Evaluation of Soybean Oil-Based Rail Curve Grease
at
The University of Northern Iowa Ag-Based Industrial Lubricants (UNI-ABIL) Research Program, Waverly, Iowa
Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), Pueblo, Colorado
and
Norfolk Southern Corporation, Roanoke, Virginia

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ABSTRACT

The University of Northern Iowa Ag-Based Industrial Lubricants (UNI-ABIL) Research Program requested Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR), Pueblo, Colorado, to perform an evaluation of two ‘winter-grade’ soybean oil-based rail curve greases. UNI-ABIL Research Program is a leading research and development facility for vegetable oil-based lubricants and greases. Soybean based greases developed by UNI-ABIL have been field tested and commercialized since 1998. The TTCI test was selected to verify lubricity performance and cold temperature pumpability characteristics of the UNI-ABIL rail curve greases. The test was followed by an actual field evaluation of the grease at Norfolk Southern’s Roanoke, Virginia facility.

A number of petroleum-based lubricants and greases applied by wayside applicators are used by railroads for gage face lubrication. The soybean oil-based rail curve grease was proposed to run in a comparative test with commercially available petroleum-based rail curve grease.

Soy oil-based rail curve greases present several advantages over petroleum-based products. They are biodegradable and the base oil has higher flash and fire points. The viscosity index is also significantly higher. Lastly, as a raw material, soybean oil is renewable and grown in the United States. With proper balancing of additives and manufacturing processes, performance may be further enhanced for needs specific to railroad users.

Because no railroad industry-wide performance specifications currently exist for rail lubricants, field performance is the most commonly used method for determining acceptability. Due to the variables and limited control encountered in revenue/service field testing, an evaluation using a closed loop train operation is typically the best way to compare the performance of rail lubricants.

The results indicated that soy grease remained pumpable at 10°F (-12°C). Also due to adherence and carrying properties, 50% less soy grease was used to achieve the same performance level of the conventional grease. In order to further confirm the results, the researchers recommended that follow up tests in actual field trials be performed.
A field test with the summer version of the grease was performed at Norfolk Southern, Roanoke, Virginia test site. The results confirmed similar carry and lubricity properties as observed at the TTCI tests.

BACKGROUND

It is estimated that approximately 9 million pounds of rail curve grease is used by US railroads. The grease is primarily applied to the side of the track, around the curves, to reduce friction between the wheel flange and track gage face. Furthermore, the grease reduces the noise pollution, which is often high pitched and troublesome in urban areas. Some [smaller] railroads go one step further and grease the entire length of the track including straight-aways. The purpose is to reduce drag created by the swaying train and thus improve the fuel savings. Some claim as high as 15% reductions in fuel consumption, which while logically plausible, requires further investigation and documentation.

The majority of the grease is applied to curves on tracks; the repeated application to the short distances, 1-3 miles, over the years could create long-term environmental concerns. Railroads have been using mats under the wayside grease applicator bars where equipment maladjustments could create large quantities of overflow. The curves themselves do not have mats and overall the large quantity of grease applied to these short distances repeatedly could overwhelm the environment’s ability to biodegrade these products.

Biodegradable lubricants and greases have been in use for some time. Due to the higher cost of petroleum, and concern for the environment, Europeans began requiring the use of biodegradable lubricants in the 1980’s. The European agricultural community also lobbied to promote legislation requiring biodegradable products in their countries. There has been an inherent interest in biodegradable products by companies with an inclination toward environmental stewardship. Management concern for long-term and retroactive liabilities and regulations too may be an impetus for use of biodegradable products. Generally the higher cost of these products and a lack of overt mandates or incentives have slowed propagation of these products. Even standard setting organizations such as the American Standards for Testing and Materials (ASTM), the Organization for Economic Cooperation and Development (OECD), and the Environmental Protection Agency (EPA) have struggled with definitions and standards for biodegradability. ASTM committees struggled with the term ‘biodegradable’ due in part to difficulty in reaching a consensus on the level and the amount of biodegradability.

