Pvt. Ltd.

At the headquarters of Siddharth Grease & Lubes, the Milestone Wall, a collection of photos, press releases, and memorabilia, chronologically depicts the journey of SGL since its inception, thus far. In this interview, the founder and current Managing Director, Mr. Sudhir Sachdeva, shared his insights about developing and managing his Company as well as his perspectives on customers, R&D and philosophy, family and travel. His projections about the future of the grease industry in India and worldwide may foreshadow new additions to the Milestone Wall. To learn more, read on!

NLGI: Please tell us a little bit about where you grew up and your education.

SS: Mine is a story of humble beginnings, I was brought up in a small house in the city where I still reside, New Delhi, the capital of India. My Father was a distributor for an oil company and hence, I was born and brought up with lubricants. I was always studious and enjoyed science, so I went ahead and pursued studies in Mechanical Engineering from the prestigious Delhi College of Engineering (now Delhi Technological University.)

NLGI: Where did you begin your career?

SS: At the young age of 23, my Father left us for his heavenly abode, and life thrust upon me more responsibility than I could ever imagine holding on my shoulders. Without really having the time to pause and contemplate a career path, I followed the only path in front of me and continued distribution of lubricants. Given the legendary personality that my Father was, I was instantly accepted by people who were associated with him and used to work with him.

Early days of Siddharth Grease & Lubes

NLGI: How did your career develop?

SS: For years, I continued in my Father's footsteps and grew a good business from distribution of lubricants. The work often led me to visit various companies where the actual application of the products was happening. For days at stretch, I would sit in these companies to understand their pain points and gaps between what lubricants they were using versus what their applications needed. It was here that I realised the large vacuum and need for good greases in these industries.

NLGI: Please tell us about the beginnings of SGL.

SS: The Company, named after my son, Siddharth, was founded a couple of years after his birth in 1988. The want to take forward my education, my zeal for creating/ finding solutions and knowledge I had gained over the years led me to take the plunge over 32 years ago. I am proud to say that many of the people who joined the small company at its inception are still part of the SGL Family. I am also proud to say that many customers who gave us their first purchase orders three decades ago are still our customers.

NLGI: Did you face particular challenges? Good luck?

SS: When I formed the Company in 1988, the petroleum trade was channelised through the Government of India; all trade in India went through the Government at that point in time. Getting licences was a struggle. But somehow we managed to obtain our licence. We were particularly lucky because, due to acute shortages of good quality products in the market, other companies were instantly interested in our products.

NLGI: What is the philosophy behind SGL?

SS: SGL was founded upon, and still upholds, the same philosophy, 'Customised solutions from a private label player'. Even after so many years of operations and streamlined processes,

Directors and senior SGL team members

we still remain flexible about the solutions we provide to our customers. For us, it is never about only a standard few products. Rather, every application, requirement and customer need is attended to separately.

NLGI: Are members of your family active in SGL? What are their roles?

SS: Yes, ours is a family business in the true sense of the word. My wife, Ritu, has been a true partner in all aspects of my life. She was a big a part of the launch of the Business. Now, my son, Siddharth, and his wife, Bhavika, are actively carrying the baton forward. Our roles constantly change according to the strategy we adopt, as we are all involved in everyday work and the Board, too.

NLGI: What are your thoughts about working with your family members in your Company?

SS: At home, we have discussed working together and succession planning at length. Of course, everyone comes with their own mindset, so over the years we have divided responsibilities according to our strengths for smooth working and clear-cut reporting. But honestly, my first thought is always pride when I feel that my 'baby' is being handled with so much love and passion by the next generation.

NLGI: What were some key decisions that helped SGL grow and become a leading manufacturer of private label lubricating greases and oils in India?

SS: The Company was started with a small plant in a remote place in India. Over the years, we expanded and added three more plants. The decision

Present day Siddharth Grease & Lubes

to invest in Infrastructure and constantly upgrade our plants and machinery, even without the orders to back such investments, sometimes proved to be lucky. As they say, the higher the risk, the more the return.

Another decision that helped sustain us over the tide of time was to continuously invest in R&D and develop more products that led to many patents and proprietary technologies and products.

NLGI: As SGL continues to expand worldwide, what are some of the greatest challenges?

SS: While it has been always easy for us to manufacture at one location and ship to 40 countries, we now have manufacturing facilities and warehousing in certain locations around the world. Putting up each new facility in another part of the world has been a huge challenge. I think the biggest challenge of them all has been learning: local know-how such as laws for government approvals, regulations, etc. These were not in our control, and they led to unprecedented delays in projects. We were already prepared for challenges related to work culture and other HR differences, local sentiments and ways of doing business, and we kept these in mind while forming policies for each new facility.

Trinity Lubes & Greases FZC, UAE (a 100% Siddharth Grease & Lubes company)

This year, 2020, has proved to be a year of many challenges; we are still working through some of them.

NLGI: What can you tell us about your new facility in Dubai in the United Arab Emirates?

SS: I am extremely proud to present our ultra-modern, state-of-the-art lubes and grease plant in Dubai. It is fully controlled by means of PLCs (programmable logic controllers). I, myself, marvel at the monument that we have created. With the latest technology and measurement mechanisms to ensure batch consistency, filling efficiency and product quality, we created a plant where there is minimum product loss, no cross contamination and the utmost safety and environmental standards.

We worked overtime and designed an enviable plant, systems and technology for grease and lube manufacturing.

NLGI: What is the role of R&D at SGL? Are you particularly proud of a special R&D accomplishment?

SS: R&D is, and will always be, the backbone of Siddharth

New laboratories at SGL

Grease & Lubes. The R&D Team is managed by industry stalwarts with notable caliber and expertise. We have consistently expanded our Siddharth Research Centre and are proud of the innovations that have come out of it. Even now, we sit ready to launch upgraded greases for applications in EVs (electric vehicles).

When the world was in turmoil as lithium prices shot up, we were in a strong position to offer an alternative grease formulated with a proprietary soap. It met and exceeded all properties of lithium greases, and matched the look and feel of lithium grease products as well.

Even now, we have installed more kettles for making polyurea greases. Under the direction of our R&D Team, we are standardising our processes to make polyurea greases to meet the needs of specific end applications because we anticipate the demand for polyurea greases to increase.

Our R&D Team provides solutions to any problem presented to us from an application perspective. They have launched amazing products to suit specific requirements not met by standard products available in the market.

NLGI: Has SGL received any awards?

