Total Friction Management on Canadian Pacific

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Summary: Canadian Pacific Railway (CPR) has been a leader in implementation of new friction control technology. Following earlier trials, we report the design, justification, roll out and early results of Total Friction Management (TFM) (GF plus TOR) over all high tonnage lines in Western Canada. Tools and processes needed for implementing TFM over a large territory are described. The roll out incorporates state of the art equipment and materials for GF and TOR application, logistics considerations for material handling, and maintenance issues through dedicated TFM staff. Development of a holistic economic case for this TFM project is discussed. Prior results were used to quantify expected savings in rail, ties, and track regauging. Wheel replacement savings were estimated. Locomotive fuel savings were projected by model. Together with the appropriate costs, the expected savings were used to develop an overall business case. TFM implementation involves installation of 325 TOR wayside applicators over 923 route miles between Calgary to Vancouver, as well as optimization and upgrade of 216 wayside GF units. Remote Performance Monitoring is used to manage unit maintenance. Performance verification includes use of L/V sites for TOR effectiveness, and regular high speed tribometer runs to validate and optimize GF performance. Monitoring of the project to date indicate fuel savings (>5%) well in excess of those used to justify the project.

Index Terms: friction, wear, fuel

1 INTRODUCTION

Canadian Pacific is North America's 6th largest railway. CP operates coast to coast, over 25,000 route-km (15,000 route-mi) between Vancouver on the west coast of Canada to New York on the east coast of the USA, and south through the US Midwest. Some of the toughest railroading in the world is experienced on the western coal route between the mines in southern British Columbia and Vancouver, where unit trains with payloads up to 14,800 tonnes (16,300 tons), powered by four 4400HP AC traction locomotives, negotiate the steep grades and sharp curves over a 750 mile (1207 km) route. Between Golden and Roberts Bank, the coal traffic joins up with the primary east-west mainline, which carries approximately 82 million metric gross tonnes (90 MGT) per year. Coal traffic joins up with long intermodal, potash, grain, sulphur and merchandise trains, all of which must negotiate over 3 mountain ranges en route to Pacific coast ports. The ruling grade in the Westward direction is 1.2%, while in the Eastward direction it is 2.4%. The route is predominantly single track with 46% of the route traversing curves tighter than 3492 m radius (1/2 degree) and 129 km (80 mi) of curves less than 312m radius (> 6 degrees). Maximum curvature is 170 m radius (11 degrees). The rail is 68 kg/m (132 lb/yd.) on predominantly timber sleepers. In sharper curves, the rail is premium with a minimum 370 BHN fastened down with Pandrol clips and screw spikes. A particular challenge is the heavy snowfall through the Roger's Pass and temperature extremes in the Thompson River valley ranging from +43°C (110F) to -34°C (-30F).

Canadian Pacific has been actively pursuing a number of initiatives to reduce the "Stress State" of the railway [1]. This paper discusses the initiative known as "Total Friction Management", (TFM) currently being implemented. This includes the technical and economic justification for this approach, and the results to date.

2. TOTAL FRICTION MANAGEMENT

2.1 The Challenge

The potential value of effectively controlling friction at the wheel / rail interface has been identified in many studies. Potential results include reduced rail and wheel wear, fuel consumption, and degradation of track structure. In practice, many railroads have struggled to capture much of these savings. The practical challenges can be due to operational, maintenance, and budgetary constraints as well as organizational structure.

In North America, wheel / rail friction control is dominated by wayside application. Effective maintenance of large numbers of units has been a challenge that some large railroads have not been able to fully overcome. Keeping units functional may not be a high priority for local maintenance staff, as the impacts may not be seen immediately, or may not be reflected in key performance indicators. Track time needed for maintenance practices may be very limited. Keeping units filled with lubricant or friction modifier may have logistical challenges such as material sourcing and handling, and equipment availability. Many systems still use pails to fill units rather than bulk handling systems.