In the early 1990’s, the US agricultural community began a more concentrated effort to push for “new uses” of their products in the “non-food” lubricants and fuels industry. Patterning after the European model, there has been research funding, preference legislation, and product introductions promoting the use of these alternative products.
Also since the early 1990’s, the federal government has introduced several initiatives in order to promote the use of renewable products within federal agencies. For example, in 1993 Executive Order 12873 was signed and passed to the EPA to establish a list of Environmentally Preferred Products (EPP) issuing guidance and serving as a point of contact for government agencies. In 1998 an Executive Order (13101) was signed to “Green the Federal Government”. This time the United State’s Department of Agriculture (USDA) was assigned to work with developers and producers to establish a list of products that compliment the EPP profiles.

In order to avoid the controversy surrounding the term “biodegradable”, the USDA introduced a new term “Biobased” for products that were comprised of 51% or more natural “bio” materials. USDA’s biobased products were inclusive of fuels, adhesives, composites, construction materials, paper, fluid lubricants, and greases. In 1999 Executive Order 13134 was signed and allocated to USDA and the United State’s Department of Energy (DOE) to encourage an increase in research and development activities in order to triple the use of biobased and bioenergy products by the year 2010. The ultimate goal set for these agencies involves a total use increase of 50% by the year 2050.

During the 1990’s the US government’s leadership by example approach to using biobased products within the federal government served as a means of encouraging private industry use. Executive Order 13134 put more emphasis on a long-term national strategy to create homegrown alternatives.

As a matter of national interest with a goal of increasing renewable products and reducing dependence on imported oil, biobased and bioenergy products are getting special attention. The recently signed Farm Bill (May 2002) contains an impressive array of funding support for research development and commercialization of biobased products. The USDA will soon be creating labels for products identifying them as meeting USDA Biobased criteria. To increase product acceptance, the USDA is contemplating accepting products that have less than 51% biobased materials, but classifying them with identifiers, thus giving the products a chance for market entry. On the bioenergy side, both ethanol and soy diesel are beginning to increase market shares. Correspondingly, biobased lubricants and greases are expected to realize market growth in the near future.

INTRODUCTION

The University of Northern Iowa’s Ag-Based Industrial Lubricants (UNI-ABIL) Research Program is entering its twelfth year with the primary mission of expanding the market for soy industrial products. Initially funded by the Iowa Soybean Promotion Board, the Program has been receiving funding from Iowa legislature, USDA, industry and corporate sponsors. The Program has gained national prominence due to its specific focus in vegetable oil-based lubricants. Over two dozen specialty lubricants, greases and base oils have been commercialized and are being supported by Program staff.
A major shortcoming of most vegetable oils, and especially soybean oil, is their lack of oxidative stability. If untreated, either in use or on the shelf, these products would oxidize, which shows in rancidity, and increase in viscosity (thickening) in the short-term. Long-term, or in extreme cases, the untreated or poorly prepared product would polymerize and the resulting tacky material could damage equipment.

In the beginning UNI-ABIL relied on chemical modifications of soybean oil and inclusion of anti-oxidants to stabilize the oil for use in industrial products. These approaches, however, increased the cost of the finished products, which has been a barrier to wide-market use. A new variety of proprietary soybeans have been developed by DuPont subsidiaries that practically eliminate oxidative stability shortcomings of the soybean oil. This “high oleic” soybean oil has shown to be at least 27 times more stable than conventional soybean oils. In oxidation tests performed at UNI-ABIL, the high oleic soybean oil proved to be five times more stable than most of the vegetable oils used in Europe and Canada such as rapeseed and canola respectively.

The new variety of soybean oil has allowed UNI-ABIL researchers to create products that require less expensive but high processing temperature. Rail Curve greases are typically lithium based and require reaction temperatures as high as 230ºC (446ºF). Since the high oleic soybean oil is stable enough to withstand these temperatures, the resulting product can be produced at prices approaching those of their petroleum counterpart.

Vegetable oils, due to their polar nature, adhere to metal surfaces better than petroleum oils. They have high flash and fire points; soybean oil has a flash point of 621ºF (327ºC) and a fire point of 665ºF (352ºC). By comparison typical petroleum based oil such as Neutral 100 has a flash point of 390ºF (199ºC).

Vegetable oils also have a high Viscosity Index (220 for soybean oil), which is an indication of how stable the viscosity is with respect to changes in temperature. In comparison, Neutral 200 petroleum oil has a Viscosity Index of 95.