SS: SGL has been the recipient of various awards and accolades over the years. None have made me as proud as receiving the MSME (Ministry of Micro, Small and Medium Enterprises of the Government of India) Award for Innovation in Grease and Lubricating Products, presented in 2016 by our Honourable Prime Minister, Sri Narendra Modi, and the ‘Best Medium-Scale Company of India’ award, from our former Prime Minister of India, Dr Manmohan Singh, in 2013.

SGL Director Mrs. Ritu Sachdeva accepted the MSME Award for Innovation in Grease and Lubricating Products from the Honourable Prime Minister Shri Narendra Modi, Ludhiana, India, 2016.

NLGI: What are some priorities for SGL?

SS: Due to the new facility in UAE, our topmost priority for the past few years has been to create systems and processes for the smooth transfer of technology, along with Company processes, culture and values. This creates a solid foundation for all further expansions that we may plan for the future.

Another priority for the Company is to “Go Green”. We are constantly working on steps to reduce our carbon emissions; to find alternatives such as biodegradable products and to create better products that increase drain cycle and thus reduce environmental impact.

NLGI: Who thought of the concept for your mascot?

SS: The term. ‘The Grease & Lubes Chef’, was coined by my son, Siddharth. It communicates the very essence of what we strive to provide: customised solutions.
It not only communicates to the customers what we stand for, but also serves as a reminder to all of us at Siddharth Grease & Lubes of our core values.

THE GREASE & LUBES CHEF

NLGI: What do you think about the position and future of India in the global lubricating grease industry?

SS: India is among the fastest growing lubricant markets globally. Grease demand is sizable at around 140 K MT and growing at a healthy annual pace of 4%. This demand is primarily met by private label manufacturers. The number of manufacturers is substantial, with a few very large players and a healthy talent pool. Currently, almost all grease technologies are available and made in India.

There are several emergent trends in the Indian grease industry:

- OEMs will partner with capable private label grease manufacturers for efficiency, development and innovation needs, thus reducing their internal cycle time.
- Indian grease makers will increasingly serve Indian MNC (multinational corporation) lubricant players for their global markets.
- New modern, large-scale grease manufacturing facilities are expected to be built in India within the next five years.
- Visionary Indian manufacturers will play an important role at the global level in the next decade.
- In the next five years, Indian manufacturers are expected to come up with high performance, semi-synthetic and synthetic grease technologies that will gain global interest.

The Wall of Fame at SGL honours the visits of distinguished guests. On the shelves are the signatures and dates of their visits along with co-branded mementos.

NLGI: How will EVs (electric vehicles) affect the grease industry?

SS: Electric vehicle demand is at a very early stage as far as India is concerned. The grease technology requirements for EVs are still wide open because OEMs have not yet firmed up their conclusive needs. There are unanswered questions such as whether they will replace metal bearings with polymer thrust bearings to save weight.

The major parameters of greases for EVs will include providing NVH (noise, vibration and harshness) benefits of smooth friction behaviour, compatibility with new plastic materials, high speed performance, suitable thermal management and low viscosity fluids. Hence, it appears that as we move up the demand cycle and as superior EVs are launched, we will see requirements for very high performance greases with very long service life. It looks as though there will be an emerging threat in terms of reduction of grease use per vehicle.

India is on the anvil to see a surge in demand for personal and commercial mobility (both fossil fuel and electric vehicles) to provide fast-paced connectivity across cities and villages along with links to major ports and railroad junctions. Last, but not least, there will be improving income levels in India.

Hence, overall, the Indian grease industry will move towards high-value products, and overall volume demand will still be on the rise for the next 15 years.

NLGI: Will other new applications affect the grease industry?

SS: E-mobility will positively impact grease demand as new applications come up. There will be the emergence of lightweight materials for vehicle bodies and parts. Hence, there will be a shift from steel to more aluminium and thermoplastics, which will require special compatible grease technologies.

Supplies of some prevalent raw materials will be limited, leading to disruptive changes such as new grease technology requirements for different applications. There will be a stronger focus on carbon footprint as part of product specifications, biodegradable raw materials and recyclability, even in industrial sectors. Thus, there will be a lot of disruption is in store for the grease industry, which will require alertness and nimbleness to quickly adopt and adapt.

NLGI: What are your thoughts about the future of the global grease industry?

SS: The major change that I foresee is that grease lubrication will be more of a service. Customers will pay for performance instead of just a product. It is envisioned that online sensors and

The entire SGL team

data-driven analytics tools and smart services will gain traction. Monitoring the health status of bearings or machines through monitoring of grease will be done in real time. The corrective actions will be immediate, and thus, unplanned downtime will be prevented.

There will be a shift in the way products are developed, from traditional empirically-driven models to simulation-based approaches. Application-linked data, field data, rig test data and field test results will serve as a statistical backbone for the emergence of Big Data. Powerful insights will enable transformative actions and help provide more precise and faster product development cycles.

The short-term question is not just when this change is expected, but where? By foreseeing disruption, the grease industry has an astonishing prospect to expand and create advantages across the value chain, aligning their core businesses and assets in an increasingly electric, hybrid, upgraded fossil fuel and digital-driven world.

NLGI: How would you describe your management style?

SS: I have actually been a father figure to my employees. I truly have a team, and I am very proud of them and feel they all are a part of our big-little family. For me, it's about getting in and getting the work done, and helping anyone who needs some handholding. I am very approachable to all who

Grease chefs at SGL: Mr. S.C. Nagar (Deputy General Manager, R & D), Mr Sudhir Sachdeva (Managing Director) and Dr E. Sayanna (Chief Technical Officer) work in the Company, and I have an open door policy. I love to get feedback from workers at the ground level, and I consider how any change will impact employees all levels. I have been 'managing' since before concepts of 'management styles' were ever discussed in our meetings.

NLGI: Do you have any advice for people who might want to become managers or leaders?

SS: For any youngsters who want to benefit from the wealth of this grey hair, I say "Be open to learning and change, whatever your age."

As well, "The shortest distance between two points is always a straight line. Thus, don't compromise on your integrity for short-term benefits, because that is never beneficial in the long run."

And, "There is no shortcut to hard work"

NLGI: Did particular people influence your career or your philosophy of business?

SS: Yes, one is always influenced by the environment and the society in which one moves. During my career, I came across many personalities who influenced my working and my career, and accordingly, I undertook the course corrections. But my Company continued to stick to our basic philosophy and focus on private label grease manufacturing.

