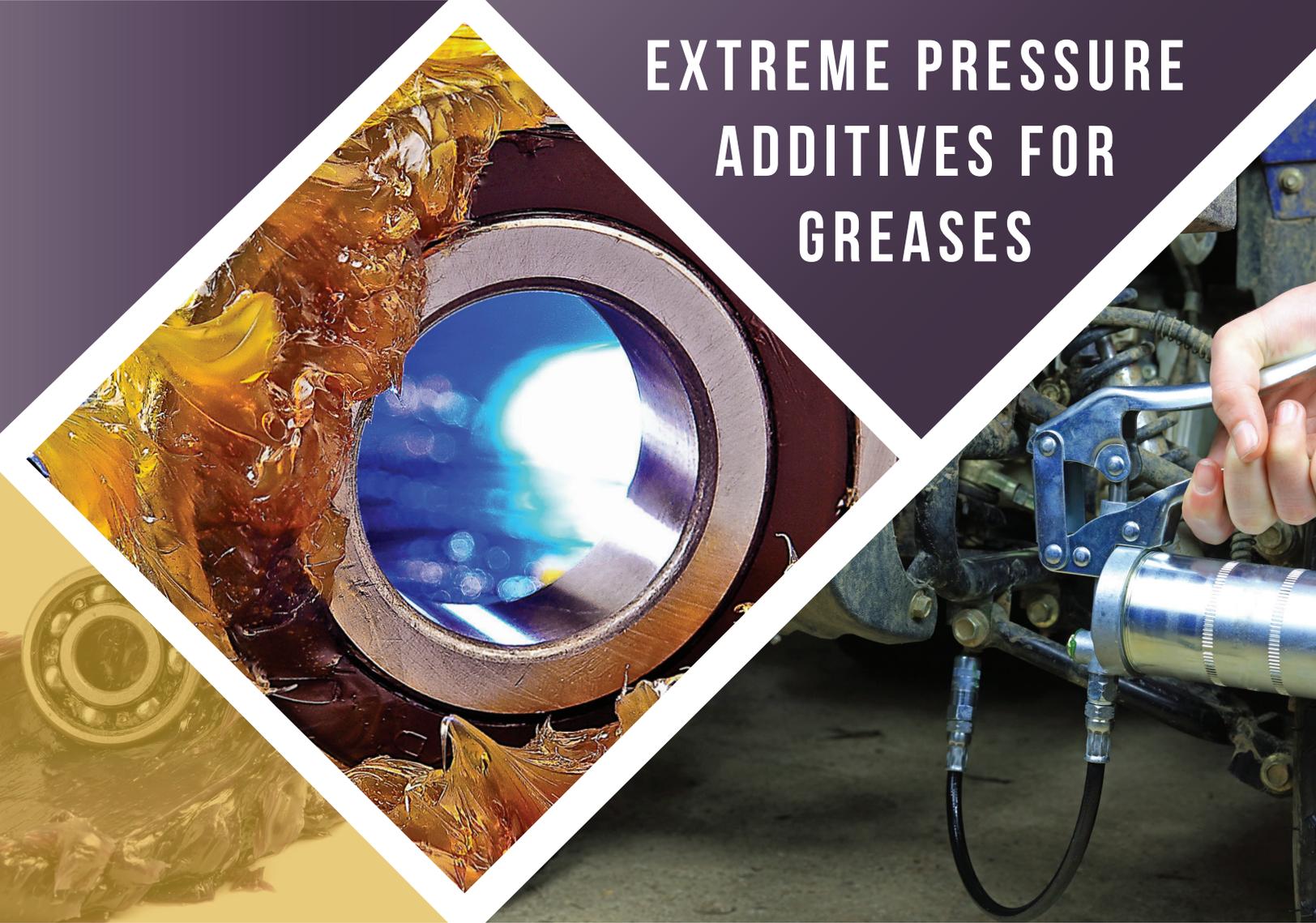




Vanderbilt Chemicals, LLC

A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.

EXTREME PRESSURE ADDITIVES FOR GREASES



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Extreme Pressure (EP), anti-wear and anti-friction additives are commonly used in greases. These additives play an important role in forming surface protective films, either by surface reaction or surface adsorption. Such surface films can prevent direct metal to metal contact, and protect metal surfaces against wear and welding, especially under high load, i.e. extreme pressure conditions.