Furthermore, vegetable oils are less volatile; they have a high thin film strength, which reduces metal-to-metal contact under heavy loads, and superior lubricity as compared to petroleum oils. Combining the high oleic soybean oil, which is the best genetically enhanced soybean oil, with over a decade of research and formulation experience has resulted in the development of an array of lubricants that promise to deliver superior performance at comparable prices. UNI-ABIL’s focus is centered on ensuring commercial success of the product line of greases for both the trucking and railroad industry in addition to a series of metalworking lubricants.

With all their benefits, vegetable oils suffer in performance below freezing temperatures. Above freezing their viscosity index helps them perform well at very high temperatures without thinning. Methods to overcome this problem include winterization and blending with other biodegradable materials that have low freezing points. UNI-ABIL has developed greases that have flowability at -7ºF (-22ºC) and specialty lubricants with cold temperature performance as low as -65ºF (-54ºC).
The TTCI test was carried out in order to provide evidence of the concept in a controlled environment. Two versions of the cold temperature soy grease were tested against commercially available petroleum based grease. A modified version of the same grease was later field tested at Norfolk Southern’s Roanoke test yard.

**GREASE PREPARATION**

The test was scheduled at Transportation Technology Center, Inc., a subsidiary of the Association of American Railroads. The evaluation was planned for the night of January 28, 2002. A review of climatic data for the test area indicated temperatures ranged from -7°F (-22°C) to 20°F (-7°C). Two soy-based greases were prepared: Version A contained mixtures of fluids that were formulated for cold temperatures and Version B that was formulated for extreme cold.

The third (control) grease was winter-grade petroleum grease. This grease was in use at Norfolk Southern Railroad and was the base line used in this test.

**LABORATORY TESTING METHODS**

Version A and B were tested in the lab prior to the TTCI testing to measure cold temperature characteristics, i.e., adherence, tackifier performance and pliability, using the following methods:

**Test Method 1.** For the evaluation of grease flowability characteristics the Lincoln Ventmeter can be used. The Ventmeter is comprised of 25 ft of coiled copper tubing. It contains a valve and grease fitting at one end and a valve and gauge on the other end. With both valves open the unit is charged with the grease sample, which is at its expected operating temperature. Both valves are closed and the unit is charged with additional grease until a pressure of 1800 psi is achieved in the tubing. With the gage reading 1800 psi the valve is opened and the grease is allowed to vent for 30 seconds. The gauge reading is recorded. A grease that fails to flow at such temperatures would either not pump at all which is indicated by no change in the pressure gage or would create a slow flow as indicated by gradual drop in the pressure gage.

This was the method of evaluation chosen to determine cold temperature characteristics. Tubes containing the three greases were placed in a freezer set at -7°F (-22°C). A hand-operated grease gun was used to pump the grease through the coiled tubing at that temperature. The unit was charged with additional grease until 1800 psi was obtained. The valve at the dead end of the tube was opened for 30 seconds and the pressure was recorded.

**Test Methods 2.** Each of the greases were placed in a grease tube and left in a freezer, which was set to -7°F (-22°C) until the temperature stabilized. The wayside lubricator and bar were placed outside in temperatures ranging from approximately 15 to 20°F (-9 to -6°C). The individual tubes were removed from the freezer and placed in a grease gun,
which was attached to the wayside lubricator. The grease was pumped and the backpressure in the applicator was monitored while observing grease flow within the lubricator (Figure 1).

![Figure 1: Wayside Lubricator with Gage for Monitoring Back Pressure](image1)

Test Method 3. Version A and B greases were placed in individual plastic pails and the pails were placed in a freezer set to -7°F (-22°C) until their temperatures stabilized. The pail of Version A grease was emptied into a Portec Rail Products, Inc. wayside electric lubricator (Figure 2). The lubricator was positioned outside of the UNI-ABIL facility and subjected to an ambient temperature of approximately 18°F (-8°C). The same procedure was followed for Version B grease.

