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Grease Compatibility for Biobased-Biodegradable Greases

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Introduction

Biobased greases are no longer considered new. For nearly 25 years numerous products have been commercially in use and on the market. Many of the commercially popular biobased greases are used in niche end uses like rail curve, drill rod, wire rope and other lost-in-use applications. But there are also biobased greases that are used in vehicle bearings and chassis and reside in the equipment for an extended period of time. Those applications present the possibility of comingling biobased greases with other greases. That is when a truck terminal, for example, regreases the bearings of a truck with a different grease than the grease that is already in the bearing, a small amount of the old grease will remain and will comingle with the new grease. This report is an excerpt of a full study that was presented and published earlier in the NLGI Spokesman. Using the ASTM D6185 test methods, the grease mix ratios ranging from 0-100 at selected increments were tested.

ASTM D6185 "Standard Practice for Evaluating Compatibility of Binary Mixtures of Lubricating Greases". This method provides a protocol for evaluating the compatibility of binary mixtures of lubricating greases by comparing their properties or performance relative to those of the neat greases comprising the mixture. The standard properties to be tested are: (1) ASTM D566 Test Method for Dropping Point (or Test Method D2265); (2) ASTM D217 Test Method for Shear Stability using a Grease Worker instrument and by 100,000-stroke worked penetration; and (3) by ASTM D217 Test Method for Storage Stability at Elevated-Temperature by change in penetration after being worked 60-strokes in a Grease Worker.

Two test approaches can be used. In one approach, two greases are mixed at a ratio of 50:50 by mass and then evaluated for changes in their dropping point, shear stability and storage stability. If the mixture passes all three tests, then the 90:10 and 10:90 mixtures are also prepared and tested the same way. However, if the 50:50 mixture fails any of the three tests, then the 90:10 and 10:90 mixtures are not further tested. Incompatibility is most often revealed in the test results of 50:50 mixtures and no testing of mixtures with smaller ratios would be necessary.

In a second approach initially three mixtures are made at 10:90, 50:50, and 90:10 and all three mixtures are tested concurrently. No matter which approach is used, if any of the three mixtures fail any of the primary tests, the greases in that mixture are considered incompatible and no further testing need be completed. If all mixtures pass the three primary tests, the greases are considered compatible and may proceed to non-mandatory secondary testing.

Secondary tests are determined based on the circumstances and/or desired application of the greases. The following flowchart illustrate the testing process for this report:

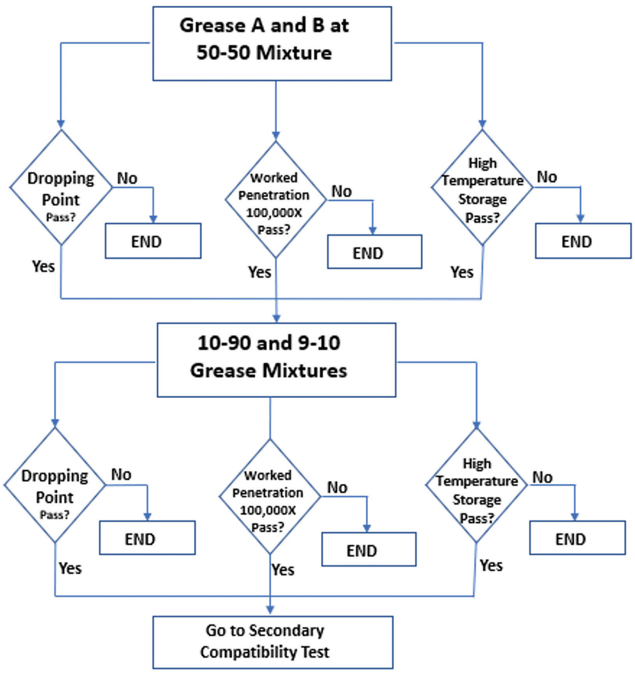

***Figure 1:** Flowchart for Sequential Testing from ASTM International*

Greases selected

Studies of compatibility have primarily dealt with mineral oil base greases made with different thickeners. Since the interaction of additives especially at higher temperatures could play a major role in compatibility of the grease, the greases selected for this study were fully formulated commercial products. Until the effect of different additives on each other can be studied separately, the compatibility of the greases selected here may be considered as a reference for screening purposes. The following two mineral oil-based greases and three biobased greases were numbered for identification as follows:

