



American Railway Engineering and
Maintenance-of-Way Association

AREMA 2020

ANNUAL CONFERENCE & EXPO

Technical Sessions / Maintenance-of-Way, Sept. 2020

Premium Synthetic Grease in a Heavy Haul Environment

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NUMBER OF WORDS

4164

ABSTRACT

The Canadian Pacific Railway (CP) have optimized TOR and gauge face lubrication in the CP West Region (Calgary to Vancouver) combining high quality equipment, consumables and maintenance to achieve maximum benefits (1). This work began with the 2001 study, 100% Effective Lubrication Initiative (2), and continues to present with the implementation of their Total Friction Management Program (TFM) beginning in 2008. CP together with L.B. Foster Rail Technologies have worked continually to improve the application equipment, logistics and consumables used in the program. Recent investigation has looked at the use of new premium synthetic-based grease in the heavy haul environment to improve the total cost of ownership.

The key factors of this improved technology will have a significant impact on unit spacing, application rates, refilling intervals, and the need for seasonal changeouts. Initial laboratory testing using twin-disk machines will compare the characteristics of these greases including lubricity and durability. Field data will focus on a year long trial on the tough operating conditions of the Shuswap Subdivision, comparing actual rail wear data collected for traditional petroleum-based (2016-2018) versus premium synthetic greases (2018-2019) within the TFM Program. The test zone consists of 126 miles of track with 25 gauge face lubricators and will look at results for different track curvatures and gradients.

This paper will review the benefits of using a premium synthetic rail curve grease compared to traditional petroleum-based options. The cost savings and ancillary benefits of the use of a premium grease will be discussed, including the reduced number of track accesses required on this high capacity line.

THE CHALLENGE

Canadian Pacific Railway (CP) have been industry leaders in implementing Friction Management (FM). Beginning with the 100% Effective Lubrication Initiative in 2001, further CP initiated studies have looked at Top of Rail friction management (TOR) and maintenance practices with the Total Friction Management (TFM) program. These published studies have quantified the benefits of a Total Friction Management program including reduced fuel consumption, rail wear and lateral forces (1,2,3).

To ensure TFM benefits are maximized, it is required that gauge face (GF) trackside units are operating at acceptable uptime values (functioning). Factors which can impact GF unit uptime include:

1. Managing the seasonal transition of summer/winter grade of rail curve grease
2. Having to frequently access & fill remote units in high traffic corridors

Seasonal Grease Switch Over

The railroad environment, with extremes of temperature, can be challenging for rail curve grease. Traditional petroleum-based rail curve greases typically have a limited operational temperature range; if it is too thick it will not pump or flow, if it is too thin it will not adhere to wheel or rail. CP uses typical winter and summer grades as well as a high temperature formulation in the warmest summertime areas on their high tonnage Western Corridor.

There are many difficulties with seasonal changeouts of grease beginning with logistics. Ideally, the present season's grease type should be mostly consumed from the GF lubricator reservoir prior to filling the next season's grade of grease. This is difficult with railroad operating conditions, inventory, varied traffic, equipment removed from track for gang work, and unpredictable weather conditions. There is a large margin for error by the maintenance personnel.

The incorrect product for the season leads to poor mixture of the grades of grease, oil separation, bar clogging, freezing of summer product in cold temperatures, poor carry-down of winter grease in warm temperatures (Figure 1), bar clogging and cavitation of product in the reservoirs.



FIGURE 1: Winter grade traditional petroleum-based grease applied in warm summer temperatures, resulting in low viscosity and fling-off.

Application Rates / Tank Refilling / Track Access

The typical application rate for traditional petroleum-based greases is between 0.7 to 1.0 pounds per 1,000 axles. This varies depending upon grease type/quality, track conditions, application equipment, maintenance, and weather conditions.

In high traffic, remote areas, it can be difficult to keep lubricators full. The large coverage territories and high numbers of lubricators requiring filling add to the difficulty. As example, at an application rate of 1 pound per 1,000 axles, a bulk filler will have to refill a standard 800 lb tank approximately every 26 days (assuming 25,000 axle passes a day) in a high traffic corridor.

Use of a high-performance grease at a reduced application rate can result in longer refilling intervals and reduced requirements for track access.

In order to address the above-mentioned deficiencies and maximize TFM benefits, CP partnered with LB Foster to evaluate the use of a premium synthetic grease in heavy haul conditions. The objective of the trial was to ascertain if an all season premium synthetic grease can provide the same level of GF curve protection (as provided by a tradition petroleum grease) but with a reduced application rate.

This paper discusses the technical and economic justification for the use of premium synthetic grease in a heavy haul environment.