Organizational challenges refer in particular to cases where benefits from friction management accrue to departments who are not responsible for the associated costs, and vice versa. At a workshop organized by TTCI in 2006, this issue (rather than technical factors) was identified as the biggest obstacle preventing Class I railroads from expansion of Top of Rail friction control. A related factor is division between capital budgets (used to purchase equipment) versus operational budgets (used to purchase lubricants and friction modifiers). The drive to reduce the "Operating Ratio" has provided challenges to local operating budgets to purchase the needed materials to control friction.

A more holistic view of the costs and benefits of friction control for the whole railway is central to Canadian Pacific's approach to friction control.

2.3 Friction Control Developments on Canadian Pacific

Canadian Pacific Railway has been a leader in implementation of state of the art friction control technology for a number of years. In Stage I "100% effective gauge face lubrication" (GF) was evaluated and implemented in 2001-03 [2]; in Stage 2 (2003-05) Top of Rail (TOR) friction control was assessed as a means to complement the GF program[3]. The work described in this paper can be considered as Stage 3, in which Total Friction Management is being rolled out over all CPR high tonnage mixed freight and coal lines in Western Canada.

2.3 Total Friction Management Concept

The key characteristics of Total Friction Management are:

1. Large scale (territory-wide) implementation
2. Effective Gauge Face (GF) lubrication
3. Effective Top of Rail (TOR) friction control
4. Remote Performance Monitoring of application systems
5. System maintenance, management and filling
6. Performance verification to ensure that expected results are being achieved

With all these components in place, it is expected that more effective and consistent wheel /rail friction control will result. This in turn will lead to higher verified cost savings.

3 BUSINESS CASE DEVELOPMENT:

CP developed a holistic business case assessment of the costs and savings to the whole organization that could be achieved through a TFM program. The project was based on the complete mainline route between Calgary and Vancouver as well as the coal line originating in Fording (South Western BC, Figure 5). This process underwent multiple stages of review both internally and with external financial consultants. The end version was presented to the highest levels of CPR management for approval. The following sections describe the various inputs to this process.

3.1 Rail Savings.

NRC-CSTT conducted a study on the effects of two friction management strategies, GF (gauge face lubrication only) and GF-TOR (gauge face lubrication with top-of-rail friction management) on rail wear rates, in a 80 km test zone [2,3]. Rail wear rates were measured on both rails in 14 curves in CP's Thompson subdivision before and after each grinding interval using a MiniProf rail profilometer. The curves were split into three curvature ranges (mild, medium and sharp) based on CP's curvature thresholds for the use of intermediate and premium rails, and elastic fastenings in curves. These ranges are:

- Mild curves, less than 5 degrees of curvature (radius > 350 m)
- Medium curves, between 5 and 8 degrees of curvature (220 m ≤ R ≤ 350 m)
- Sharp curves, 8 degrees of curvature and above (R ≤ 220 m)

From the rail profile data, average natural (wheels) and artificial (grinding) wear rates were generated for the high and low rail in each curvature range for both friction management strategies (GF and GF-TOR).

CP provided two databases of information for the Thompson subdivision. The first contained records for each curve and tangent segment, along with fields describing the degree of curvature, the rail section, current annual tonnage, and the dates at which both curve rails would reach their wear limits as defined in CP's "Rail Wear Limits & Rail Management Decision Zones" chart (Figure 1) [4]. The second database contained historical records for each curve and tangent segment, along with information on the current state of rail wear (vertical and gauge face) measured by track geometry vehicle.

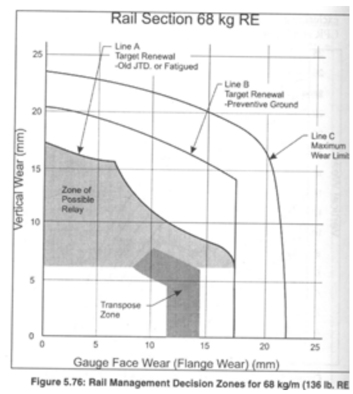

Figure 1 CP Rail Wear Limits

Data on the Thompson subdivision revealed that only 7 curves had high rails in which the gauge face wear exceeded the vertical wear. This was a strong indication that the gauge face lubrication on this subdivision was 100% effective. Since gauge face wear had been effectively arrested, the remaining life for each rail was predicted as follows:

