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Rail Technologies

Overview of Biodegradable, Petroleum and Synthetic Rail Greases

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Grease contains three main groups of raw materials: base oils, thickeners and additives. The base oils are the major component of the grease, often greater than 85% concentration. The strength and quality of the oils are directly related to grease film durability. The higher the propensity for the base oil to be oxidized or "burned off" under wheel-rail conditions, the less carry down and gauge face/gauge corner protection you will receive from the grease. L.B. Foster has the ability to differentiate rail grease performance using specialized testing instruments that simulate contact dynamics at the wheel-rail interface. This technical proficiency combined with grease chemistry knowledge, enables us to differentiate performance of multiple grease types. This paper reviews the performance differences under wheel-rail conditions of biodegradable, petroleum and synthetic rail curve greases.

Chemical Background

There are three major classes of base oils used in grease for rail applications: Synthetic oils, Petroleum oils and Biodegradable oils. Synthetic oils and petroleum oils are strictly carbon based oils, whereas biodegradable oils contain carbon and oxygen. The carbon-oxygen linkage is weaker than the carbon-carbon linkage, which is why biodegradable oils are able to break down in the environment quicker than petroleum or synthetic oils. This also makes biodegradable oils or their parent greases more susceptible to oxidation and breakdown under the extreme pressures, creep and temperatures at the wheel-rail interface. Furthermore, biodegradable greases tend to be formulated with no or weaker solid lubricants than used in conventional petroleum greases. This is to increase biodegradability properties, but makes the grease more susceptible to breakdown under railway traffic. Petroleum oils are sourced from refineries, and can vary in performance depending on the quality of the refinement. The higher the amount of refinement, the purer the oil is, with less propensity to break down when exposed to high pressures and temperatures. Synthetic oils are man-made oils and are the purest forms of oils available. Highly refined petroleum oils can be referred to as synthetic because the purity often matches that of a synthetic product.

Laboratory Performance Testing

L.B. Foster has three greases that incorporate the three different classes of oils: BIOCURVE™ (biodegradable oil), PROCURVE™ (higher end petroleum oil), and SYNCURVE™ (highly refined oil, synthetic). As a representative sample, BIOCURVE™, PROCURVE™, and SYNCURVE™ were performance tested using a twin disk machine that simulates the slip (creep), speeds and pressures at the wheel-rail interface (Figure 1). The outcome of this test represents the product retentivity, or the length of time the grease lasts under the simulated wheel-rail interaction. Retentivity testing of greases using twin disc instrumentation has been shown to correlate very well with product carry down in field trials.[i] The retentivity of the greases matches the quality of the base oil used. BIOCURVE™ has the poorest performance, and is expected to have poorer film durability in the field in comparison to PROCURVE™ or SYNCURVE™. Twin disc testing further indicates that SYNCURVE™ will have the longest carry down in the field compared to the biodegradable and petroleum greases.

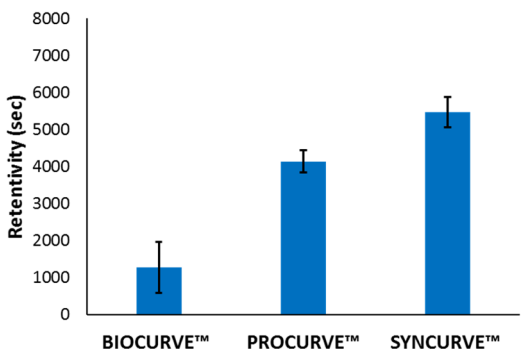

Figure 1. Twin disc testing results for SYNCURVE™, PROCURVE™ and BIOCURVE™.

Field Performance Testing

A large field study of rail curve greases was performed on a highly curved, high tonnage freight railroad in semi-desert conditions.[ii] The test involved petroleum and biodegradable greases from multiple suppliers (synthetic was not included), and compared their ability to protect the gauge face/corner. The greases were applied at the same application rate, with rail coefficient of friction (CoF) measurements recorded using a high speed tribometer. The lower the CoF measured, the better performing a grease is, providing greater protection to the rail gauge face/corner. Figure 2 shows average CoF results for each grease, measured 3.2-4.8 km from the application site. Greases E and F were labelled biodegradable from the suppliers and show a higher CoF value than most of the petroleum greases. This data confirms gauge face/corner rail wear will occur faster when using biodegradable greases compared to most petroleum greases. The large variability in performance for the petroleum greases is most likely due to differences in the quality of oil used to manufacture each grease. PROCURVE™ uses a higher end petroleum oil and demonstrated the best performance during this test (Grease A).