PREMIUM SYNTHETIC GREASE OVERVIEW

There are three major classes of base oils used in grease for rail applications: synthetic oils, petroleum oils and naturally sourced (readily biodegradable) oils. 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 of the wheel-rail interface.

Premium synthetic greases have been used successfully for many years in transit applications for gauge face (GF) rail curve lubrication. These types of grease have excellent lubricity properties and extended carry-down distances.

Base oil selection is critical for achieving the desired lubrication performance from a GF trackside applicator. A grease composition is expected to effectively lubricate 3-5 miles of rail downstream from the unit (less in areas of extended tread braking). To be effective, it must be durable enough to withstand the temperature and pressure conditions found at the wheel/rail interface as it continually transfers between the (wheel) flange and (rail) gauge face.

To quantify a grease's durability characteristic, one can utilize a twin disc machine to simulate the pressure and slip conditions found at the wheel/rail interface (5). Testing typically consists of applying a controlled amount of the grease of to the disks and running them under equivalent load, speed, slip conditions. The friction levels and time to wear/decompose the grease film are recorded.

Figure 2 is an excerpt from a National Research Council report (7) which conducted a twin disc test comparing the premium synthetic grease selected for the CP trial vs. the summer grade traditional petroleum grease. As one can see, the synthetic product lasted significantly longer than the traditional lubricant. Eadie et al (6) also indicated a general correlation between twin disc and field results whereas no such correlation existed between grease field performance and four ball testing.

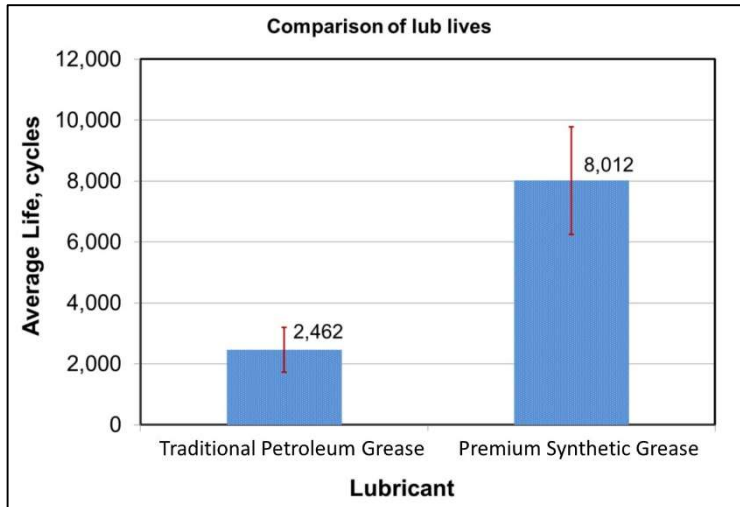


FIGURE 2: Twin disk testing of traditional petroleum grease and premium synthetic.

Another important difference between traditional petroleum greases and the premium synthetic grease used in the trial is the thickener type. Traditional petroleum greases typically use a metal soap thickener (usually Lithium or Calcium) whereas the selected synthetic grease employs a nanoparticle-sized thickener. The metal soap thickeners are fibrous in nature and combined with high oil separation in the grease, can cause a higher propensity for application bar clogging by grease cake formation. The nanoparticle thickeners used in the selected synthetic grease is smaller in size and much more efficient at holding the oil in the grease matrix. As a result, the synthetic greases essentially do not propagate bar clogging.

Product Characteristics	Traditional Petroleum Grease	Synthetic Grease
Base oil type	Petroleum	Synthetic or highly refined petroleum
Thickener Content	>10%	<10%
Thickener Type	Typically Metal Soap-type	Typically Silica-based
Thickener size	Macro-sized	Nano-sized
Solid Lubricant Content	0-5%	0-5%
Grades	Summer, Winter, Arctic	All-season
Temperature ranges	Summer: 60 to 115F Winter: 0 to 60F Arctic: -20 to 40F	-10 to 115F
Cold Temperature Pumpability	Summer: Poor Winter: Good Arctic: Excellent	Excellent
Biodegradability	Not biodegradable	Ultimately biodegradable

TABLE 1: Comparison of product characteristics.

FIELD TRIAL BACKGROUND

The evaluation of premium synthetic grease at CP began in 2016 with a single unit test on the Cascade Subdivision. Carry-down effectiveness at a low application rate was achieved and this led to an expanded small zone trial. A test area on the Thompson Subdivision in 2017 used 4 trackside lubricators in bidirectional traffic showed promising results. A full-scale trial was initiated on the Shuswap Subdivision using 25 GF lubricators over 126 miles of track.

