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INNOTRACK

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Glossary

Abbreviation/acronym	Description
TOR	Top-of-Rail
IM	Infrastructure Manager
FM	Friction Modifier
RCF	Rolling Contact Fatigue
GCC	Gauge Corner Cracking
HC	Head Check

1. Executive Summary

INNOTRACK work package 4.5 investigated the potential for rail wear and noise to be reduced by lubricating the gauge corner, and the potential for top-of-rail (TOR) friction modification to reduce corrugation, noise and RCF.

This document describes the present situation with regard to the use of both techniques, and concludes that gauge face lubrication is a commonly used practice for reduction of lateral wear; however long-term field tests are required in order to determine appropriate innovative TOR friction management strategies.

2. Introduction

The INNOTRACK work package WP4.5, entitled “Innovative Maintenance Processes”, includes the task 4.5.4 “Specification, identification and optimisation of friction conditions”. Unfortunately, within the group there has been no representative from the industry with experience of working in the field of friction modification. The representatives from the rail producing and rail grinding industry have a more general interest in the subject, but are not primarily concerned with research work in this area. Furthermore, the IM’s represented in this work package have only limited knowledge or experience of the use of friction modification. Heavy-haul networks have started to investigate or even implement this technology under their specific operational conditions.

Consequently no concrete results with regard to new maintenance processes can be expected. However, it is hoped that the deliverable provided contains sufficient information about the present situation with regard to the use of gauge face lubrication and friction modification, and recommended actions for future research work.

3. Lubrication and Friction Management

3.1 Technical background

The coefficient of friction between wheel and rail varies in track between a minimum of almost 0 and a maximum of up to 0.8. It is widely accepted that the ideal coefficient of friction µ in the contact area between wheel and rail on the running surface should be between 0.30 and 0.35, whereas the respective value at the flange / gauge corner contact should be a minimum. Providing consistently such desirable friction values would result in reduced abrasive wear, reduced development of RCF and short wave corrugation in curves as well as improved steering performance of vehicles, energy savings (e.g. a 5% reduction is reported from heavy haul railways in North America [5]) and reduced noise levels. The positive effects might differ depending on the type of traffic (heavy haul, mixed traffic, light rail…).

3.2 Development up to date

Lubricants were developed initially to reduce the coefficient of friction at the flange / gauge corner to a minimum. These substances are either applied locally in track with stationary equipment (greasing the gauge face of high rails in curves) or using vehicle based equipment. Gauge face lubrication of high rails in tighter curves has become a widely used maintenance activity and can be classified as state-of-the-art. Nevertheless there might be some potential to improve efficiency and economic savings particularly in the field of optimised logistics and maintenance of the lubrication equipment.

Other applications of friction modifiers have started to be tested and implemented, their aim being to keep the coefficient of friction in the range of 0.3. Generally, these products are applied using similar installations as for gauge face lubrication, but are applied to the running surface of the rail. Other systems exist that achieve the same goal, but are vehicle-mounted and apply the friction modifier to the wheel tread. Globally spoken laboratory tests have shown the ability to reduce wear and RCF. In track tests these results have been confirmed, but the main problem seems to be to verify the practicality of applying the friction modifiers in a large scale and maintaining the required installations (e.g. Canadian Pacific has decided to implement friction modification in large scale in their heavy haul network but the first results will not be available until the end of 2009).

Areas that were identified where research could lead to potential improvements are:

- Logistics of application
- Maintenance of applicators
- Optimisation of dosage of material and applying cycles
- Identification of criteria for choosing stationary or mobile applicators
- Life- cycle-cost analysis

A CEN – committee (TC256 - SC2 - WG38) is dealing with lubrication and top-of-rail friction modification and is about to define European standards.

3.3 Experiences of partner IM's

The following chapters summarise the experiences of the partners participating in WP 4.5 in the use of lubrication and top of rail friction modification. As additional information, a presentation "Lubrication Benchmark Europe" that was given by ProRail to the UIC Track Expert Group in February 2009 has been attached as Annex A.

3.3.1 Network Rail

Present lubrication activities

Rail mounted lubricators have been used successfully for many years on the GB railway network to reduce wear of the high rail gauge face and rail vehicle flanges in contact with it on curves. The use of lubricators increased significantly when it was identified that increased rail lubrication at curves also helped to reduce the risk of rolling contact fatigue.

Rail mounted lubricators are currently used on Network Rail infrastructure for the following reasons:

- To reduce the rate of gauge face wear of rails.
- To reduce the traction coefficient and limit the initiation of RCF, in particular gauge corner cracking (GCC).
- To help prevent incidence of insulated block joint failure by reducing the risk of metal particle inclusion (insulation break down).
- To reduce the risk of potential derailment due to the combination of dry gauge face/wheel flanges causing high friction and flange climb derailment.

The relevant Network Rail Company Standard mandates that lubricators shall be fitted at all possible locations where high lateral forces between wheel and rail are known or observed to exist (using the rail wear pattern as a guide). Such sites would meet the criteria below:

- All curves exhibiting or having had a history of excessive gauge face wear;
- All curves with a history of RCF;
- All curves with a radius of less than 1500 metres;
- Cant deficiency greater than 50 mm;
- All curves with continuous check rails installed due to curvature should also be considered, and designed or adapted for this purpose. In such instances the check rail is to be lubricated for reducing noise and wear.