I continued working on a basic philosophy of asking myself, what value am I adding to:

1. My Company
2. My Team
3. My Self
4. My Country

NLGI: Do you have any suggestions for good relationships with customers?

SS: "Atiti devo bhava " – our old scriptures say, "Guests are a form of God", and I say, so are my Customers. It is because of them that my household and the households of all my staff, and even my vendors, run. Keeping this thought in mind is actually very humbling and helps form relationships based on respect.

For us at SGL, we have been a partner in the growth of all our customers. We have never considered ourselves as 'just a vendor', and I think that reflects in the long-term relationships we have formed with every company that has come to us over the years.

NLGI: Do you and staff attend meetings of NLGI India Chapter?

SS: Yes! We not only attend the NLGI-IC meetings, but also sponsor the event and contribute to the organisational and technical activities. As the current Senior Vice President, I am involved in all the activities of the Chapter.

NLGI: How does NLGI-IC contribute to the grease industry?

SS: NLGI-IC renders technical advice to government and commercial bodies on matters pertaining to lubricating grease specifications. Additionally, it organises Grease Education Courses every year for a cross section of industries to inculcate awareness on the importance and intricacies of greases and their right use and applications. The India Chapter hosts annual conferences to bring all the stake holders onto a common platform to exchange ideas and information on new developments, equipment, additives, packaging material, etc. We also publish a quarterly journal, Grease-Tech India, that includes papers presented at the annual conference and other research papers.

NLGI: What are some of NLGI-IC's plans for the future?

SS: The NLGI India Chapter has plans to support basic and applied research in reputed academic institutes by founding an NLGI Fellowship and by allocating Research Grants. We are also considering research facilities, either at the Headquarters of the Chapter or another place, which will be decided by NLGI-IC Board Members.

NLGI: Do you have time to be involved in other volunteer activities?

SS: I am a firm believer in giving back to society, and I have been consistently involved with activities related to education for children. I also am actively involved in planning CSR (corporate social responsibility) activities that can be taken up by my Company. I highly enjoy spiritual activities and organize many such events that are open for all who are interested in coming to attend and learn.

NLGI: When you are not working, where is your favorite place to travel?

SGL Director Mr. Siddharth Sachdeva at the 20th NLGI-IC Meeting, February 1st to 4th, 2018, Amritsar, India.

Mr. Sudhir Sachdeva, Senior Vice President NLGI-IC, and Dr. T. Singh, Senior Vice President NLGI-IC, at the 86th Annual NLGI Meeting, June 8th to 11th, 2019, Las Vegas

SS: Exploring the world is my passion beyond anything. After all, I will only get this journey of life once. I travel with my family, my friends and my wife. I have been to over 70 countries, and have a bucket list of various other countries and places to explore. I am very fond of trying new things and exploring new cuisines.

NLGI: If NLGI members travel to India, do you recommend special places for them to visit or things to do?

SS: It is always the endeavour of the India Chapter to organize our annual conference at exotic locations in India. So far, we have met at 22 locations including hill stations, coastal towns, temple towns and other places of topical importance. We allocate a day for sightseeing to nearby places for the benefit of both domestic and international delegates. I openly ask anyone who wants to visit India to call me, and I personally will help in creating an itinerary of places to visit. I am proud of our beautiful country and love to showcase the colors, culture, food, diversity and so much else that makes India so unique.

NLGI: Do you have favorite books or movies?

SS: I am an avid reader and particularly fond of reading management books, autobiographies and spiritual books. I have a long list of favorite books that includes

- *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* by Jeffrey K. Liker, 2004
- *Pour Your Heart Into It: How Starbucks Built an Empire One Cup at a Time* by Howard Schutz and Dori Jones Yang, 1997
- *The Goal: A Process of Ongoing Improvement* by Eliyahu M. Goldratt and Jeff Cox, 1984 (revised 2014)
- *The Seven Spiritual Laws of Success* (1994) and every other book written by Deepak Chopra

I love movies that inspire, but my all-time favourites are still old Bollywood films, which we watched in our young days. Thanks to all this technology, I find myself going back and watching them again.

NLGI: If you could have dinner with any three people, living or deceased, who would they be and why? And what might be on the menu?

SS: 1. My Dad – Whom I miss too much in my life. God did not provide me with an opportunity to work with him. He was a great soul and a huge source of inspiration to me.
2. Dr. APJ Abdul Kalam – The former President of India who was someone truly inspirational. I highly admire him for his actions, his beliefs and his achievements. Dr. Kalam was a visionary who always focused on improving the future. Two things that Dr. Kalam always stressed were travel and innovation, which are really what can make all the difference to any individual. His famous quote, "Dream is not that which we see while sleeping it is something that does not let you sleep. And thoughts result in action.", is forever an inspiration to me.
3. Bill Gates – A technologist, business leader and philanthropist. His vision has transformed the complete way of life of each and every person on earth. He is a great source of inspiration to millions, and he is a ray of hope of millions of deprived.

On the menu would be a long fruitful discussion to learn their way of life, business and how they were instrumental in bringing revolutions to mankind, along with a meal of simple vegetarian food.

This interview series, started in 2019 by Dr. Moon and Dr. Shah, gives NLGI members a bit of insight into the professional

The Milestone Wall at SGL

and personal lives of their colleagues, developments in the grease industry, and the role of NLGI worldwide. If you would like to suggest the name of a colleague for an interview (or volunteer to be considered as a candidate), please kindly email Mary at mmmoon@ix.netcom.com or Raj at rshah@koehlerinstrument.com

Dr. Mary Moon is Technical Editor of *The NLGI Spokesman*. She writes scientific and marketing features published in *Lubes'n'Greases and Tribology & Lubrication Technology* magazines, book chapters, specifications, and other literature. Her experience in the lubricant and specialty chemicals industries includes R&D, project management, and applications of tribology and electrochemistry. She served as Section Chair of the Philadelphia Section of STLE.