The Shuswap Subdivision between Kamloops and Revelstoke was selected for the field trial. This territory has areas of heavy curvature in a large portion of the track, as well as heavy grade at Notch Hill, giving a good representation of all types of track conditions. This area also has varied climatic conditions, with the western portion near Kamloops being hot and dry in the summer and the eastern end having severe winter conditions with cold and snow. These varied conditions test the characteristics of a GF grease.

The Shuswap Subdivision is in the high tonnage Western Corridor that is part of the TFM zone. This area has had GF and TOR application combined with excellent maintenance for more than 12 years. A single experienced lubricator technician has covered this territory for more than five years. GF and TOR unit uptime and function are recorded by RPM remote monitoring and has always been above 85% operational during the TFM project.

The trial plan consisted of monitoring 25 GF lubricators, 20 selected curves for carry-down of grease and rail wear. CP selected 12 curves divided in two zones with different track conditions. One zone in a heavy curvature single track river grade area along Shuswap Lake between MP46 to MP55. The other on the western side of Notch Hill between MP83 and MP100 with heavy curvature single track with heavy descending grade where tread brakes are applied by westbound loaded trains. The selected curves are shown in Figures 3 and 4. The remaining 8 selected curves were split between the far eastern and western ends of the territory to evaluate performance in extreme weather conditions.

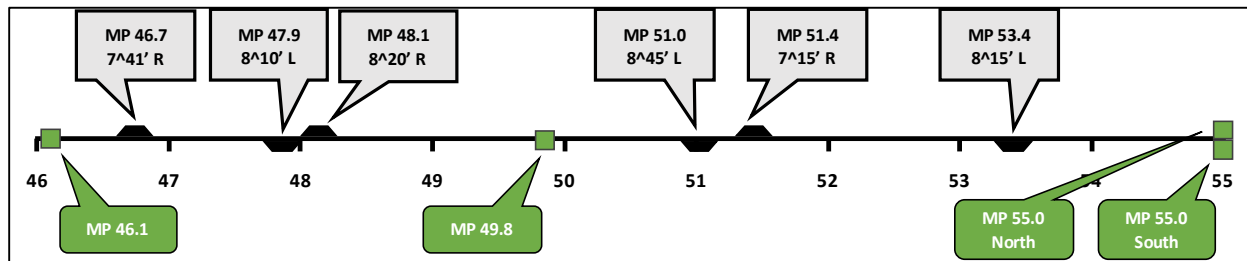


FIGURE 3: River grade test zone with locations of lubricators and measurement curves.

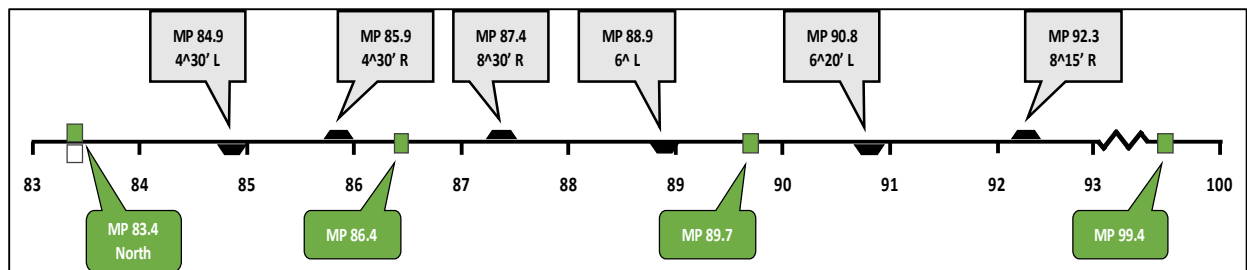


FIGURE 4: Heavy grade test zone with locations of lubricators and measurement curves.

The trial began in June 2018 with an inspection of the grease carry-down in the 20 curves and conditions at the 25 GF lubricators with traditional petroleum-based grease. The product was switched to premium synthetic grease in early July 2018. Inspections of the synthetic grease were carried out approximately every two to three months for the next 16 months. This time period allowed evaluation of the new grease in all weather conditions and rail wear over 100+ MGT.

Rail wear was compared using geometry car wear data. Historical data from April 24th, 2014 to July 1st, 2018 was used for traditional petroleum-based grease. This period had approximately 425 MGT. The rail wear for premium synthetic grease ran from July 1st, 2018 to October 31st, 2019 with over 100MGT.