1. Biobased EP Premium (NLG GC-LB rated) – Lithium Complex Grease
2. Biobased EP Plus (NLGI LB rated) – Lithium Complex
3. Biobased Aluminum Complex – Food Machinery (NSF registered)
4. Mineral Oil-based Polyurea Grease (NLGI GC-LB rated)
5. Mineral Oil-based Lithium Complex (NLGI GC-LB rated)

Table 1 shows the abbreviated technical data for the selected greases as published by their respective manufacturers.

1. Biobased Li Complex Grease #1	
NLGI Grade	1
Appearance	Red
Cone Penetration, Worked 60 Strokes (mm/10)	310-340
Four Ball Wear Scar (mm)	0.47
Four Ball Weld Load (kg)	500
Water Resistance @80°C (% loss)	11.6
Base Oil Viscosity at 40°C (cSt)	86
Base Oil Viscosity at 100°C (cSt)	16
Base Oil Flash Point (°C)	326
Base Oil Biodegradability	Pass
Base Oil Aquatic Toxicity	Non-toxic
2. Biobased Li-Complex Grease #2	
NLGI Grade	2
Appearance	Red
Cone Penetration, Worked 60 Strokes (mm/10)	260-290
Four Ball Wear Scar (mm)	0.5
Four Ball Weld Load (kg)	600
Base Oil Viscosity at 40°C (cSt)	86
Base Oil Viscosity at 100°C (cSt)	16
Base Oil Flash Point, (°C)	326
Base Oil Biodegradability	Pass
Base Oil Aquatic Toxicity	Non-toxic
3. Biobased Al Complex Food Machinery	
NLGI Grade	1
Appearance	Golden
Cone Penetration, Worked 60 Strokes (mm/10)	340
Four Ball Wear Scar (mm)	0.48
Four Ball Weld Load (kg)	200
Corrosion, ASTM D-1743	Pass
Base Oil Viscosity at 40°C (cSt)	40
Base Oil Viscosity at 100°C (cSt)	8.6
Base Oil Viscosity Index	213
5. Mineral Oil-Based Multi-Purpose SD Polyurea Grease	
NLGI Grade	2
Appearance	Green
Cone Penetration, Worked 60 Strokes (mm/10)	275-295
Dropping Point (°C)	260

***Table 1:** Technical Data for Test Greases*

The mixing of these five neat greases (Biobased : Mineral Oil-based) resulted in six mixtures using numbers associated with these five greases:

6. 50:50 of Grease 1 : Grease 4
7. 50:50 of Grease 1 : Grease 5
8. 50:50 of Grease 2 : Grease 4
9. 50:50 of Grease 2 : Grease 5
10. 50:50 of Grease 3 : Grease 4
11. 50:50 of Grease 3 : Grease 5

The eleven total samples were tested for Dropping Point, Sheer Stability, and High-Temperature Storage Stability properties. The latter should be helpful to determine the impact of heating on mixture of two different greases.

Table 2 shows changes in the penetration values of neat and mixed greases before and after heating and test in a Grease Worker at 60 up and down strokes. For high-temperature storage stability, the sample grease was twice worked 60X and then its penetration value was determined: once without heating and once after storing at 120°C heat for 70 hours. The change in these penetration values was calculated on both the neat greases and grease mixtures.