1. Determine the maximum vertical wear permitted for the current gauge face wear, (Line C, Figure 1), with gauge face wear on low rails always taken as zero. Subtract the current vertical wear from the maximum permitted to get the remaining vertical wear.
2. Divide the remaining vertical wear by the total vertical wear rate for the degree of curvature of the rail in question. This yields the remaining tonnage that the rail can sustain before reaching the wear limit.
3. Divide the annual tonnage into the remaining tonnage (from Step 2) to get the remaining life of the rail in years (at current tonnage levels).
4. Add the remaining years of life to the date at which the rail wear was measured to get

the predicted date at which the rail will reach its wear limit.

The extra years of rail life between CP's own predictions and those based on the two friction management strategies were calculated for 2009 – 2013. This provided the length of rail for which replacement could be deferred each year.

From the analysis of the Thompson subdivision wear limits, each of the 8 subdivisions in western Canada were assessed for projected rail replacement levels over a 5 year period (2009 to 2013) for 3 cases: 1) CPR estimated rail replacement projections (no changes); 2) 100% effective GF lubrication and 3) 100% effective GF and TOR friction management. This analysis excludes rail that may be replaced for other reasons, such as fatigue defects, shelling, rail breaks, track upgrades, track buckles, etc. The projected total miles of rail to be replaced for each of the 3 operating strategies over 5 years for western Canada were calculated to be 475.4, 136.4, and 62.2 miles respectively (765, 220 and 100 km). These figures demonstrate that TOR-FM can reduce rail replacement in curves on CPR by approximately 50%. For the next 5 years (2014 to 2018) a more conservative estimate was used to calculate rail savings for the business case. Using the historical CPR rail life in various degrees of curvature (0-2, 2-4, 4-6, 6-8 and >8 degrees in each subdivision) a reduction of 20% in rail replacement was used.

These numbers were included in the economic analysis of each subdivision. Figure 2 shows a comparison of the typical rail life achievable on CPR for 3 curvature ranges with GF and GF-TOR friction management strategies.

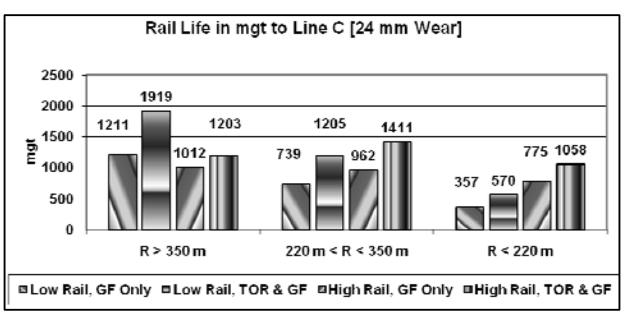

Figure 2 rail life in mgt for the high and low rail in 3 curvature ranges with 2 friction management strategies.

3.2 Wheel Savings

The measured rail wear reductions in the Thompson subdivision were projected to the rest of CPR's western Canada subdivisions based on curvature, and it was a logical extension to expect a reduced wheel wear rate. Wheel defects are assigned a WHYMADE description code (for removal/replacement) in CPR's western Canada wheel shops located in Lethbridge, Alyth, Golden and Coquitlam. The actual number of wheels replaced in 2006 for thin flange, high flange and shelled tread are recorded each year. The percentage used for the reduction in wheel replacement for high flange and thin flange was 30% and 10% respectively. Published work [6,7,8] indicates that TOR-FM can significantly reduce the surface initiation rates of RCF, so it could be expected that better control of wheel / rail friction would also reduce wheel shelling. CP's Mechanical Department agreed to a conservative estimate of 15% reduction in wheel replacement for high flange and shelled treads based upon mutual understanding of the implications of measured lateral force and rail wear reductions.