MONITORING AND CONTROLLING APPLICATION RATES

At the beginning of trial, the application rate was conservatively set at historical settings. Measured application rates, taken in July 2018, varied between units from 0.28 to 1.6 lbs/1,000 wheels, with most of the readings around the average of 0.62 lbs per 1,000 wheels. The cause of the noted larger variations was primarily due to aging pumps in the 12-year old GF lubricators and the selection of different application rates to increase coverage in particular curves. In August 2018, worn out pumps were replaced, and application settings were adjusted to achieve a uniform application rate of 0.3 lbs per 1,000 wheels.

Following the optimization period in August 2018, the application rate of the synthetic grease was closely monitored over the trial period, with a total of 5 additional measurements taken. Not all units had the output measured at each inspection. The application rate target was 0.3 lbs per 1,000 wheels. Application of this all-season grease was adjusted slightly below in the winter conditions and slightly above in the hot weather summer conditions.

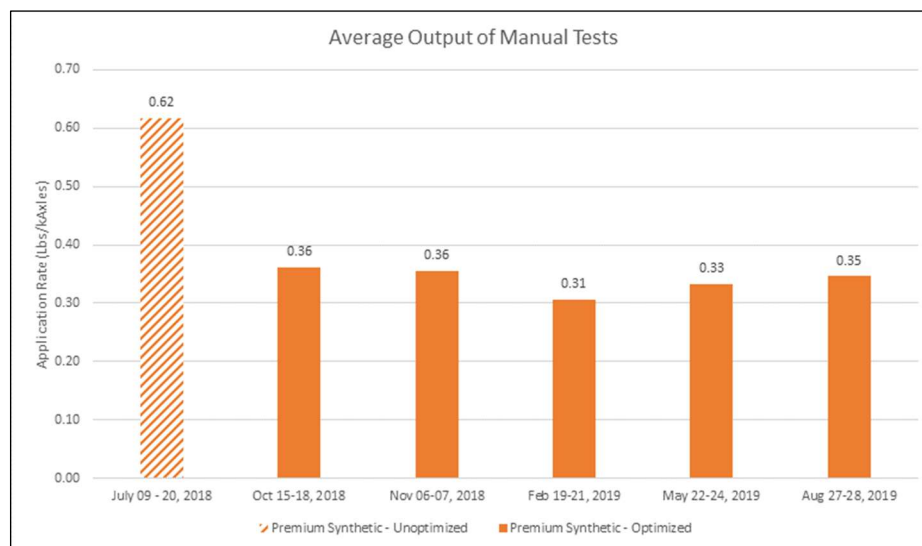


FIGURE 5: Average grease output rates for the trial period at measured units.

For the trial period July 2018 to October 2019, 62,065 lbs of premium synthetic grease were supplied to CP. A total of 18,394 lbs was measured in the lubricators and inventory at the conclusion of the trial. A total of 43,671 pounds of grease were consumed by the 25 lubricators for the 6.2 million wheel passes during the 16-month trial period. Based on these numbers, the average output rate for the trial period from the 25 lubricators was approximately 0.28 lbs per 1,000 wheels which was close to our target application rate of 0.30/lbs per 1,000 wheels.

FIELD TRIAL RESULTS

RAIL WEAR

The rail wear comparison of the tradition petroleum-based and the premium synthetic greases were done using CP's geometry car wear data. Track geometry data is measured every foot and rail profile data every 15 feet. The wear data includes milepost, curve/tangent information, gauge wear and vertical wear. The methodology uses the body of each selected curve, ensuring location matching and stable wear conditions. The vertical and lateral wear is calculated using a linear regression of wear rate with traffic tonnage information (4). The wear data includes natural wear caused by rail traffic and metal removed by grinding. The rail wear data was analyzed for more than 500MGT in the 20 selected curves.