The newly introduced NLGI HPM + HL Specification (2021), which is a subcategory of High-Performance Multiuse (HPM) Specifications emphasizing the High Load performance of greases, has well-defined, industry standards for an EP grease with High Load-carrying capability. The new HPM + HL Specification puts further demands on the treat level and type of EP additives for grease.

Vanderbilt Chemicals manufactures a wide range of EP additives that helps formulators meet the higher performance HPM + HL specification. These additives are specifically designed for the high load conditions that can cause welding between metal surfaces.

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Rev. 03/01/2022

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EXTREME PRESSURE ADDITIVES FOR GREASES

Many of the EP additives offered by Vanderbilt Chemicals are based on sulfur and phosphorous chemistries and are among the most effective grease EP additives. Our grease EP additives range from classical sulfurized olefin, such as sulfurized isobutylene **VANLUBE® SB** with 45% sulfur, and high sulfur-containing 2,5-dimercapto-1,3,4-thiadiazole (DMTD) derivatives, to metal-containing dithiocarbamates and dithiophosphates.

DMTD DERIVATIVES

SUMMARY

VANLUBE 829, **VANLUBE 972M** and **VANLUBE 972 NT** are ashless EP additives for grease; based on 2,5-dimercapto-1,3,4-thiadiazole (DMTD). **VANLUBE 829** is a DMTD dimer in powder form, **VANLUBE 972M** is a DMTD dimer complexed in liquid polyalkylene glycol (PAG), and **VANLUBE 972 NT** is also a DMTD dimer but complexed in a more environmental-friendly liquid PAG, avoiding SARA 313 reporting requirements.

VANLUBE 829 – A yellow powder containing 62-67% sulfur that effectively adsorbs on iron or steel surfaces through bidentate surface coordination (Figure 1).

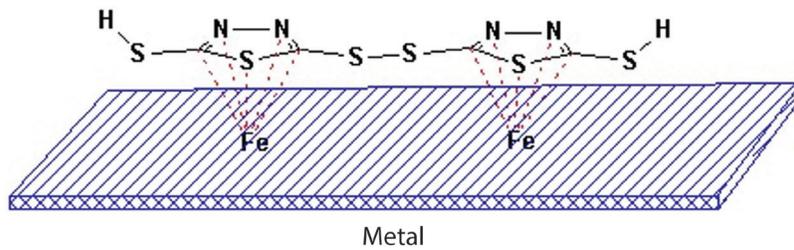


Figure 1. Depiction of bidentate surface coordination of **VANLUBE® 829**

Results from 4-ball weld point testing are listed in Figure 2 using **VANLUBE 829** in different base greases. As indicated by the significant weld point increases, **VANLUBE 829** exhibits excellent extreme pressure properties in a wide variety of grease types.

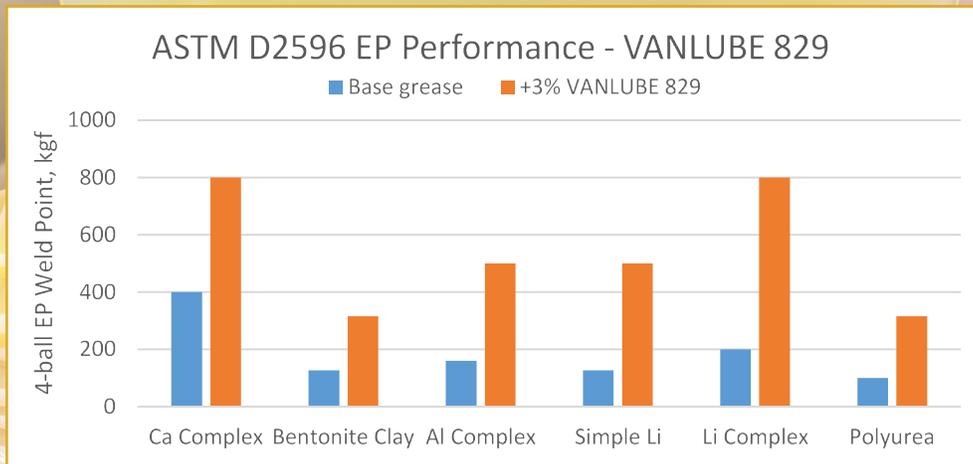


Figure 2. Extreme pressure performance of different greases with 3.0% **VANLUBE® 829**

VANLUBE® 972M and **VANLUBE 972 NT** – Both are DMTD dimers complexed in slightly different polyglycols to make these liquids dispersible into grease. Adsorption on the metal surface is through polydentate coordination (Figure 3). These EP additives are especially effective in providing high OK load in the grease Timken test – ASTM D2509.