3.3 Track Structure

The CPR track geometry car runs 4 to 6 times per year through western Canada. Part of the TOR test project was to assess the suitability of geometry car data to monitor the effect of TOR-FM in reducing track structure degradation [5]. Calculations were made of progressive gauge (i.e. increasing values of loaded gauge as a function of accumulating tonnage). Progressive gauge has direct impacts on re-gauging frequency and tie life, which lead to significant economic implications. The TOR systems were active for 9 of 12 months in the Thompson test zone and the reduction in lateral forces was 50% for high rails and 57% for low rails [3].

Analysis of CPR Thompson Sub data demonstrated statistically significant reductions in progressive gauge of 49% and 52% for curves of 0-3 and 3-7 degrees (>580 m and ≤ 80 and 250 m respectively). For the economic analysis it was assumed that the planned annual re-gauging costs for curves less than 8 degrees in curvature would be reduced by 30%.

However no statistically significant reductions in progressive gauge were observed for the ≥8 degree (≤ 218m) curvature group in the CP Rail Thompson. This is believed to result from specified use of premium plates, 4 screw spikes and elastic fastenings in these curves. With the GF-TOR strategy and substantially reduced lateral rail forces there was an expected reduction in the number of broken screw spikes for this sharper curve range. However this was not included in the economic analysis.

3.4 RCF and Grinding

CPR has been grinding rail in Western Canada using a preventive grinding strategy for over 20 years. A large production grinder cycles through the territory 4 times per year using a single high speed grinding pass to manage the profile and control RCF in curves and tangent track.

On average, 100% effective friction management has significantly reduced high rail vertical wear by 50% and low rail vertical wear by 57% [2]. Gauge face wear has been eliminated. It was projected that this reduction in wear and the expected reduction in the RCF crack initiation RCF [6,7,8] would reduce the grinding requirement in curves that utilise GF-TOR. This factor has not been included in the economic analysis. Ongoing work will look to optimize grinding for the new TFM regime. It is expected that reduced grinding costs and less metal removal will result.

3.5 Fuel Savings

The business case required for a large scale implementation of TFM presented a particular challenge when it came to estimating the potential fuel savings. A credible fuel savings prediction was required that would account for the specific alignment of CP's western corridor and use of frame-braced trucks. The project would require that budget dollars be transferred from the fuel budget to the engineering budget, demanding auditable and accurate estimates. Proper estimates of fuel savings would allow calculation of the effect of TFM on CPR's Operating Ratio. The Thompson subdivision 88 km (53 mile) test zone was not of sufficient scale to provide accurate fuel monitoring. Earlier testing by the BNSF and TTCI had estimated fuel savings between 2% in tangent to 35% in the extreme curvature of the Pueblo closed loop test track. The main element of potential fuel savings was determined to be reduced curve resistance, traditionally estimated at 0.8 lbs. per ton of vehicle weight per degree of track curvature.

The most reliable information on fuel savings had been developed in a 2004 study on BC Rail [9]. This project consisted of equipping two instrumented BC Rail locomotives with prototype dispensing systems to spray KELTRACK® onto the rail behind the trailing wheel on the tail end locomotive. Twenty test runs of a loaded 45 car consist were completed, ten runs without the system spraying and ten runs with the system spraying. Measurable savings were based on monitoring changes in diesel fuel consumption, as well as mechanical drawbar forces. The test results indicated a strong correlation between curve density and fuel savings when the train is under tactive effort (Figure 4).

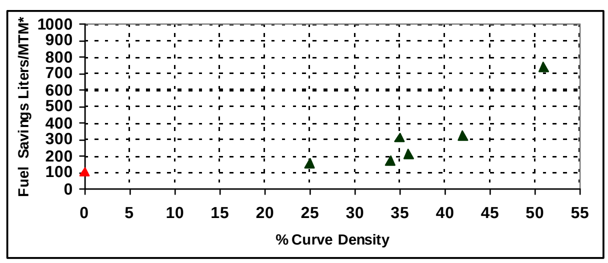

Figure 4: Relationship Between Fuel Savings in Litres per Million Ton-miles and Routing Curve Density.