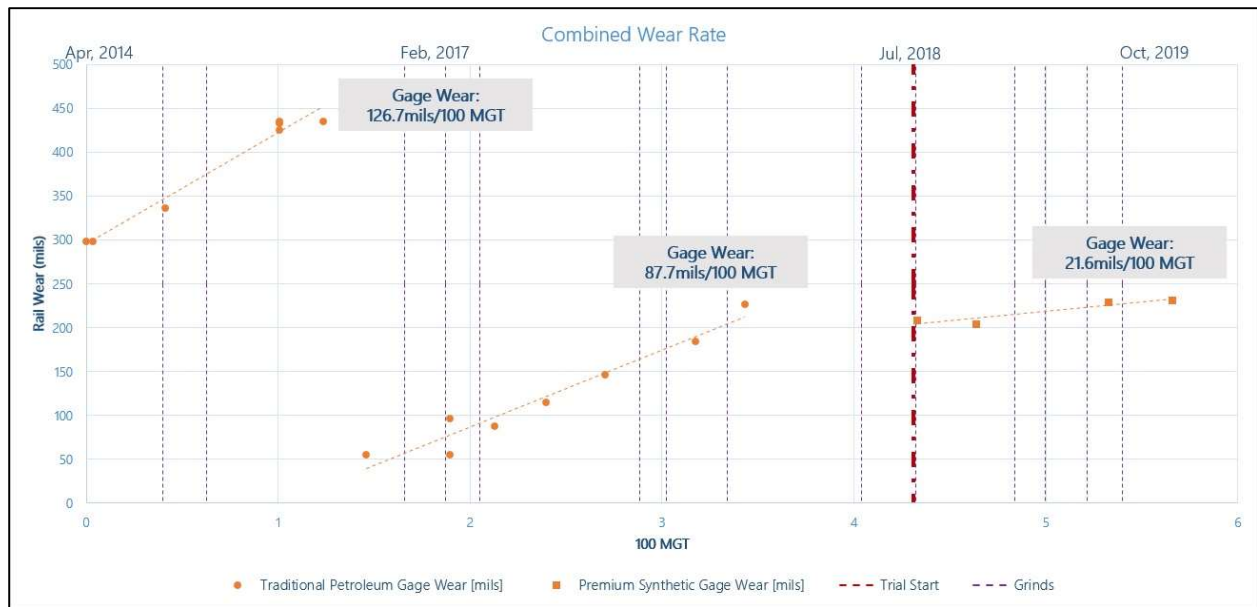


FIGURE 6: Rail wear data for MP3.6 South Track 6° right hand curve.

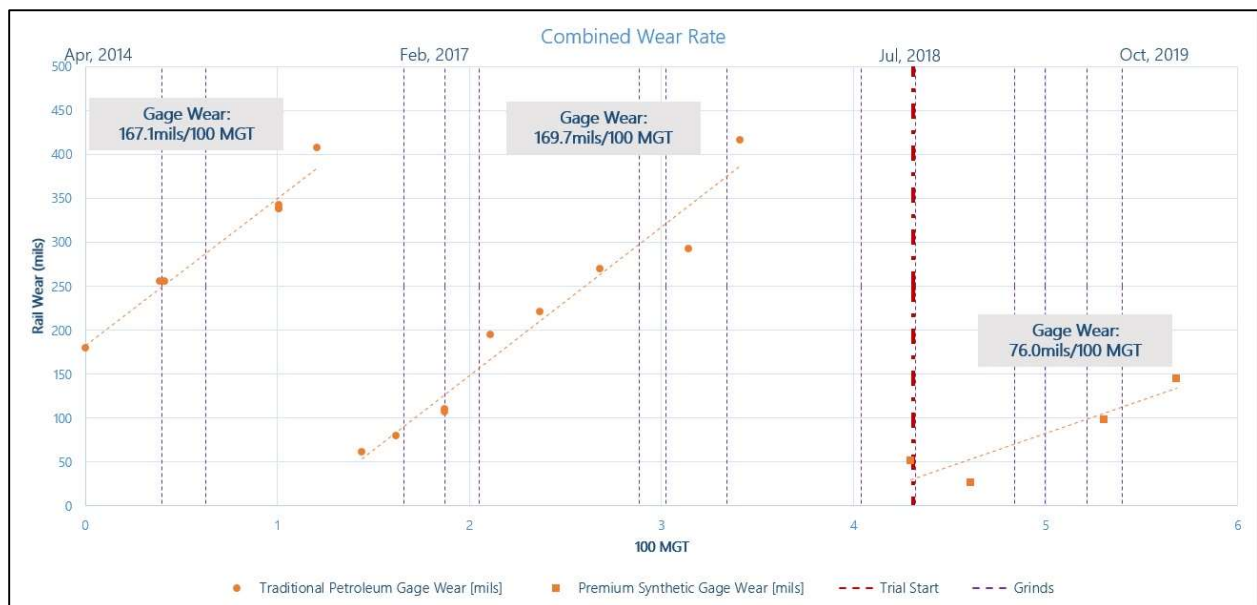


FIGURE 7: Rail wear data for MP87.4 South Track 8° right hand curve in descending heavy grade.

Data from April 24th, 2014 to July 1st, 2018 was used for traditional petroleum-based grease. This period had approximately 425 MGT of traffic. Over this time period all curves had 1 or 2 high rail replacement events and can be observed in the graphs where the trend lines return to 0 on the Y-axis (Figures 6-7). The average horizontal wear rate for the 20 curves over this period was 74.02mil/100MGT.