![Figure 2: Portec Electrically Operated Wayside Lubricator](image2)

Test Method 4. A grease gun containing a tube of Version A grease was placed in a freezer until the temperature was stabilized at -7°F (-22°C). The grease was subsequently applied to a rotating 8-inch flanged wheel. This test was utilized to determine adherence of the grease to the surface of the rotating flanged wheel. Using the control grease as reference, each of the tests greases was applied to the flanged wheel to observe
adherence. Both the temperature and the speed of the wheel were adjustable. The speed was calculated to equal a 45 mph speed for a 42” flanged wheel, Figure 3.

Figure 3: 8” Flanged Wheel on Variable Speed Shaft

**Test Method 4.** All three greases were tested in a centrifuge fitted with a 19” aluminum plate. The plate was marked in 1-inch increments. Approximately 5 grams of grease was placed on a selected increment and rotated at 500 rpm. The distance traveled was measured. This test was used to determine how the tackiness of the grease affected adherence to a high speed-rotating wheel. Each of the test greases was compared with the control grease (Figure 4).

Figure 4: 19” Aluminum Wheel in Centrifuge

Finally, in order to ensure the grease showed stable performance after storage, the greases were placed in the heated laboratory for 24 hours to stabilize (thaw out) and measured for
consistency. They were then returned to the freezer and after stabilizing at -7°F (-22°C) they were retested.

The commercially available petroleum-based grease could not be used as a comparison in laboratory test Methods 1-4. It was solid at -7°F (-22°C).

**TCCI TESTING PROCEDURE**

After the laboratory testing of the sample greases, the products were sent to TTCI for evaluation. This evaluation was performed at the Facility for Accelerated Service Testing (FAST) High Tonnage Loop (HTL). The HTL (Figure 1) is a 2.7-mile loop containing 5- and 6-degree curves.

![High Tonnage Loop](image)

**Figure 5 – Key Features of the High Tonnage Loop**

The top of the inside rail in Section 25 of the HTL is lubricated with a small amount of heavy oil, leaving the gage face dry. This is required to maintain a balance of high- and low-rail lateral wheel/rail forces.

For this evaluation, Portec Rail Products, Inc. and the Burlington Northern Santa Fe Railway supplied a Portec wayside electric lubricator complete with 102-inch wiper bars. This wayside system was installed in Section 23 (Figure 5), a short section of tangent track, approximately 200 feet prior to the existing wayside lubricator site at the entry spiral of the 6-degree curve. The wiper bars were attached only on the outside rail of the loop. After the completion of testing on each lubricant, the tank was cleaned, lines were purged, and the tank was refilled with the next grease for evaluation. Heavy oil was applied to the top of the inside rail as mentioned above.
The test train consisted of four 4-axle locomotives with 62 trailing cars for the baseline lubricant and 59 trailing cars for the soybean oil-based grease. All cars were loaded to 315,000-pound weight on rail (39-ton axle load). All train passes during the evaluation were made in the counterclockwise direction at an average lap speed of 40 mph.

The primary performance indicator used to evaluate the effectiveness of a lubricant is rail friction. A hand-operated tribometer (Figure 6) was used to measure top of rail (TOR) and gage face (GF) coefficient of friction (COF) on the outside rail of the loop at three locations. COF measurements were primarily recorded at the beginning of Section 25 (Figure 5) approximately 1,000 feet from the location of the lubricator. COF was also periodically measured at the end of Section 25 and the end of Section 03 (Figure 1XX).

Two Grade 1 soybean oil-based greases, labeled Versions A & B, were supplied for testing. Both greases were "winterized" through the use of additives to pump at temperatures of down to zero degrees Fahrenheit. The primary difference between the two versions was that Version B had more additives to increase pumpability in yet colder temperatures.

![Figure 6: Hand-Held Tribometer Used to Monitor Coefficient of Friction](image)

**TEST CONDUCT AND RESULTS**

**Baseline Lubricant:** The evaluation began on the evening of January 28, 2002, using a currently accepted petroleum-based lubricant as a baseline. The following table outlines the test operations for the baseline lubricant.
Table 1: Baseline Lubricant Evaluation Train Operations