This basic fuel savings model was then applied to the CP western corridor and coal route. The routing was broken down into total distance where locomotives would not be in dynamic braking and would have coverage from the planned locations of TOR units. (No fuel savings are expected when the train is braking). In each of these zones, the percentage of the routing with curvatures tighter than 3493m R (0.5 degree) was tallied.

Historical tonnages by direction and fuel consumption rates were then applied. This resulted in an estimated ton-miles and a curve density factor, which was then applied to the Figure 4 model to develop an estimated fuel savings in litres. Coal trains were estimated separately due to their being equipped with frame-braced steerable trucks that generated lower base lateral forces, and hence had a lower factored fuel consumption saving in the composite fuel estimate. This resulted in fuel savings estimates conservatively ranging from 1.4% to 3.3% for the 8 CP mainline subdivisions in the western corridor and coal route for a TOR wayside installation density of 1 unit every 4.5 km (2.8 route mi.). At 70 cents per litre for diesel fuel, the incremental value of fuel savings from top of rail friction modification, overlaid on efficient gauge face lubrication, was estimated at $6 million Canadian dollars per year.

3.6 Cost Inputs

Major cost inputs needed to complete the business case included items such as:

- Portec Rail Protector IV wayside TOR applicators.
- Upgrades to “state of the art” or replacement of existing electric wayside GF lubricators and all hydraulic units.
- New trucks for lube maintainers and material handlers.
- Bulk handling systems for GF grease and TOR friction modifier.
- Dedicated lubrication maintainers (5 positions) and material handlers (3 positions for refilling units).
- Friction modifier and grease consumable materials.
- Access to AC power where appropriate.
- A monthly management fee paid to Portec Rail to manage the maintenance, refilling, and monitoring of performance (Section 4.3).

4 TOTAL FRICTION MANAGEMENT IMPLEMENTATION

4.1 Territory and unit numbers

The Western Canada territory covered by the TFM project is shown in Figure 5 below. The different blocks represent the territories to be handled by the material handling resources as originally planned.

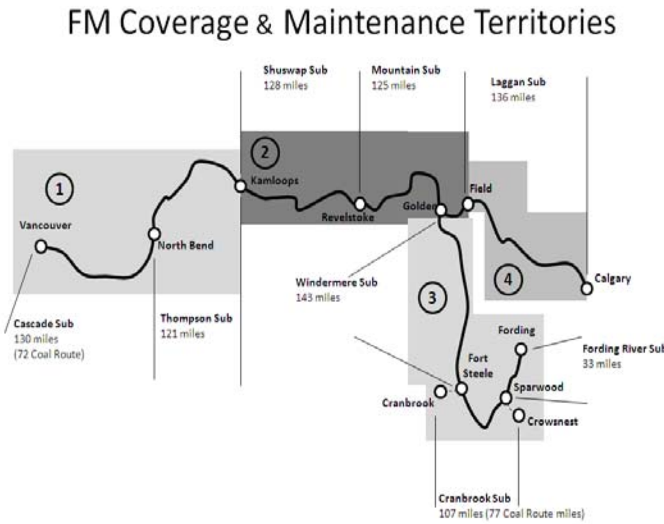

Figure 5 TFM coverage and territories

Table 1 shows the number of GF and TOR units covering the different sub-divisions. Wayside placement estimates were developed by Kelsan Technologies using in-house models. The general process has been previously described [10].

Table 1 TOR and GF unit distribution

Territory	GF Units	TOR Units	Route Miles
1	54	73	251
2	79	126	253
3	47	84	283
4	36	42	136

4.2 Project Team

An important step in the project was the formation of the Project Team, consisting of key personnel from CP, Kelsan and Portec. The team included CP representatives from HR, Engineering, Purchasing and Truck Department. An important step was in informing and educating the local supervisors in each territory about the concept and expected results of the project.

4.2.1 Project Roll Out

The general Plan for the Project Roll Out is shown in Figure 6. The roll-out started in the spring of 2008, is continuing in 2009, and is expected to be completed in 2010.