The rail wear for premium synthetic grease ran from July 1st, 2018 to October 31st, 2019 with over 100MGT. The average horizontal wear rate for the 20 curves over this period was 55.51mil/100MGT. The average reduction in horizontal wear rate was 14% for Zone 1 river grade curves and 38% for the Zone 2 heavy grade curves. Overall, the measured reduction in average high rail horizontal wear with the use of premium synthetic grease for all 20 selected test curves was 25%.

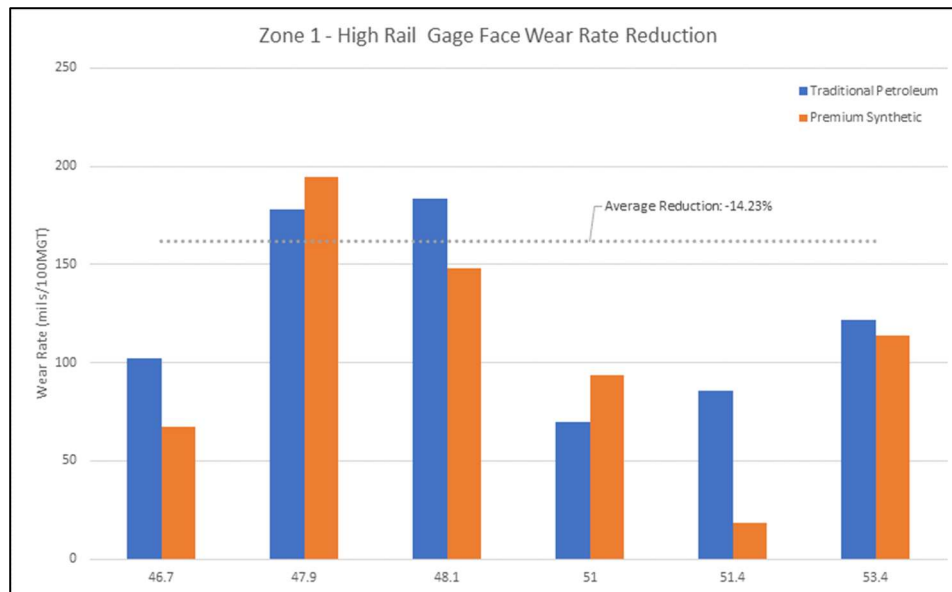


FIGURE 8: Average horizontal (gauge) rail wear rates (mils/100MGT) for Zone 1 river grade test curves.

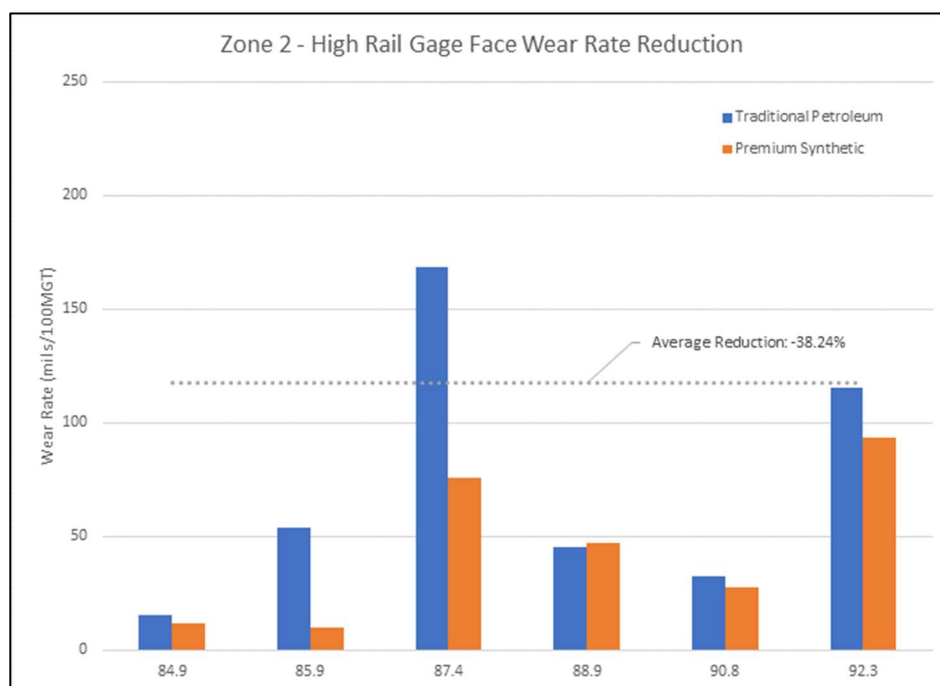


FIGURE 9: Average horizontal (gauge) rail wear rates (mils/100MGT) for Zone 2 heavy grade test curves.