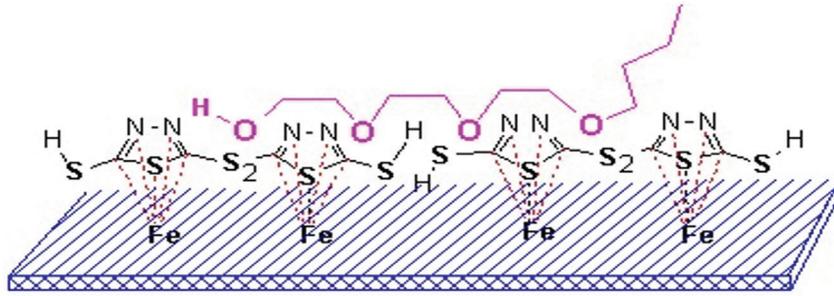


Figure 3. Depiction of polydentate surface coordination of **VANLUBE® 972M**

The EP performance of **VANLUBE 972M** in various base greases is shown below. As indicated in Figures 4 and 5, this additive at a low treat rate of 2% can provide a Timken OK load of up to 80 pounds and 4-ball weld point up to 400 kgf in some base greases.

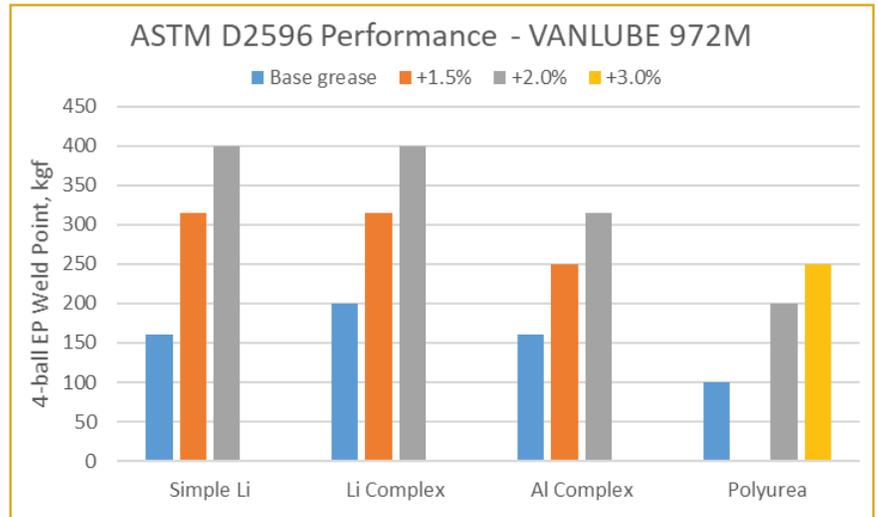


Figure 4. 4-Ball extreme pressure properties of **VANLUBE® 972M** in various base greases