Dr. Raj Shah is currently a Director at Koehler Instrument Company and was an NLGI board member from 2000 to 2017. A Ph.D in Chemical Engineering from Penn State University and a Fellow from the Chartered Management Institute, London, Dr. Shah is a recipient of the Bellanti Sr. memorial award from NLGI. He is an elected fellow of NLGI, IChemE, STLE, INSTMC, AIC, CMI, Energy Institute and the Royal Society of Chemistry. A Chartered Petroleum Engineer from EI and a Chartered Chemical Engineer from IChemE, he is currently active on the board of STLE and on the advisory boards of the Engineering Departments at SUNY Stony Brook, Hofstra University, Auburn University and Pennsylvania State University. More information on Raj can be found at https://www.astm.org/DIGITAL_LIBRARY/MNL/SOURCE_PAGES/MNL37-2ND_foreword.pdf

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NLGI Spokesman Author Q&A

Q: What is NLGI's criteria for publishing technical papers in *NLGI Spokesman* publication?
A: NLGI publishes technical papers that:

- Address a technical or scientific question or problem related to raw materials, formulation, production, testing, properties, applications, or performance of lubricating grease;
- Report results from research and development, science, or engineering studies such as laboratory experiments, field trials, computer simulations, etc.;
- Are original to the extent that they have not been published elsewhere;
- Cite at least one reference, book, article, or other source material;
- Are written in the English language;
- Comply with the current NLGI policy on commercial content;
- Complete NLGI's current technical review and editing processes with final approval by the Editor-in-Chief, the Chair of the Editorial Review Committee and the Technical Editor

Q: Who may submit a technical paper for publication in *NLGI Spokesman*?
A: Most technical papers are written by scientists, engineers, and others affiliated with commercial, academic, and government organizations anywhere in the world. Papers can be submitted one of two ways:

i. Papers based upon an approved technical presentation from the Annual Meeting

ii. Other technical papers that do not contain commercial content.

Q: Does NLGI only accept papers from authors who are NLGI members?
A: No, it is not required for authors to be members of NLGI, although membership is encouraged.

Q: Does NLGI only publish papers that are based on presentations at NLGI Annual Meetings?
A: The majority of published papers are based on approved presentations from the previous Annual Meeting. Other papers may be submitted throughout the year, subject to acceptance by NLGI as well as review and approval by NLGI's Editorial Review Board.

Q: How do authors submit a paper for publication?
A: The primary author submits their paper in Word format as an email attachment to the Editor.

Q: What happens once I submit a paper for approval?
A: The main steps in NLGI's current technical review and editing processes include:

1. The Editor emails the paper to the Chair of the Editorial Review Committee and/or the Technical Editor.
2. The Chair of the Editorial Review Committee and/or the Technical Editor read the draft paper and email it to two members of the Editorial Review Committee for review.
3. The reviewers email their recommendations to the Chair of the Editorial Review Committee and/or the Technical Editor.
4. Communications between the primary author and the reviewers are facilitated by the Technical Editor while maintaining the anonymity of the reviewers.

5. The Technical Editor communicates results of the review to the primary author. Reviewers may require the primary author to submit additional information before they complete their review.
6. Reviewers typically accept a paper with the condition that the authors make revisions.
7. Authors revise their paper and submit it to the Technical Editor, who verifies that the revisions meet the requirements of the reviewers.
8. The author can challenge the review and email their comments to the Technical Editor, who will forward them to the reviewers. The Technical Editor makes the final decision to resolve any disputes. The anonymity of the reviewers is maintained throughout the process by the Technical Editor.
9. The Technical Editor reviews and edits the revised paper for clarity, organization, grammar, spelling, etc.
10. Authors and Technical Editor work together to polish the paper and its format.
11. The primary author reviews and accepts the final draft.
12. NLGI encourages authors to send JPG files for digital photos to the Technical Editor for best clarity when published in the *NLGI Spokesman*.
13. The Technical Editor submits the final draft and JPG files to NLGI HQ.
14. NLGI's graphic designer uploads the final draft into T*he NLGI Spokesman* layout, which uses Cambria font, colored borders, arrangement of photos and graphs, etc.

Q: What is the NLGI policy on commercial content of papers?

A: Authors must avoid use of specific brand names except instruments, reagents, etc. used to perform the work. Authors must use chemical, scientific, or generic terms whenever possible instead of commercial names of lubricants, base stocks, and additives, e.g., 'a Group I oil', 'a high MW polymethacrylate', etc. Questions regarding the appropriateness of content and suggestions for changes made will be raised throughout he editorial review process. NLGI's Editorial Review Board will have the final say with regard to commercial content prior to publication of papers.

Q: When will a paper be published?

A: Technical papers are typically published in the year following the presentation at the Annual Meeting. The Editor-in Chief publishes the Editorial Calendar in December outlining the next year's schedule. Additional papers/technical material may be published as available after they complete the review and approval process.

Q: What are NLGI's guidelines for writing a paper?

A: NLGI's current guidelines include:

- Begin with a concise title that clearly identifies the subject of the paper.
- Provide the name, affiliation, and location of each author, e.g., Terry Tribologist, Great Grease, Inc., Dallas, TX USA.
- Typical papers include: Abstract – a brief summary of the study and results
    - Outline – for relatively long, complex papers
    - Introduction
    - Experimental Technique – enough detail so that others could repeat the experiment, includes safety considerations and PPE
    - Raw Materials, Formulations
    - Observations, Data
    - Analysis, Results
    - Conclusions

- ◊ Acknowledgements – when and where this paper was presented, thank coworkers and sponsors, etc.
- ◊ References – NLGI currently does not require a specific format for references.
- ◊ Appendices

- Extensive reviews of patent and technical literature, detailed histories of the field, mathematical derivations, and other material that may sidetrack readers belong in appendices.
- Use consistent writing style, e.g., 'Tests included dropping point, tackiness, and water resistance. Grease temperatures were 20, 40, and 60^0 C.' but not 'Tests included dropping point, tackiness, and ASTM D1264. Grease temperatures had been 68, 104 and 140^0 F.'

Q: What are NLGI's guidelines for formatting a paper?

A: NLGI's current guidelines include:

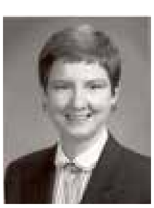
- Submit your paper as a Word file.
- Use single-column format.
- Do not use page numbers, headers, or footers.
- Put each graph, photo, and table between two paragraphs. Do not mix graphics with text. Do not put more than one graphic on a line.
- Each graph, table, photo, etc. needs a number and title, e.g., Table 1 Base Oil Properties, Figure 1 Grease Properties vs. Temperature, etc.
- Check that axis labels and legends are clear. Use fonts that are large enough for readers to understand. Consider using Cambria font to match the text when it is prepared by NLGI's graphic designer.
- Use headings for sections and subsections.
- Write in third person and not in first person point of view, e.g., 'Tests at room temperature showed...' and 'The author observed…', but not 'We performed tests at room temperature to show…' and 'I observed … '
- Active voice can be clearer than passive voice, e.g., 'This study focused on measuring grease tackiness.' instead of 'This study was focused on having greases tackiness measured.'
- Minimize use of superscripts and subscripts. Cite references as '[1]' or [Smith]', etc.
- Use SI (metric) units of measure, with customary units where appropriate. Put a space between a number and the unit, e.g., 6 h but not 6h. Express temperatures in degrees Celsius (0^0 C) or degrees Fahrenheit followed by degrees Celsius in parentheses, e.g., 32^0 F (0^0 C).