<table>
<thead>
<tr>
<th>LAP</th>
<th>CONDITION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>Dry/Baseline</td>
<td>Drying down track to establish baseline. Air temp 39°F.</td>
</tr>
<tr>
<td>11</td>
<td>Lubricator on</td>
<td>Turn on lubricator in Section 23. Air temp 37°F.</td>
</tr>
<tr>
<td>12-13</td>
<td>Lubricating</td>
<td>Excessive lubricant migrating to top of rail.</td>
</tr>
<tr>
<td>14</td>
<td>Lubricating</td>
<td>Reduce lubricator output due to top of rail contamination</td>
</tr>
<tr>
<td>15-89</td>
<td>Lubricating</td>
<td>Top of high rail showing contamination in Section 25. Air temp @ lap 60, 35°F.</td>
</tr>
<tr>
<td>89</td>
<td>Lubricator off</td>
<td>Turn lubricator off and begin dry down. Air temp 32°F.</td>
</tr>
<tr>
<td>90-107</td>
<td>Dry down</td>
<td>Lubricator off. Drying down track for following night.</td>
</tr>
<tr>
<td>108-109</td>
<td>Sanding</td>
<td>Sanding track to remove remaining lubricant.</td>
</tr>
<tr>
<td>110-119</td>
<td>Dry down</td>
<td>Complete train operations. Lubricant not completely removed from gage face.</td>
</tr>
</tbody>
</table>

The first 10 laps of train operations were run with all lubricators turned off. This was done to ensure the rails were dry and to establish baseline COF values with a dry rail. The lubricator was turned on after the 10th train pass. After 3 laps with the lubricator on, excessive lubricant contamination was detected on the top of the high rail at the beginning of Section 25. The lubricator output was reduced to prevent locomotive wheel slip. Train operations then continued without further adjustment to the lubricator until lap 89 when it was turned off to begin the dry down.

Figure 7 shows the COF measurements taken with the hand-operated tribometer for the baseline lubricant. Notice that loose metal flaking from the gage face due to dry rail conditions caused the low gage face COF values for the dry/baseline condition.
Table 2 shows the locations where the COF measurements were taken. The primary location for COF measurements was Section 25 tie 200, about 1,000 feet from the lubricator located in Section 23 and 350 feet into the 6-degree curve. Other measurement locations included Section 25 tie 1250 and Section 3 tie 1500.

Table 2: Baseline Lubricant Evaluation Measurement Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Train Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec. 25/tie 200</td>
<td>4, 9, 12, 13, 15, 18, 35, 38, 41, 60, 65, 71, 76, 81, 89, 91, 96, 102, 106</td>
</tr>
<tr>
<td>Sec. 25/tie 1250</td>
<td>20, 24, 27, 30, 32, 45</td>
</tr>
<tr>
<td>Sec. 03/tie 1500</td>
<td>48, 49, 54</td>
</tr>
</tbody>
</table>

Steady-state lubrication conditions were established within approximately 10 laps. TOR COF remained low (0.20) over the entire loop; however, no wheel slip was reported by the locomotive engineers. The gage face COF under steady-state conditions measured between 0.18-0.20. Ambient air temperature went from 37 degrees Fahrenheit at the beginning of the test to 32 degrees Fahrenheit at the end.

**Version A Soybean Oil-Based Grease**

Version A was evaluated on the evening of January 29, 2002. The following table outlines the test operations for the baseline lubricant.
Table 3: Version A Lubricant Evaluation

<table>
<thead>
<tr>
<th>LAP</th>
<th>CONDITION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-13</td>
<td>Lubricator off</td>
<td>Complete dry down from previous nights running. Air temp 20ºF</td>
</tr>
<tr>
<td></td>
<td>Dry/Baseline</td>
<td></td>
</tr>
<tr>
<td>14-16</td>
<td>Lubricator on</td>
<td>Turn lubricator on. Air temp 19ºF</td>
</tr>
<tr>
<td>17</td>
<td>Lubricating</td>
<td>Reduce lubricator output to match baseline test conditions</td>
</tr>
<tr>
<td>18-33</td>
<td>Lubricating</td>
<td>COF readings rising starting at lap 30</td>
</tr>
<tr>
<td>34</td>
<td>Lubricating</td>
<td>Checked lubricator tank. Lubrication cavitated. Stir lubricant and re-prime lubricator. Air temp 16ºF</td>
</tr>
<tr>
<td>35-51</td>
<td>Lubricating</td>
<td>Steady-state lubrication</td>
</tr>
<tr>
<td>52</td>
<td>Adjust</td>
<td>TOR contamination. Turn lubricator down and see if TOR COF rises while maintaining GF COF</td>
</tr>
<tr>
<td></td>
<td>Lubricator</td>
<td></td>
</tr>
<tr>
<td>53-75</td>
<td>Lubricating</td>
<td>Steady-state lubrication. Air temp 12ºF</td>
</tr>
<tr>
<td>76-95</td>
<td>Dry Down</td>
<td>Last measurement Lap 95. Begin sanding on lap 96 to prepare for next evaluation.</td>
</tr>
</tbody>
</table>