CURVE INSPECTION

The inspections of the 20 selected test curves was carried out regularly throughout the trial period. During each inspection swipe tests were conducted to observe the grease film on the gauge corner and gauge face. Observations were recorded on the presence of metal filings. Train movements prior to each inspection were recorded to understand the influence of loaded versus unloaded or fleeted traffic. The conditions of the lubricators to the east and west of the site were also inspected and recorded. Inspections were carried out at a minimum of quarterly to observe the premium synthetic grease under all weather conditions.

The inspections for the traditional petroleum-based grease were carried out in June 2018 prior to the hot summer temperatures. Carry-down to the curves recorded good grease coverage for most curves with little metal filings from rail wear visible. There was a black wrap of grease on the gauge face and a thinner band on the gauge corner. A small number of curves had thinner, marginal coverage. The average application rate for this inspection was an average of 0.6 to 1.0 lbs per 1,000 wheels.

The inspections for the premium synthetic grease showed the grease coverage to look different on the rails. The color is lighter due to the grease itself being white as opposed to dark grey or black for the traditional petroleum-based grease. The lighter color of the grease gives a more translucent appearance to the film on the rail but has good lubricity which was confirmed by the previously shown rail wear data [Figure 6-9]. The difference in grease film color is shown in Figure 10. As stated previously, the average application rate during the inspections was approximately 0.3 lbs per 1,000 wheels. Very few metal filings were recorded at any of the curves during the 16-month trial period, no matter the weather conditions.



FIGURE 10: MP10.8 4°45" left hand curve inspection: traditional petroleum-based June 2018 (left), premium synthetic August 2018 (center) and October 2018 (right).

ALL SEASON CAPABILITY

The premium synthetic grease was installed in July 2018 and observed for more than a full calendar year to observe all weather conditions. The climate of the subdivision is different from the western end to the eastern. The western end has dry, almost desert like conditions with summer temperatures above 90°F and winter temperature averaging 15°F. The eastern portion of the territory is more mountainous and experiences moderate summer temperatures but heavy snow and severe cold in the winters.

The premium synthetic grease performed well in the dry or wet conditions present in the different areas of the subdivision. The grease has good pumpability at lower winter temperatures but still retains enough viscosity in summer temperature, not becoming too thin to be picked up effectively by the wheels.

PORT CLOGGING

The propensity of distribution bar port clogging can be caused by the design and age of equipment, maintenance, sand application, coal or iron ore dust and grease characteristics. Maintenance activities, such as how long bars are inactive and off track for gang activity are especially important. Port clogging not only affects the application of product but requires large amounts of maintenance time to rectify. This is a dirty time-consuming job that is often not completed by non-dedicated personnel.

During the trial, port clogging for the traditional petroleum grease was not closely recorded but it is the most common maintenance issue. It is well accepted that the bars at each lubricator will require cleaning a few times per year, especially during hotter weather and around gang related activities when the application bars sit off track.



FIGURE 11: Common examples of port clogging recorded with tradition petroleum grease application.

As part of each inspection of the 16-month premium synthetic grease phase of the trial, port clogging was closely monitored. A minimal number of ports were found to be clogged at some of the units. For the 25 lubricators during the trial only 2 bars fully clogged over the 16 months. As the maintenance on the Shuswap Subdivision has been consistent over the trial period, differences in the amount of bar clogging can be attributed to the differences in the grease applied.



FIGURE 12: Reduced port clogging recorded in heavy sanding areas with premium synthetic grease

OIL SEPARATION OF GREASE

The consistency of rail curve grease and its ability to stay homogeneous directly impacts performance, pumpability and bar clogging. When the oil lubricant separates from the carriers in the tank reservoir, the grease will not pump correctly. Oil can build up at the pump inlet causing the pump to spin and not draw the grease into the chamber. If the oil is pumped and applied from the application bars, it is too thin without the carrier and will not adhere to the wheels for carry down the track. Conversely, the solids left in the tank can cause blockages of the pumps, hoses, and application bars. If the solids are pumped, they do not contain the proper level of oil and will not properly lubricate the curves down track. Therefore, the level of oil separation of the grease within the reservoir is critical to the overall trackside gauge face lubrication process.



FIGURE 13: Comparison of oil separation of traditional petroleum grease (left) versus premium synthetic (right).

The oil separation during the 16-month premium synthetic grease phase of the trial was minimal. Most units had no separation at the time of inspections. The tradition petroleum grease showed heavier oil separation during inspection and historically this is a common occurrence at CP. This issue is due to chemical composition, manufacturing consistency and effected by seasonal changeouts of grease.