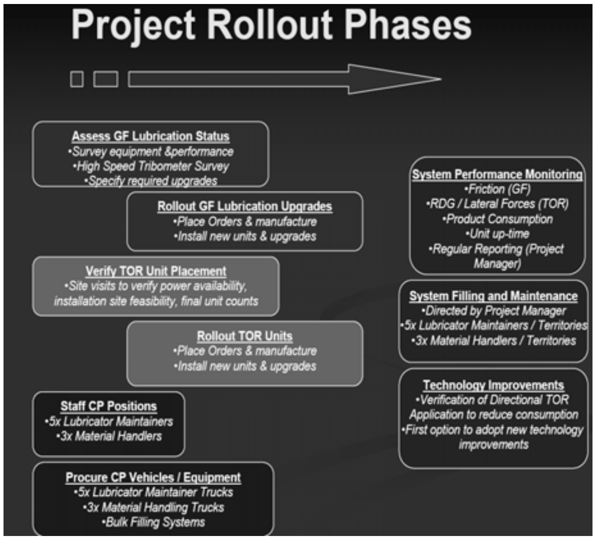

Figure 6 Project Roll Out Plan Summary

Some of the key points learnt from Year 1 of the roll-out were:

- Identifying and having stability in maintenance and material handling personnel was critical.
- As much unit preparation as possible to be done off track.
- Local information such as snow removal, road access, avalanche areas need to taken into consideration in planning unit placement.

4.3 Remote Performance Monitoring, Management and Maintenance

As noted in **2.3,** two of the key components of the Total Friction Management concept include:

- Remote Performance Monitoring of application systems
- System maintenance, management and filling

In the case of CP's Western Canada TFM project, management is carried out by a Portec Rail Project Manager. The Project Manager directs and manages unionized CP wayside applicator maintainers and dedicated materials handlers. The sole task of material handlers is to ensure that wayside applicators are refilled at appropriate intervals. CP had carried out a successful pilot project of this "out-sourced" management of friction control for several years in the Northern Ontario region.

Timely access to the information needed to efficiently and effectively manage maintenance and refilling is needed to ensure a high percentage uptime for the applicators. This is accomplished by the use of Remote Performance Monitoring on the wayside applicator units.

All GF and TOR applicators are equipped or being retrofitted with sensors that measure parameters such as tank level, wheel count, voltage etc to indicate the general state of health of the equipment. In areas with cellular coverage the information is transmitted wirelessly to a web based data base, where the information can be reviewed by the Project Manager and others as needed (Figure 7). Since cellular coverage is not available in the majority of the CP Western Canada territory, for most units the signal is transmitted by RF.

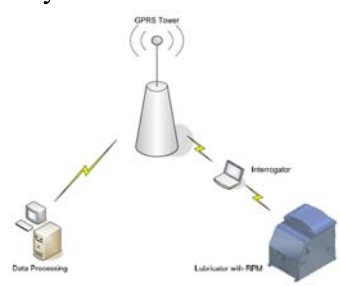

Figure 7 Remote Performance Monitoring

Local track supervisors' trucks are outfitted with Interrogators, which automatically picks up the data as the supervisor drives past on routine track inspections. When the truck enters an area with cellular coverage, the Interrogator device automatically downloads the data to the web server.

4.4 Performance Verification

Performance verification is a key part of the TFM process to ensure that expected results are being achieved.

4.4.1 Unit Uptime

Verification methodologies are being developed for uptime performance of GF / TOR units, using RPM data. Technical challenges with the Interrogator as well as measurement of reservoir levels have limited progress to date on this front. These issues are expected to be resolved in 2009. Target minimum uptime is 90% (excluding extraneous factors).

4.4.2 GF Effectiveness

Gauge face friction effectiveness is being monitored by periodic runs of a high speed tribometer through the territory. This allows optimization of unit placement to ensure all intermediate and sharp curves are properly protected. This is supplemented by spot measurements of friction using a hand held tribometer, as well as visual inspection.