If the change in the penetration value of the mixture was equal to or between the changes of the constituent greases, the greases were considered compatible. If the change in the penetration value of the mixture was less than the lower constituent grease value or greater than the higher constituent grease value by 7 points or less, the greases were considered borderline compatible. If the change in the penetration value of the mixture was less than the lower constituent grease value or greater than the higher constituent grease value by more than 7 points, the greases were considered incompatible.

Figures 2 and 3 show examples of the appearance of a grease after being worked 100,000X (this is 100,000 down and up strokes).

Figures 4 and 5 show an example of the appearance of greases after they had been subjected to 120°C heat for 70 hours. Those greases were then worked 60X and were compared to the 60X Worked Penetration results of the same grease mixture that had been heated, thus providing the high-temperature storage stability results.

Grease Number and Name	High Temperature Expsoure for Storage Stability Performance		
	Penetration 60X unheated	**Penetration 60X Heated**	**Change in Penetration Values**
1. Bio-Grease Lithium Complex	314	264	50
2. Bio-Grease Lithium	256	222	34
3. Bio-Grease Food Grade Aluminum Complex	329	311	18
4. Mulit-Purpose Polyurea Grease	263	258	5
5. Multi-Purpose HD Lithium Complex	271	265	6
6. Mixture of Grease 1 & Grease 4 at 50:50	344	263	81
7. Mixture of Grease 1 & Grease 5 at 50:50	303	273	30
8. Mixture of Grease 2 & Grease 4 at 50:50	312	303	9
9. Mixture of Grease 2 & Grease 5 at 50:50	280	286	-6
10. Mixture of Grease 3 & Grease 4 at 50:50	333	327	6
11. Mixture of Grease 3 & Grease 5 at 50:50	285	311	-26

Table 2: *High Temperature Storage Performance of Test Greases Neat and Mixed*

Figure 2

Figure 3

Figure 4

Figure 5

Summary and conclusions

Commercially available biobased and conventional greases were tested to determine the impact of their mixing on their performance. While some past studies have used un-additised greases for compatibility testing, this study used fully formulated greases. The interaction of additives used in two different greases especially at higher temperatures could play a major role in compatibility of the grease.

The diversity of additives used in different greases on the market and how they may interact with each other when comingled together is an uncontrolled variable.

So, until the effect of different additives on each other can be studied separately, the compatibility of the greases selected here may be considered as a reference for screening purposes.

Biobased Grease 3, Biobased Al Complex, was either borderline compatible or incompatible with both mineral oil-based greases. This could be because it is intended for a different purpose, being the only food grade of the selected greases, and uses a different thickener, aluminum vs. lithium and polyurea.

Alternatively, the other two biobased greases (1 and 2), both lithium greases, were either compatible or borderline compatible with both mineral oil-based greases (4 and 5). In fact, both of the biobased lithium complex greases were compatible with the polyurea mineral oil-based grease (4), whereas only the NLGI GC-LB rated biobased lithium complex grease (1) was compatible with the mineral oil-based lithium complex grease (5).

The LB rated biobased lithium complex grease (2) was only borderline compatible with the mineral oil-based lithium complex grease (5) after being worked 100,000X and the penetration value of that mixture.

Overall Compatibility	4. Mineral Oil-based Polyurea (GC-LB)	5. Mineral Oil-based Li Complex (GC-LB)
1. Biobased Li Complex (GC-LB)	Compatible	Compatible
2. Biobased Li Complex (LB)	Compatible	Borderline Compatible
3. Biobased Al Complex	Borderline Compatible	Incompatible

Table 3: *Compatibility Results of Test Grease*

Dr. Lou Honary*, currently President of Environmental Lubricants Manufacturing, Inc. (ELM) is an emeritus professor and founding director of Agriculture-Based Lubricants Center at the University of Northern Iowa. A leading expert in biobased grease and lubricants, Honary has numerous presentations and publications including a book on biobased lubricants, published by Wiley Publications. Honary is active member of several organizations and has served a member of the board of directors on several organizations including National Lubricating Grease Institute and International Fluid Power Society.*

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