Q: Who can I contact if I have questions?

A: Contact NLGI HQ at 816-524-2500 or nlgi@nlgi.org, or Mary Moon at 267-567-7234 or mmmoon@ix.netcom.com. Templates to help authors write a paper based on their presentation slides are available from the Technical Editor.

Q: Where can I go for more information?"

A: Please visit the NLGI website for Author Guidelines and more.

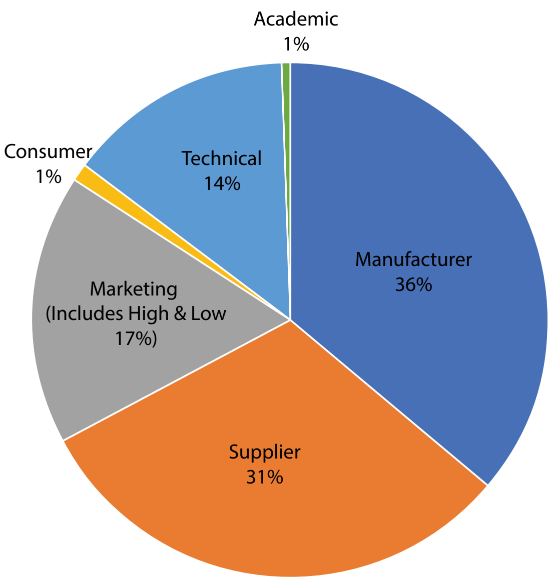


Written by:
Mary Moon, PhD
Technical Editor, NLGI Spokesman

Serving the grease industry since 1933

NLGI Year End Recap 2020

2020 NEW MEMBERS



Colonial Chemical Inc.	*Technical*	USA
ABB Inc.	*Supplier*	USA
Infineum USA L.P.	*Supplier*	USA
EXAKT Technologies, Inc.	*Supplier*	USA
Ingevity	*Supplier*	USA
Reliance Fluid Technologies	*Marketing – Low*	USA
POLARIS Laboratories	*Technical*	USA
Ellis Enterprises East LLC	*Manufacturer*	Serbia
Savant Group	*Technical*	USA
CNH Industrial America LLC	*Marketing – Low*	USA
IMERYS Graphite & Carbon	*Supplier*	USA
CountryMark Cooperatives LLC	*Marketing – Low*	USA
Old World Industries, LLC	*Marketing – Low*	USA
Security Oil, LLC	*Marketing – Low*	USA
Savant Labs	*Supplier*	USA

91% member retention rate

RESEARCH GRANT

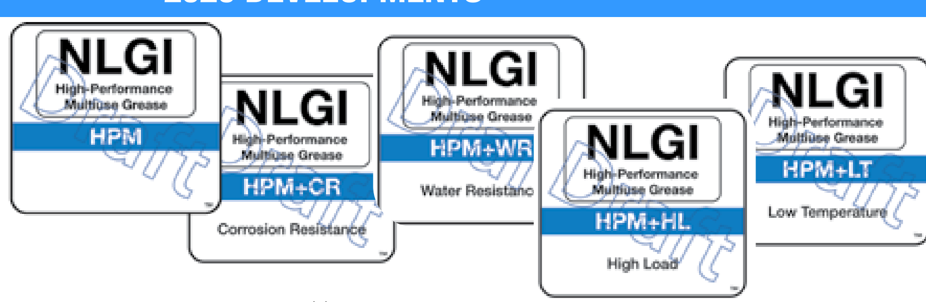
University of Akron for their research proposal titled "Strategies for Optimizing Greases to Mitigate Fretting Wear"
The grant will take place over a one-year period (2020 – 2021)

GLOBAL OUTREACH

- NLGI India Chapter (Represents 8% of NLGI's total global membership and growing)
- Asian Lubricant Manufacturers Union (ALMU)
- Chinese Lubricating Grease Institute (CLGI)
- European Lubricating Grease Institute (ELGI)
- Society of Tribologists and Lubrication Engineers (STLE)
- Independent Lubricating Manufactures Association (ILMA)

2020 DEVELOPMENTS

HPM Specification



2020-2021 BOARD MEMBERS

President
Jim Hunt
Tiarco Chemical

Vice President
Anoop Kumar
Chevron Lubricants

Secretary
Wayne Mackwood
Lanxess Corporation

Treasurer
Tom Schroeder
AXEL Americas, LLC

Past President / Advisory
Joe Kaperick
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David Turner
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Technical Committee
Co-Chair Academic:
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Molykote Lubricants

Barbara A. Bellanti
Battenfeld Grease & Oil Corp of New York

Benny Cao
The Lubrizol Corporation

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Grease Technology Solutions

Muibat Gbadamosi
Calumet Branded Products, LLC

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George Sandor
Livent Corporation

Simona Shafto
Koehler Instrument Company, Inc.

Jeff St. Aubin
AXEL Royal, LLC

Tom Steib
Italmatch Chemicals

Pat Walsh
Texas Refinery Corp

Ray Zhang
Vanderbilt Chemicals, LLC

FINANCIAL

$

NLGI is financially healthy and on track to produce over budgeted revenue in 2020.

VIRTUAL TECHNICAL WEEK

SCIENCE FRICTION
THE TRIBOLOGY OF GREASE
2020 NLGI
VIRTUAL TECHNICAL WEEK
August 24 - 28

Virtual Technical Week (in lieu of Annual Meeting) offered:

- Industry Speaker: Dr. Christopher DellaCorte, Senior Technologist: Tribology & Rotation Machinery at NASA, Glenn Research Center presented "Space: A Surprisingly Greasy Environment"
- 12 Technical Presentations
- NLGI's education courses (Basic and Advanced)
- Awards ceremony highlighting 2020 award recipients
- Live panel discussion on High-Performance Multiuse (HPM) grease

Total Attendees: **118**

Total Attendees from Abroad: **29**

Basic Course Participants: **28**

Advanced Course Participants: **13**

Technical Presentations: **12**

NLGI COMMITTEES

MEMBERSHIP: The membership committee focuses on recruiting new company members as well as retaining current members, enhancing membership benefits and international expansion.