Laps 1-13 were run to complete the dry down from the baseline evaluation and to establish COF values for dry rail conditions. The lubricator was turned on after the 13th lap at the same output setting as the baseline lubricant. After three train passes, the output rate was reduced, again to match the setting of the baseline lubricant, to repeat the steps of the baseline lubricant evaluation. After 27 laps with no further adjustments, the COF values for both TOR and GF began to rise. The lubrication tank was inspected and cavitation was observed. (The primary cause of the cavitation was determined to have been that the lubricant was neither stirred when the tank was being filled, nor “sloped” from the center of the tank to reduce exposure to cold temperatures. Also, the 250-gallon lubricant tank was filled with only 40 gallons of the Version A grease.) The lubricant was stirred and the system re-primed. This was performed while the train maintained test speed.

Seventeen laps were then run to re-establish steady-state lubrication conditions. TOR COF measurements indicated contamination with values ranging between 0.18 and 0.22. The locomotives engineers reported no locomotive wheel slip. The gage face was well lubricated with COF values from 0.08 to 0.15. After the 51st lap of operations, the lubricant output was again adjusted down by 50 percent to reduce the TOR contamination and see if a well-lubricated GF could be maintained with the lower output rate. Laps 53 through 75 were run at the lower output rate. Steady-state measurements showed TOR COF from 0.27–0.29 and GF COF from 0.11– 0.12. Figure 3 shows the COF measurements taken with the hand-operated tribometer for Version A lubricant. Ambient air temperature went from 20 degrees Fahrenheit at the beginning of the evaluation to 12 degrees Fahrenheit at completion.
Table 4 shows the location where the COF measurements were taken. The primary location for COF measurements was Section 25 tie 200, about 1,000 feet from the lubricator located in Section 23 and 350 feet into the 6-degree curve. Other measurement locations included Section 25 tie 1250 and Section 3 tie 1500.

Table 4. Version A Evaluation Measurement Locations

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<td>13, 14, 15, 16, 17, 19, 21, 23, 31, 37, 42, 47, 56, 61, 66, 71</td>
</tr>
<tr>
<td>Sec. 25/tie 1250</td>
<td>26, 49, 73, 84, 93</td>
</tr>
<tr>
<td>Sec. 03/tie 1500</td>
<td>28, 51, 52, 75</td>
</tr>
</tbody>
</table>

**Version B Soybean Oil-Based Grease**

Version B was evaluated on the evening of January 30, 2002. As testing began, snow was falling heavy enough to affect COF measurements. The lubricator was turned on to check if Version B grease would cavitate as Version A did. The ambient air temperature at the beginning of testing was 21 degrees Fahrenheit falling to 10 degrees Fahrenheit at the end of testing.

The lubricator tank was inspected several times during train operations and no cavitation was observed. Because of the snow, no COF measurements were taken. However, observation and inspection around the HTL indicated the presence of lubricant on the gage face of the high rail.
DISCUSSION ON THE TTCI TEST

Results of the COF data for this evaluation indicate that the performance of the Version A soybean oil-based grease was comparable to that obtained with petroleum lubricant. Average steady-state GF COF for the baseline lubricant was 0.20. Average steady-state GF COF for Version A grease was 0.14, indicating slightly better GF lubrication. TOR contamination was measured at 0.20 for the baseline and 0.23 for Version A grease. However, when lubrication output was reduced with the Version A grease, as mentioned above, TOR COF rose to 0.28, while GF COF was maintained at 0.12.