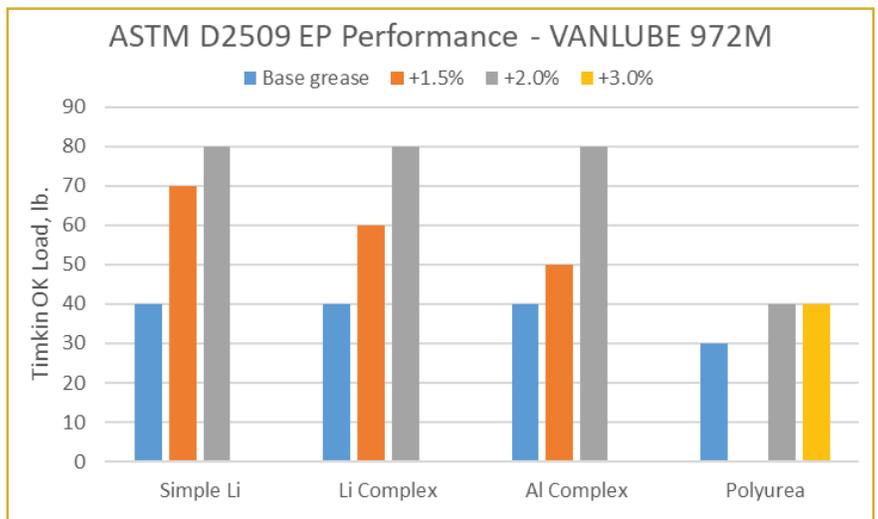


Figure 5. Timken extreme pressure properties of **VANLUBE® 972M** in various base greases

DITHIOCARBAMATES

SUMMARY

VANLUBE® 73, **VANLUBE 73 Super Plus** and **VANLUBE 8610** are grease EP additives based on antimony dialkyl dithiocarbamates (SbDTC). While **VANLUBE 73** is an antimony dialkyl dithiocarbamate (SbDTC), **VANLUBE 73 Super Plus** is a mixed metal dialkyl dithiocarbamate, containing antimony and zinc (Sb/ZnDTC); **VANLUBE 8610** is a blend of SbDTC with sulfurized isobutylene (**VANLUBE SB**).

VANLUBE 73 - a very cost-effective EP additive used by formulators to improve the 4-ball weld point and Timken OK load of greases. Table 1 below demonstrates the typical EP performance of **VANLUBE 73** in a simple lithium grease.

TABLE 1: VANLUBE® 73 IN LITHIUM 12-HYDROXYSTEARATE GREASE

ADDITIVES:	MASS %
VANLUBE 73	4.00
VANLUBE RI-BSN	0.35
CUVAN® 484	0.25
PROPERTIES:	
ASTM D217 Penetration Worked: 60 Strokes	287
Worked: 10,000 Strokes	292
ASTM D566 Dropping Point, °C	190
ASTM D2509 Timken Pass, lbs.	50
ASTM D2596 4-ball EP Weld Point, kgf	315
ASTM D2266 4-ball Wear, Scar Diameter, mm	0.60
ASTM D1743 Rust Test	Pass
ASTM D942 Grease Oxidation PSI Loss: 100 hours	8
ASTM D130 Copper Corrosion 100°C, 24 hrs.	1b

Note: **VANLUBE RI-BSN** is a barium sulfonate based rust inhibitor. **CUVAN 484** is a DMTD-based copper corrosion inhibitor.



VANLUBE® 73 Super Plus - provides balanced performance in both EP and antiwear properties in a grease. Table 2 compares the performance achieved by **VANLUBE 73 Super Plus** at reduced antimony content to a combination of **VANLUBE 73** (SbDTC) and **VANLUBE AZ** (ZnDTC), in a lithium complex base grease.

TABLE 2: COMPARISON OF VANLUBE® 73 SUPER PLUS WITH VANLUBE 73 AND VANLUBE AZ IN A LITHIUM COMPLEX BASE GREASE

COMPONENT:	MASS %	
VANLUBE 73 Super Plus	2.50	0.00
VANLUBE AZ (Zinc DTC)	0.00	1.00
VANLUBE 73 (Antimony DTC)	0.00	4.00
Antimony DTC Content, m%	1.00	2.00
ASTM D2266, 4-ball Wear, mm	0.54	0.60
ASTM D2596, 4-ball EP, Weld Point, kgf	400	400
ASTM D2596 4-ball EP, LWI, kgf	59	59
ASTM D2509, Timken OK Load, lb	90	90
ASTM D217 Penetration, 60 Strokes	325	326

VANLUBE 73 Super Plus at 2.5% exhibits comparable performance to a simple blend of 4% **VANLUBE 73** with 1% **VANLUBE AZ**

VANLUBE 8610 - provides excellent EP performance with low odor. It is 100% active with no diluent oil. Typical EP performance in a simple lithium grease is shown in Table 3.