EDUCATION: The Education Committee focuses on the overall strategy for NLGI education including education courses, certifications (CLGS and certification marks) as well as working groups.
*Consists of four sub-groups

Courses	Focuses on fine-tuning the Basic & Advanced Courses.
CLGS Sub-Group	Must be CLGS certified to participate on this committee. Focuses on the test given at the Annual Meeting.
Certification Marks Sub-Group	Focuses on audit process and certification renewals for GC-LB, LB and GC products;
Working Groups Sub-Group	These meetings happen once per year at the Annual Meeting and minutes are provided to NLGI members. Ideas for discussion topics and help with action items is needed.

ANNUAL MEETING: The Annual Meeting Committee serves as the advisory group for the Annual Meeting including selecting speakers, award recipients, solidifying technical sessions and direction on the site selection process.
*Consists of four sub-groups

Speakers Sub-Group	Help select keynote and industry speakers
Site Selection Sub-Group	Help determine future locations/hotels for upcoming meetings.
Awards Sub-Group	Determine award winners
Technical Sessions Sub-Group	Oversee technical presentations presented at Annual Meeting, collecting papers that will be used in Spokesman issues as articles.

ACADEMIC: The Academic Committee seeks to strengthen the grease industry by fostering relationships with universities containing tribology programs as well as evolving the organization's research grant program.
*Consists of two sub-groups

Outreach Sub-Group	Foster partnerships with Universities and professors regarding NLGI membership and attending Annual Meeting.
Research Grants Sub-Group	Help determine deserving University for annual NLGI research grant.

EDITORIAL: The Editorial Committee collaborates on content circulated to NLGI members and non-members including the NLGI Spokesman, Annual Production Survey and Ask the Expert Q&A.
*Consists of two sub-groups

Editorial Review Board	Oversee content for The NLGI Spokesman as well as enhance readership
Technical Reviewers	Review papers that are ultimately included in the Spokesman as articles for readers. Work with authors on changes.

***If interested in serving on a committee/sub-group, complete the volunteer form on the NLGI website.**

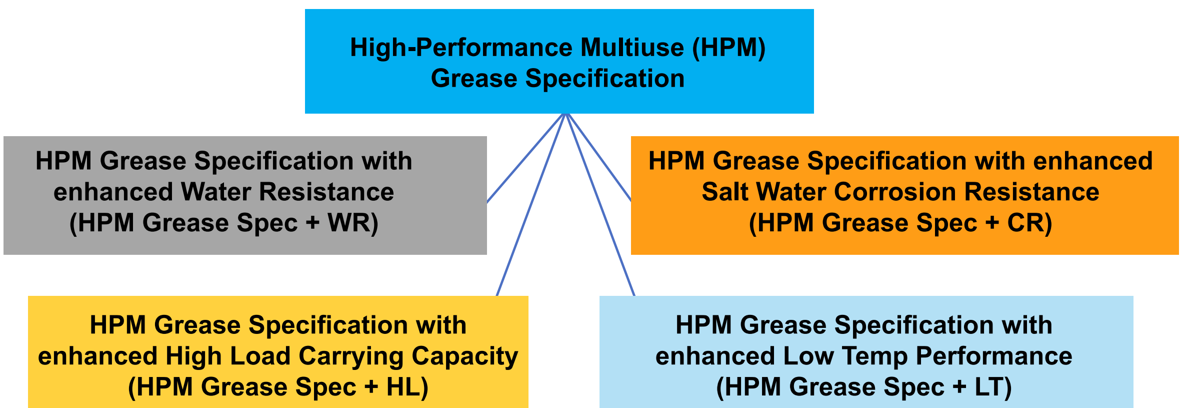

Providing expanded educational opportunities
Effective governance and leadership for NLGI (financial growth and health)
Communication of NLGI knowledge-based resources and certification (Spokesman, marketing NLGI value)
Certification upgrade - implementation, engagement, marketing
Enhancing opportunities for networking and discussion on emerging industry trends/ applications (webinars, panel discussion, Spokesman, social media)
Membership growth, engagement, and global outreach
NLGI 2021 STRATEGIC PRIORITIES

High-Performance Multiuse (HPM) Grease Certification

NOW AVAILABLE
Click HERE for More Information

In 2015, NLGI began efforts to upgrade the GC-LB specification due to advancements in materials, technologies and applications, as well as precision issues with several of the D4950 tests. NLGI is pleased to launch the High-Performance Multiuse (HPM) grease certification, along with enhanced performance in the following areas:

NLGI's High-Performance Multiuse Grease Classifications



How to Apply

1. Visit https://www.centerforqa.com/nlgi-about/
2. Click on "Register Your Products"
3. Enter Contact Information and Click Submit
4. Application Documents will be Available for Immediate Download
5. Complete the 5-Step Process

The Center for Quality Assurance (CQA) administers the program on behalf of NLGI and monitors quality standards through each step as the grease progresses through the licensing process. CQA has over 15 years of expertise in managing licensing and quality control programs.

Pricing Information

MEMBER PRICING

CORE PRODUCTS

Core Product Registration

2021	2022
$2,900	$3,900

Tag Pricing (per tag)

	2021	2022
1 Tag	$870	$1,170
2 Tags	$566	$761
3 Tags	$479	$644
4 Tags	$435	$585

CORE PRODUCTS Renewal

Core Product Renewal

2021	2022
	$2,535

Tag **Renewal** (per tag)

	2021	2022
1 Tag		$761
2 Tags		$494
3 Tags		$418
4 Tags		$380

NON-MEMBER PRICING

*Non-members with re-branded products will be charged as below.If interested in joining NLGI for discounted pricing, please contact nlgi@nlgi.org

CORE PRODUCTS

Core Product Registration

2021	2022
$3,625	$4,875

Tag Pricing (per tag)

	2021	2022
1 Tag	$1,088	$1,463
2 Tags	$707	$951
3 Tags	$598	$804
4 Tags	$544	$804

CORE PRODUCTS Renewal

Core Product Renewal

2021	2022
	$3,169

Tag **Renewal** (per tag)

	2021	2022
1 Tag		$951
2 Tags		$618
3 Tags		$523
4 Tags		$475

RE-BRAND PRICING

*Available to NLGI Members Only

**First product must be registered at full fare. Remaining products can be registered at re-brand pricing.

CORE PRODUCTS

Core Product Registration

2021	2022
$580	$780

Tag Pricing (per tag)

	2021	2022
1 Tag	$174	$234
2 Tags	$174	$234
3 Tags	$174	$234
4 Tags	$174	$234

CORE PRODUCTS Renewal

Core Product Renewal

2021	2022
	$507

Tag **Renewal** (per tag)

	2021	2022
1 Tag		$152
2 Tags		$152
3 Tags		$152
4 Tags		$152

Certification and *Renewal* Process

Certification – Applicants submit the appropriate registration and certification mark user agreement forms, as well as the appropriate certification fees. A data set including all tests and results for the relevant specifications is submitted along with a 2 pound sample of production grease.