4.4.3 TOR Effectiveness

TOR effectiveness is being monitored by lateral / vertical force measurements initially at two heavy grade locations as verification of the results that were initially seen in the test program [3]. The first location is a 300m radius (6 deg) curve in the Shuswap Subdivision. At this location, loaded westbound trains negotiate a steady 1% ascending grade, with locomotives operating under speed and near peak adhesion. As reported separately [1], implementation of TOR friction control at this location (over and above existing GF lubrication) has produced substantial reductions in lateral forces.

The second measurement location is a 295m radius (5 deg 55 min) curve in the Mountain Subdivision. At this dual track location, loaded westbound trains operate on a descending 1% grade with heavy use of air (tread) brakes to control train speed. Under these conditions effective TOR-FM requires particular attention to inter-unit spacing and application rates to combat the disruptive effects of brake shoes on the friction modifier film.

Figure 8 shows Low Rail results from this site, with data for loaded Westbound 124-car unit grain trains with 32.5 tonne axle loads. The power configuration for these trains includes two head end (AC4400) locomotives and one tail end locomotive in pusher service. Baseline (GF only) data was collected between September 13th and November 4th, 2008 (68 trains) and TOR-FM data was collected between November 28th, 2008 and February 7th, 2009 (46 trains). Reductions in lateral forces via TOR-FM were verified at this site with 23% and 31% reductions reported in average Low Rail and High Rail lateral loads, respectively.

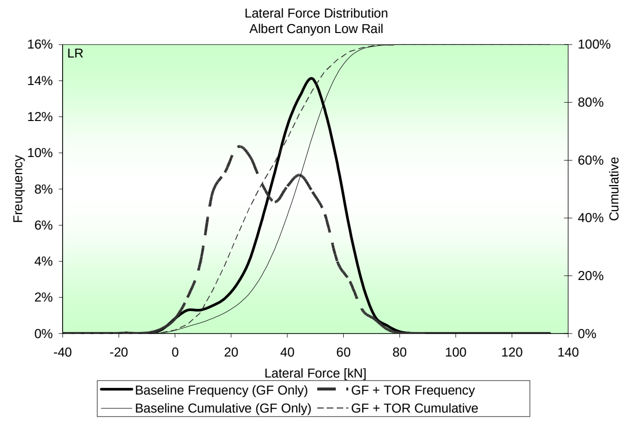

Figure 8. Low Rail lateral force distributions for baseline (GF only) and GF + TOR conditions at the Albert Canyon measurement site.

It is planned to audit TOR performance through the territory by measurement of either rail deflection or L/V forces at several locations in each subdivision. Audits will be carried out every other year per subdivision.

4.4.4 Fuel savings

As of April, 2009, 137 TOR units had been installed and commissioned to add to the 14 existing units, out of the 325 planned for the western corridor and coal route. Three subdivisions had been completed: the Cascade, Thompson and Shuswap, plus one half of the Mountain Subdivision. The business case includes a commitment to post audit the savings achieved. As an interim step, CP has been monitoring the changes in the fuel consumption of a random sample of trains by downloading data from the Qtron® system on locomotives. At the end of each month, the average fuel consumption measured for trains on each of the subdivisions with significant additions of TOR units is compared with a similar sample from the same month in the previous year. This is done to equate seasonal factors such as weather and traffic mix.

Fuel consumption can be measured with reasonable accuracy with data from locomotive event recorders like Q-Tron®. Event recorders record the time the locomotive has spent in various throttle notch positions. This is compared with known fuel consumption rates for benchmark units based upon the speed vs. torque curve for the model. Fuel consumption is equated to the trailing tons carried as the metric "Litres of diesel fuel consumed per 1000 gross ton-miles".