During the evaluation of the Version A grease, the lubricant cavitated in the tank after 33 train passes. Ambient air temperature at the time of cavitation was 16 degrees Fahrenheit. After stirring the lubricant and re-priming the lubricator, no further cavitation occurred. When the grease was placed in the lubricator, the high-ambient temperature for the day did not go above 32 degrees Fahrenheit. The lubricant was also not sloped when the tank was filled. Version B of the soybean oil-based lubricant was stirred and sloped when filled and it did not cavitate during the evaluation even though it was exposed to colder daytime and evaluation period temperatures. Again, only 40 gallons of the Version B lubricant was put in the 250-gallon lubricant tank.

This evaluation was designed to control the number of variables when comparing the baseline grease with the soybean oil-based greases. This included running on the same track with the same train traveling in the same direction using the same lubricator. However, ambient air temperature variations and precipitation were both experienced during the course of this evaluation. On average, ambient air temperature was 20 degrees Fahrenheit warmer during baseline testing than when testing the soybean oil-based greases, with temperatures staying well above freezing for the baseline tests. Also, the ambient daytime air temperature was significantly warmer when the lubrication tank was full for the baseline grease. Precipitation when testing Version B grease prevented COF measurements from being obtained. Therefore, all references to Version B performance are observational.

FOLLOW UP FIELD TESTS

Due to the change in temperature a version of the same soybean oil-based grease with reduced winterization additive and a higher consistency (thicker) was prepared for testing at the Norfolk Southern Testing Facility in Roanoke, Virginia. The field test was conducted in the month of May 2002 and the temperature ranged from lower 40’s°F (4°C) to upper 60’s°F (16°C). This formulation allowed for both summer use and transitional periods in early spring or late summer.

The field test results appeared to correspond with the test preformed at TTCI. Where the FAST High Tonnage Loop at TTCI was 2.7 miles, the Norfolk Southern Track in the test section was open ended. The full report on the field test will be presented in the future.

Two 48” grease applicator bars were installed to each track and were attached to an identical Portec Electric Lubricator (Figure 9). The soy grease showed to pump well
even when small quantities (5-10) gallons were placed in the Portec Electric lubricator even though the movement of the grease on the lower portions of the slope sheets of the lubricator is minimal at low grease volume. The grease proved to adhere to track and carry to distances of 5 miles from the lubricator position.

Figure 9: Two 48” Bars for each Track Used at the Norfolk Southern Roanoke Test Site

Using a proprietary Norfolk Southern lubrication demand model to quantify the comparative lubricant performance the soy oil grease carry distance was determined as 118% of the Norfolk Southern standard petroleum track grease. The durability of the soybean oil-based grease as a film on the rail gauge face in the test site environment was notable. The train operations in the test site included an area that trains were moved in a shove back movement utilizing pusher units. That area of track was especially prone to the standard properly applied petroleum grease being wiped dry from the shove back movements. Although not yet quantified, the soybean oil-based grease was observed to maintain a protective film of lubricant on the rail gauge face in the shove back area.

These observations indicate that the soybean oil-based grease film is more durable than the standard petroleum grease. The coefficient of friction for the soy oil grease application was measured in the 0.12 – 0.15 range while the petroleum product was measured in the in the 0.15 – 0.20 range. This difference in applied coefficient of friction may indicate the mechanism for the greater durability of the soy oil grease. A similar durability comparison was noted in wet weather. Quantification of the soybean oil-based grease durability will require more long-term field tests.

CONCLUSIONS

Soybean oil-based grease has made significant strides to meet the demanding performance requirement of the railroad industry. While there is still a need to have summer grease and winter grease, the year-round grease should be the goal for future product development.
Using specialty soybeans with higher stability and relying on biodegradable materials with lower freezing points, greases have been developed that can perform in temperatures as low as -7°F (-26°C). Future use will show that the soy grease adheres better to the gage face and carries farther down the track. With superior lubricity and reduced grease use, the overall cost of these biobased greases can reach those of current petroleum prices. To date over two dozen railroads in the United States use ABIL developed soybean oil-based grease. This grease was recently approved by Norfolk Southern, which has become the first Class 1 railroad to begin using the grease. Further use by this large railroad along with other smaller railroads should help show the economic and environmental benefits of these specialty biobased greases.