Renewal – Each certification holder submits a 1 pound sample of each certified grease on the anniversary of the certification date to renew their registration, along with appropriate renewal fees. These samples are subject to audit testing.

HPM Specification Details

	Property	Test Conditions	Test method	Units	Min	Max
HPM Spec	Cone Penetration of Lubricating Grease	Worked 60 Strokes	ASTM D217	dmm	220	340
	Cone Penetration of Lubricating Grease	Prolonged worked penetration (Δ100k)	ASTM D217	dmm	- 30	+ 30
	Elastomer compatibility of Lubricating Greases and Fluids [using NBR standard reference elastomer per ISO13226]	168 hours @ 125°C	ASTM D4289	Δ Hardness (Shore A points)	-15	+2
				Δ Volume percent	-5	+30
	Oxidation Stability of Lubricating Greases by the Oxygen Pressure Vessel Method	Pressure drop after 100hrs @ 100°C	ASTM D942	kPa (psi)		35 (4.9)
	Determining the Water Washout Characteristics of Lubricating Greases	60 minutes @ 79°C	ASTM D1264	wt%		10
	Low Temperature Torque of Ball Bearing Grease	-20°C	ASTM D1478			
	Starting torque			mNm (g·cm)		1000 (10,200)
	Running torque @ 60 minutes			mNm (g·cm)		100 (1,020)
	Oil Separation from Lubricating Grease During Storage	24 hours @25°C	ASTM D1742	wt%		5.0
	Oil Separation from Lubricating Grease (Conical Sieve Method)	30 hours @100°C	ASTM D6184	wt%		7.0
	Roll Stability of Lubricating Grease [using 1/2 scale penetration]	2 hours @ Room Temperature	ASTM D1831	dmm	-10%	+10%
	Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method) Wear Scar Diameter	75°C, 1200 rpm, 60 minutes	ASTM D2266	mm		0.60
	Measurement of Extreme-Pressure Properties of Lubricating Grease (Four- Ball Method), Weld point	1770 rpm @ 27°C	ASTM D2596	kgf	250	
	Determining Corrosion Preventive Properties of Lubricating Greases	48 hours @ 52°C	ASTM D1743	rating	Pass	
	Determination of Corrosion-Preventive Properties of Lubricating Greases Under Dynamic Wet Conditions (Emcor Test)	Distilled Water, 2 bearings	ASTM D6138	rating		0,1
	Detection of Copper Corrosion from Lubricating Grease	24hours @100°C	ASTM D4048	rating		1B

Table 1- HPM "core" Specification

In the HPM core Specification, seven tests are common to the GC-LB specification, but may have more restrictive limits: Cone Penetration (ASTM D217), Elastomer Compatibility (ASTM D4289), Water Washout (ASTM D1264), Oil Separation (ASTM D1742), 4-Ball Wear (ASTM D2266), 4-Ball EP (ASTM D2596), and Corrosion Prevention (ASTM D1743). Other tests, not included in the GC-LB specification include two mechanical stability tests: Extended Worker Penetration (100,000 strokes by ASTM D217), and Roll Stability (ASTM D1831). Two corrosion tests were added: EMCOR Rust Test (distilled water by ASTM D6138) and Copper Corrosion (ASTM D4048). Two high temperature tests were added: Oxidation Stability (ASTM D942) and High Temperature Oil Bleed (ASTM D6184). And finally, Low Temperature Torque of Ball Bearing Grease (ASTM D1478) replaced Low Temperature Torque of Wheel Bearing Grease (ASTM D4693). All of these tests are intended to raise the level of performance compared to GC-LB and to make the specification more relevant to multiuse industrial applications.

HPM+WR Specification

	Property	Test Conditions	Test method	Units	Min	Max
HPM +WR	Determining the Water Washout Characteristics of Lubricating Greases	60 minutes @ 79°C	ASTMD1264	wt%		5.0
	Determining the Resistance of Lubricating Grease to Water Spray	5 minutes @ 38°C	ASTM D4049	wt%		40
	Roll Stability of Lubricating Grease in Presence of Water(10% by wt distilled water) [using1/2scalepenetration]	2 hours @ Room Temperature	ASTM D8022	dmm	-15%	+15%

Table 2 – HPM+WR specification

The HPM+WR Specification includes three tests intended to demonstrate an increased level of performance over the HPM core Specification in wet or water wash environments. Water Washout (ASTM D1264) is the same test as used in the HPM core Specification, but has a more restrictive limit. Water Spray Off (ASTM D4049) demonstrates a grease's ability to resist water spray, while Wet Roll Stability (ASTM D8022) evaluates the effect of water on grease mechanical stability.

HPM+CR Specification

	Test Conditions	Test method	Property	Units	Min	Max
HPM + CR	Corrosion-Preventive Properties of LubricatingGreases in Presence of Dilute Synthetic Sea Water Environments	10% Synthetic seawater (as in ASTM D665)	ASTM D5969	rating	Pass	
	Determination of Corrosion-Preventive Properties of Lubricating Greases Under Dynamic Wet Conditions (Emcor Test)	100% Synthetic seawater (as in ASTM D665)	ASTM D6138	rating		1 , 2
	Determination of Corrosion-Preventive Properties of Lubricating Greases Under Dynamic Wet Conditions (Emcor Test)	0.5Nsolution (~ 3% NaCl solution)	ASTM D6138	rating		2 , 3

Table 3 – HPM+CR Specification

The HPM+CR Specification includes three tests intended to demonstrate improved corrosion resistance over the HPM core Specification in saltwater environments. Saltwater Rust (ASTM D5969) is similar to ASTM D1763 in the HPM core Specification, but uses 10% synthetic sea water. Two versions of EMCOR Rust (ASTM D6138) evaluate corrosion protection in both 100% synthetic sea water and 0.5 N sodium chloride solution.