Figure 10 compares the cumulative average from the samples which have been compiled over the period of September 2008 through March 2009. This figure compares the sampled litres per 1000 gross ton-miles over each of the 4 subdivisions with September 2007-March 2008, i.e. the equivalent periods before and after addition TOR-FM. The sample of trains included 1606 trains over this 813 km (488 mi.) length of the railway before implementation of the TOR-FM program and 1350 trains over the routing after TOR-FM. The measured fuel consumption before installation of TOR units was within 2% of the estimates used in the business case. But the measured fuel savings compared before and after implementation of TOR-FM are greater than 5%, rather than the 1.4 to 3.3% assumed in the business case. This was in spite of the fact that the audit period covers the most severe cold weather and snow conditions of the year. The fuel savings would have averaged closer to 8%, except that the audit showed an increase in fuel on the Thompson Subdivision. The baseline period in this case included the effect of already having an 88 km (53 mile) TOR-FM pilot program installed during the baseline period, thereby reducing the potential measured savings. A bigger factor is the influence on the average of two recent months in the TOR-FM sample where fuel consumption was up considerably. During one of these months, the applicators had been turned off for a large work program.

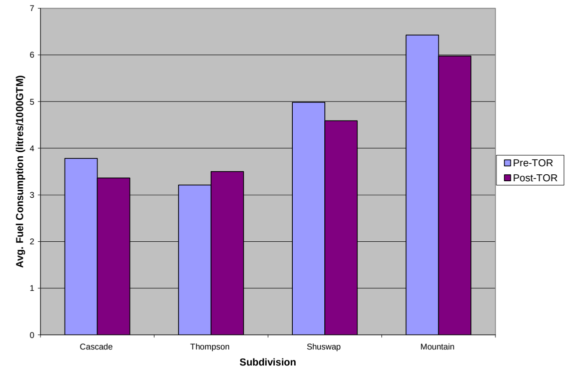

Figure 10 Measured Fuel Consumption in Litres per Million Ton-miles before and after implementation of Top of Rail Friction Modification

4.4.5 Rail life monitoring

As an ongoing method of monitoring rail wear performance NRC-CSTT reviewed the CPR geometry car developed rail wear data base. The 14 test curves in the Thompson subdivision measured with the Miniprof gauge were compared with the geometry car vertical and gauge face wear measurements. It was found that the variation was within 0.016 inch (0.406 mm), 0.013 inch (0.332 mm) and 0.051 inch (1.295 mm) for the high rail top, low rail top and high rail gauge face respectively. As gauge face wear has been eliminated due to the GF lubrication strategy, the geometry car data is a reasonably accurate method of monitoring rail performance with a GF-TOR strategy, and it is planned to use it for this purpose.

5 CONCLUSIONS

A new approach (TFM) is described for efficient and effective implementation of friction control (both GF and TOR) over a large territory. This covers 923 miles of high tonnage track, much of it in mountain territory with challenging weather conditions.

A holistic business case was developed covering all the anticipated costs and savings for this project across CP. Conservative values for deferred rail replacement were calculated based on past test programs to generate cost savings.

Fuel savings from TOR-FM were estimated from past studies on other railways taken together with vehicle, track and operating conditions on CP.

Budgetary funds were assigned from the fuel area. With fuel savings included, the project was expected to achieve a reduction in Operating Ratio (ratio of overall railway costs to revenue).

Costs identified include sufficient dedicated wayside applicator maintainers and material handlers, together with associated trucks and bulk handling equipment. An external Project Manager provides direction to these resources, guided by information from remote monitoring of unit conditions such as product level. These changes are expected to lead to many efficiencies in friction control prior to past practices.

A systematic plan was developed to roll out 325 TOR units over 923 track miles, as well as upgrade GF units. About half of the new installations have been completed to date (April 2009). The roll out is expected to be completed in 2010. Many practical lessons have been learnt about efficient deployment across such an extensive territory.

Monitoring results to date have indicated actual fuel savings of >5% on average, which exceeds by a considerable margin the figures on which the project was justified.

Ongoing monitoring activities include GF friction measurements, L/V measurements for TOR effectiveness and (longer term) rail wear reduction using geometry car data. Further studies will assess the long term effect of TOR on grinding requirements and metal loss.

A number of new technology initiatives are also being proven out on CP's network which is expected to further improve costs and performance.

Future consideration is being given to expanding this concept to other areas of the CP network.

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