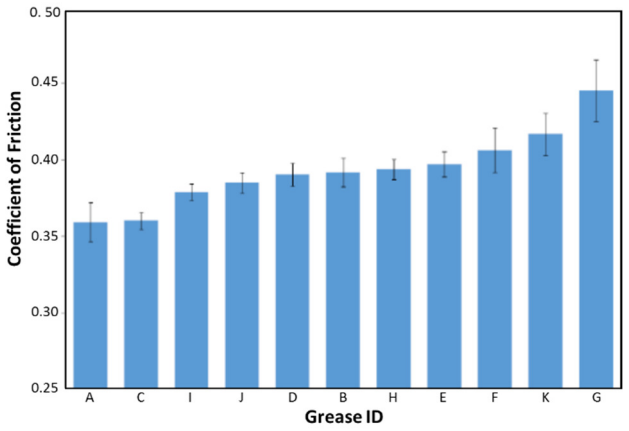

Figure 2. Average friction level for different greases 3.2-4.8 km from application site. Greases E and F were labelled biodegradable by the suppliers. Grease A is PROCURVE™.[ii]

Environmental Considerations

For railroad greases, there are many environmental concerns considering residual grease will inevitably end up in the railway corridor. The OECD 301B test is widely accepted as a method to classify the biodegradability of a grease. Table 1 shows the suite of L.B. Foster greases and their biodegradability rating. As expected, BIOCURVE™ has the highest rating ("Readily"). Although considered a synthetic grease, SYNCURVE™ has a rating of "Ultimately" biodegradable. Ultimately biodegradable means the product is expected to completely breakdown in a reasonable amount of time, whereas, "Inherently" biodegradable reflects a product that will experience some degradation but ultimately exist in the environment for quite some time. It is expected that most petroleum greases will have the "Inherently" biodegradable rating. The higher biodegradability rating for SYNCURVE™ stems from the purity of the oil - This rating should apply for other true synthetic greases.

Grease	Biodegradability Rating
BIOCURVE™	Readily
PROCURVE™	Inherently
SYNCURVE™	Ultimately

Table 1. Biodegradability ratings for greases (Summer grades are considered for BIOCURVE™ and PROCURVE™). Based on OECD 301B Biodegradability testing.

Summary

Biodegradable greases: Biodegradable greases have inferior carry down and film durability than petroleum or synthetic-based greases. In consideration of this, biodegradable greases are not recommended for freight applications as the heavier axle loads will produce more rapid breakdown of the material to adversely impact grease carry down performance effectiveness. Biodegradable grease use in a freight railway environment should only be considered if required to accommodate more restrictive operating conditions such as track being in an environmental sensitive area or corporate purchase specifications mandating use of a bio-based product. Biodegradable greases, such as BIOCURVE™, are better suited for transit railways where axle loads and carry down requirements are smaller.

Petroleum greases: Petroleum greases comprise the majority of rail curve greases used in the railway industry. As discussed, there is a broad spectrum of performance effectiveness for these greases depending on the quality of base oil used, and other constituents incorporated. A good petroleum grease, such as PROCURVE™, would adequately protect a curve at cost-effective application rates. The primary shortcoming of a petroleum grease is they are less biodegradable than the other two classes of greases. Furthermore, the carry down of a petroleum grease will be inferior to that of a synthetic grease.

Synthetic Greases: Synthetic greases offer superior performance and overall best value for rail curve protection. SYNCURVE™ has been proven to require lower application rates compared to conventional petroleum greases used for L. B. Foster field trials. The lower rates produce additional benefits such as improved site cleanliness and less frequent visits to fill wayside applicators. The purity of the base oil used in SYNCURVE™ allows it to be classified as "Ultimately" biodegradable, with improved lower temperature operating properties. SYNCURVE™ is also considered an all season grease, eliminating the need for seasonal product switch outs. Although the unit cost of synthetic greases is typically higher than conventional petroleum greases (due to the higher quality base oils used), the total cost of ownership compared to all other greases is much lower when factoring in savings achieved from reduced application rates and fewer site visits for filling.

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[i] D.T. Eadie *et. al. J. Rail and Rapid Transit*, 227(3), 245-253, **2012**.

[ii] D. T. Eadie, *Field Evaluation of Multiple Gauge Face Lubricants: New Methods, Results and Economic Modelling*. Proceedings from the IHHA, June 21-24, **2015**.