TABLE 3: EP PERFORMANCE OF VANLUBE® 8610 IN A LITHIUM GREASE

ADDITIVES:	MASS %
VANLUBE 8610	2.00
VANLUBE RI-BSN	1.00
CUVAN® 484	0.25
PROPERTIES:	
Timken OK Pass, lbs. ASTM D2509	85
4-ball EP Weld Point, kgf ASTM D2596	315
LWI, kgf	41.3
4-ball Wear, Scar Diameter, mm ASTM D2266	0.58
Rust Test ASTM D1743	Pass
Oxidation ASTM D942	
PSI O ₂ Loss @ 100 hours	1.5
500 hours	10
Copper Corrosion @ 100°C, ASTM D130	1b
Note: VANLUBE RI-BSN is a barium sulfonate based rust inhibitor. CUVAN 484 is a DMTD-based copper corrosion inhibitor.	

DITHIOPHOSPHATES

SUMMARY

VANLUBE® 622 and **MOLYVAN® L** are both metal dialkyl dithiophosphates (DTP). **VANLUBE 622** is an antimony-based EP additive for grease, while **MOLYVAN L** is a molybdenum-based anti-wear and friction-reducing additive which will not compromise the EP efficiency of other EP additives.

VANLUBE 622 - an antimony dialkyl dithiophosphate (SbDTP). As one of the several organo-antimony EP additives offered by Vanderbilt Chemicals, it can provide excellent EP performance to a grease. In addition to EP functionality, it also provides very good anti-wear performance due to its dithiophosphate functional group.

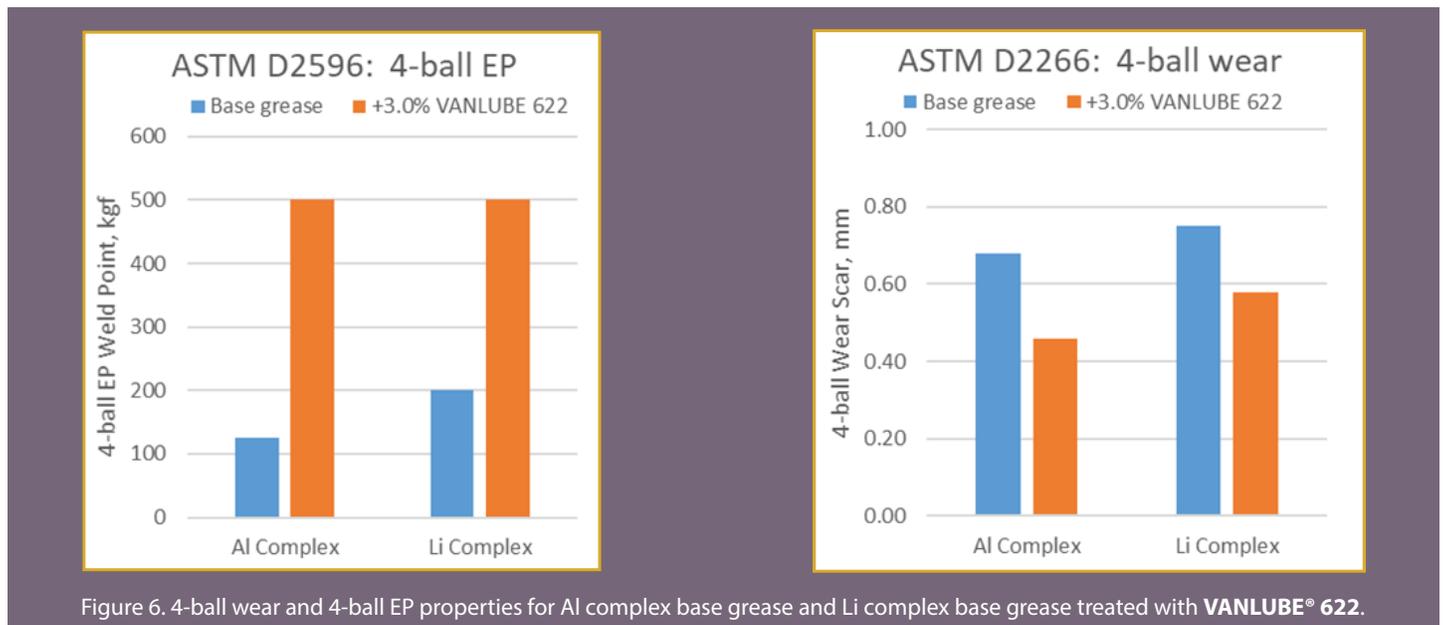


Figure 6. 4-ball wear and 4-ball EP properties for Al complex base grease and Li complex base grease treated with **VANLUBE® 622**.