HPM+HL Specification

	Property	Test Conditions	Test method	Units	Min	Max
HPM +HL	Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method) Wear Scar Diameter	75 °C, 1200 rpm, 60 minutes	ASTM D2266	mm		0.50
	Measurement of Extreme-Pressure Properties of Lubricating Grease(Four-Ball Method), Weld point	1770 rpm @ 27°C	ASTM D2596	kgf	400	
	Determining Extreme Pressure Properties of Lubricating Greases Using a High- Frequency, Linear-Oscillation (SRV)Test Machine	(Procedure B at 80°C)	ASTM D5706	N	800	
	Fretting Wear Protection by Lubricating Greases	Average of 2 runs,22 hours @ Room Temperature	ASTM D4170	mg		5.0
	Determining Fretting Wear Resistance of Lubricating Greases Under High Hertzian Contact Pressures Using a High- Frequency, Linear-Oscillation (SRV) Test Machine	50°C, 100N, 0.300mm, 4 hours	ASTM D7594	mm		0.500

Table 4 – HPM+HL specification

The HPM+HL Specification includes five tests intended to demonstrate improved load carrying capability over the HPM core Specification. Both the 4-Ball Wear (ASTM D2266) and 4-Ball EP (ASTM D2596) tests are the same tests as in the HPM core Specification, but have more challenging limits. Extreme Pressure Properties by SRV (ASTM D5706) and Fretting Wear by SRV (ASTM D7594) are included to further demonstrate improvement in these properties over the HPM core Specification. Fretting Wear by FAFNIR test (ASTM D4170) is also included with a tighter limit than the same test in the LB Specification.

HPM+LT Specification

	Property	Test Conditions	Test method	Units	Min	Max
HPM +LT	Low Temperature Torque of BallBearing Grease	-30°C	ASTM D1478			
	Starting torque			mNm (g·cm)		1000 (10,200)
	Running torque @ 60 minutes			mNm (g·cm)		100 (1,020)
	Grease Mobility	-20°C	US Steel LT-37	g/min	10	
	Determination of flow pressure of lubricating greases according to Kesternich method	-30°C	DIN 51805	mbar		1400

Table 5 – HPM+LT specification

The HPM+LT Specification includes three tests intended to demonstrate improved low temperature performance over the HPM core Specification. Low Temperature Torque of Ball Bearing Grease (ASTM D1478) is the same test as used in the HPM core Specification, but is run at a lower temperature. Grease Mobility (U.S. Steel method LT-37) demonstrates grease resistance to flow at low temperatures, while Flow Pressure (by Kesternich method DIN 51805) is another way to look at flow at low temperatures.

Frequently Asked Questions

Will HPM require a certain thickener type or base oil type or additive chemistry?

The answer is "No". There is no aspect of a grease formulation's chemistry that is part of the new HPM grease specifications. Since the new specifications are focused on the performance aspect of the greases, there is no restriction put on the raw materials, including thickener type, base oil, additives or, or manufacturing processes used to create a product certified as a High-Performance Multiuse grease.

How will the end-user ensure that greases of different chemistries certifying to the HPM specifications will be compatible in real application situations?

Because the HPM and HPM + enhanced specifications are "chemistry neutral", there is a possibility for different HPM-certified greases to be incompatible, even if the greases are from the same supplier. If NLGI were to include some sort of compatibility requirement in the HPM specifications, it would likely lead to exclusion of some types of grease thickener technologies, which goes against the HPM specification "chemistry neutral" design principles. Given the wide variety of chemistries utilized in grease products, there is no way to include such a compatibility requirement in the HPM specifications.

What type of applications will an HPM certified grease work in?

While the NLGI HPM grease specifications are designed to ensure a high level of performance for many different applications (multiuse), they are not suitable for all applications. We consider that multiuse applications may include the following:

- Conveyor Bearings
- Pillow Block Fan Bearings
- Industrial Gearbox Bearings
- Ball Screws
- Linear Bearings
- Plain Bearings
- Hinges
- Rollers
- Presses
- Winches
- Bushings
- Rolling Element Bearings
- Electric Motor Bearings
- Thrust Bearings
- Pump Bearings
- etc.

What is critical to remember is that the *HPM specification should not to be used as a short cut to grease selection*. Each application should be evaluated for its requirements, based on speed, load, temperature and operating environment. These parameters will affect the choice of base oil viscosity, consistency, thickener type and additive needs. An HPM-certified grease may or may not meet these requirements. *Consult an application engineer from your grease supplier to find out if an HPM grease is right for your application.*

The enhanced performance tags which may be included with the HPM core specification (+WR, +CR, +HL, +LT) are designed to provide improved performance in the areas of water resistance, corrosion resistance, load-carrying, or low temperature performance compared with the core HPM specification. However, note that the HPM specifications may not ensure adequate performance for some specialized applications, such as those with extremely high loads, extremely high or low temperatures, extremely high speeds, extremely high water wash conditions, or any combination of

Future Plans – HPM and Beyond

After the launch of HPM core specification and four enhanced performance sub-categories, NLGI will:

- Continue work on High Temperature and/or Long Life categories (2 to 5 years) as well as considering initiation of work on other categories or applications as is deemed appropriate

- Work on current test reproducibility issues in conjunction with ASTM. Example: when the reproducibility issues with ASTM D4170 Fretting Wear test are resolved, the limits will become a requirement for HPM+HL registration or renewal, eliminating the "provisional licensing" status.

- Continue to refine test requirements and adjust or add to specifications as needed to reflect testing capabilities and industry needs with the intention to treat the specifications as "Living Documents".

Where Can I Find More Information?

Greases certified in the program are submitted with test data to show that they meet the performance standards related to parameters such as wear resistance, structural stability, oxidation resistance, elastomer compatibility, and corrosion resistance. Since the HPM specification limits define the grease's performance, the HPM Grease Program is "chemistry neutral". There are no formulation requirements for the greases to meet these specifications. Innovations in grease formulating are welcomed by the program in order to continuously improve the performance of greases in the market.

For more information, visit: https://www.centerforqa.com/nlgi-about/ or https://www.nlgi.org/about-us/high-performance-multiuse-grease/

For questions, contact: The Center for Quality Assurance at +1 989-496-2399 or grease@centerforqa.com OR NLGI at +1 816-524-2500 or nlgi@nlgi.org