ECONOMIC IMPACT

One of the largest economic benefits of premium synthetic grease for CP is the reduced number of track accesses required for bulk fill and maintenance activities as shown in the following example:

On the CP 126-mile Mountain Subdivision, there are 44 GF lubricators (31 single & 13 dual track). Average annual traffic is approximately:

- 2.75 million wheels between MP 0.0 & MP 33.2
- 4.5 million wheels Between MP 33.2 & MP 126.0

For an 800 lb tank (with an 80% functional capacity of 640 lbs) operating at 90 % uptime, switching to a Premium Synthetic grease will increase the refilling interval to:

- 314 days from 157 days in the segment with 2.75 million wheel passes
- 192 days from 96 days in the segment with 4.5 million wheel passes

On the entire Mountain subdivision this would translate to an approximate 40 % reduction in the number of required track accesses to fill the lubricators as shown in Table 2.

	Application Rate (lbs/1000 axles)	Total Grease Consumed (lbs)	Annual Number of Track Access ¹	Total Filling Time (Hrs) ²
Traditional Petroleum Grease	0.6	90,855	186	124
Premium Synthetic Grease	0.3	45,428	115	77

Table 2: Comparison of Total Number of Required Track Access and Total Filling Time

Notes:

- 1) Number of required track access are rounded up per unit for an annualized basis
- 2) Filling an 800 lb unit takes approximately 40 minutes

Other additional direct economic benefits of using a premium synthetic grease include:

- Eliminate all track access requirements associated with grease seasonal changeout.
- Reduced inventory costs associated with the need to hold more than one grade of grease.

Additional indirect benefits include reduction of the risk of high wear “dry rail” conditions by:

- Lubricators running empty
- GF bar (port) clogging
- Non-optimal seasonal grease switch-over

On a strict annual budget basis, the use of a premium synthetic grease is likely to be cost neutral. The higher unit cost of the grease is offset by the lower application rate. Furthermore, it is recommended that premium synthetic greases are only used where there is robust oversight for the Friction Management Program to ensure the optimal application rate is utilized.

CONCLUSION

The 16-month long controlled test on the CP Shuswap Subdivision showed that premium synthetic grease is viable for gauge face lubrication in the heavy haul environment. Key findings of the trial were as follows:

1. Demonstrated that a highly durable premium synthetic grease can achieve comparable (and even superior) rail wear performance at a 50% reduced application rate as compared to traditional petroleum greases.
2. Reduced application rate resulted in a corresponding 50% reduction in the number of required track accesses to fill the GF lubricator tank.
3. Demonstrated that a single grade premium synthetic grease can operate in a broad temperature environment as an all-season grease and eliminate the need to carry multiple grades.
4. User of a low solids grease can significantly reduce the incidents of bar clogging.
5. A premium synthetic grease can be cost neutral from the perspective of a railroad's annual grease budget.

REFERENCES

- (1) Roney, M., Eadie, D., Oldknow, K., Sroba, P., Caldwell, R. and Santoro, M. (2009) Total Friction Management on Canadian Pacific, Proceedings of the International Heavy Haul Association, Shanghai, June 2009.
- (2) Sroba, P., Roney, M., Dashko, R. and Magel, E., (2001) Canadian Pacific Railway's 100% Effective Lubrication Initiative, Presentation for AREMA 2001 Conference & Exhibition, Chicago, Illinois, September 9-12, 2001.
- (3) Sroba, P., Oldknow, K., Dashko, R. and Roney, M. (2005) Canadian Pacific Railway 100% Effective Friction Management Strategy, Proceedings of the IHHA Conference, Rio de Janeiro, Brazil, June 2005.
- (4) Stock, R., Paradise, S., and Santoro, M. (2017) Friction Management and Rail Wear CP's Western Corridor: 2008-2016, Proceedings of the Wheel Rail Interface Conference, Montreal, June 2017.
- (5) Gutsulyak, D., Stanlake, L. and Qi, H. (2018) Twin Disk Evaluation of Third Body Materials in the Wheel/Rail Interface, Proceedings of the 11th International Conference of Contact Mechanics and Wear of Rail/Wheel Systems, Delft, September 2018.

- (6) Eadie, D. et al (2015) Field Evaluation of Multiple Gauge Face Lubricants: New Methods, Results and Economic Modelling, Proceedings of the IHHA Conference, Perth, Australia, June 2015 (10 pp)
- (7) Jiang Jimmy (2017) NRC Tribological Testing on LB Foster Lubricants Using Amsler Test Machine, National Research Council Test Report (ST-R-TR-0092)