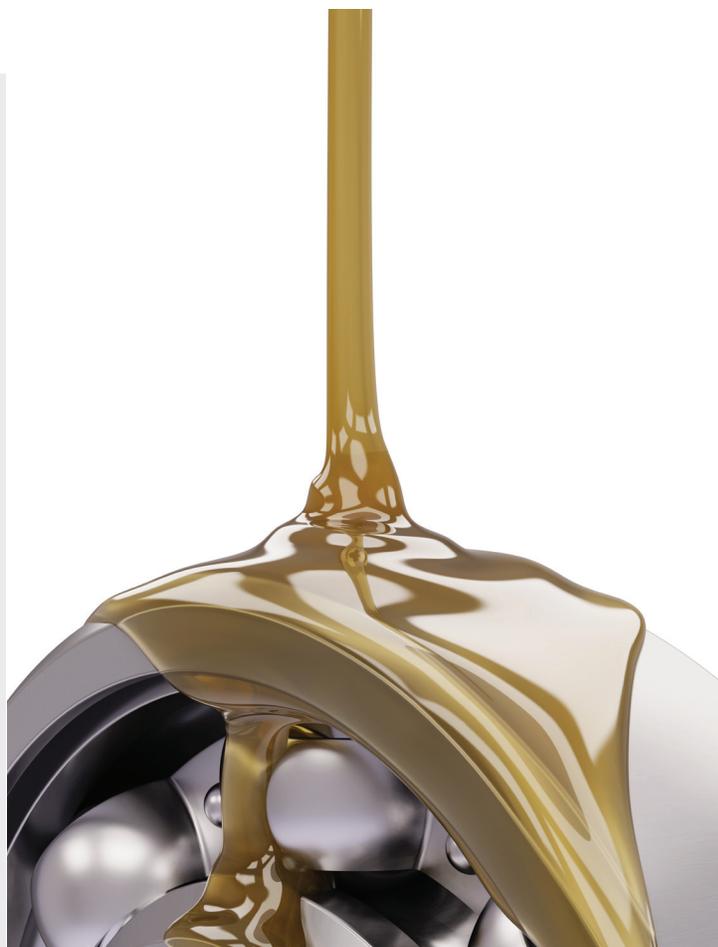
MOLYVAN® L is preferentially used as an anti-wear and friction-reducing additive. When it is used with DMTD derivatives, such as **VANLUBE® 829** and **VANLUBE 972M**, **MOLYVAN L** brings improved friction and wear performance without compromising the EP performance of a lithium complex grease, as shown in Table 4 below.

TABLE 4: COMPARISON OF THE PERFORMANCE OF TWO EP GREASE ADDITIVES, VANLUBE® 829 AND VANLUBE 972M, WITH AND WITHOUT THE ADDITION OF MOLYVAN® L REGARDING FRICTION, WEAR AND EXTREME PRESSURE PERFORMANCE IN A LITHIUM COMPLEX BASE GREASE

GREASE FORMULATION	ASTM D2266: 4-BALL WEAR, MM	COEFFICIENT OF FRICTION*	ASTM D2596: 4-BALL EP, WELD POINT, kgf
Li Complex Base Grease	0.552	0.119	126
+2.0% VANLUBE 829	0.650	0.113	400
+2.0% VANLUBE 829 + 1.0% MOLYVAN L	0.461	0.077	400
+1.0% VANLUBE 972M	0.685	0.105	250
+1.0% VANLUBE 972M + 1.0% MOLYVAN L	0.412	0.064	250
+2.0% VANLUBE 972M	0.766	0.086	315
+2.0% VANLUBE 972M + 1.0% MOLYVAN L	0.418	0.060	315

*Average of coefficient of friction measured by the 4-ball test machine with torque gauge

Vanderbilt Chemicals, LLC provides a wide range of grease EP additives which are specially designed to provide protection under extreme high load conditions and prevent the welding between the metal surfaces. When used at appropriate treat rates, these EP additives can help to meet most EP performance specifications, including the new specification of HPM + HL. For information about EP additive options or the new HPM + HL requirements, please talk to a Vanderbilt representative in your area.





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