The majority of lubricators in use on Network Rail are of the hydraulic type, followed by mechanical. On long curves, multiple lubricators may be installed at intervals, or multiple and/or longer bars may be installed at the start of a curve.

The use of electrically operated lubricators has grown rapidly over the past few years and this trend is set to continue for reliability and performance reasons. Electric lubricators, unlike mechanical or hydraulic lubricators, are able to lubricate both rails at a particular curve; this means that a single electric lubricator can be used to lubricate a series of left-handed and right-handed curves.

For new installations, visual inspection is undertaken to determine the correct lubricator position. The optimum grease pick up point is often located at the point at which gauge corner/flange contact begins and will generally be between half and two thirds up the transition, depending on:

- Rate of gain of cant deficiency;
- Rail profile;
- Wheel profile;
- Rolling stock characteristics.

Lubricators are set up according to the manufacturers' instructions, with subsequent checks after a short period of service to assess whether lubricant is being dispensed as effectively as possible and grease is not applied to the rail head. Lubricant application rates are as specified by the manufacturers, as are lubricator maintenance regimes. To assess whether adequate lubrication is taking place, the condition of the rail throughout curves served by lubricators is inspected using the following measures:

- Rail wear;
- Friction;
- Visual inspection and presence of grease, to confirm that lubricant is being applied in the proper amount and is not migrating to the top of rail.

Minor relocation of lubricators may become necessary over time as a result of changes in track cant, track alignment after tamping, train speed, cant deficiency and changes in the mix of rolling stock.

3.3.2 DB AG

Present lubrication activities

On DB AG traction units and driving trailers, the wheel flanges of the first leading wheel set are lubricated automatically with special wheel-flange lubricants during running. The rapidly biodegradable lubricant spreads itself to the following wheels and the rails as a result of wheel-flange/rail contact.

As almost 100 % of the trains are fitted with these systems, it is assured that particularly the gauge corner of the high rails in curves is indirectly lubricated regularly.

Both single-rail as well as dual-rail systems from various manufacturers are used here as on-board lubricators. The control of the installations is either distance- or time-dependent - and in some cases also curve-dependent - and can be varied within certain limits according to requirements.

Depending on the installation, the wheel flanges are lubricated every 250 to 600 metres with about 0.03 grams of wheel-flange lubricant. The requirements for wheel-flange lubricators are set out in prEN 15427:2005. The requirements for wheel-flange lubricants are currently being defined at a European level (CEN / TC 256 / SC2 / WG 38) with the participation of DB AG.

Stationary lubrication installations (rail lubricators) are employed only at some locations on the DB AG network, which are subjected to heavy loads and stresses, wear or noise. In the last years 38 stationary lubricators (rail flange lubrication) were installed in the network of S-Bahn Berlin (2003/2004) and 48 stationary lubricators were installed in the network of S-Bahn Hamburg (2004, 2008). Most of the installations were financially supported by the government within a German noise reduction program.

Switch lubrication will be dealt with within SP3.

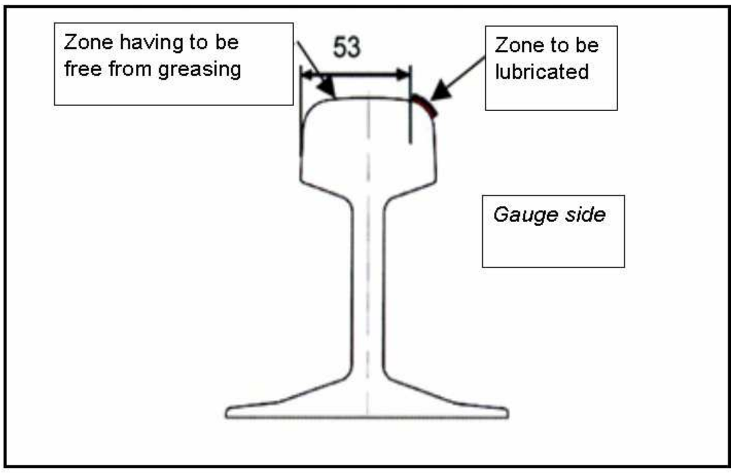
Comments regarding TOR friction modifiers

Within the German noise reduction program 18 stationary lubrication systems (combination of rail flange and TOR lubrication) of the Rail Partner Deutschland (RPD) Company were installed at some curves of one line in 2008.

DB AG pursues and accompanies the technical developments regarding TOR friction modifiers. Recommendations for the use of TOR friction modifiers will be derived as more information about achievable economic benefits becomes available.

3.3.3 SNCF

Present lubrication activities



The whole track network is treated by using on-board lubrication systems, which are activated in pre-determined locations (oil). Depending on rolling stock, this system is activated at regular times or only in curves.

The objective of lubricating is the radius of 13 mm on the gauge side of the rail in order to reduce lateral wear in curves with a radius of less than 1200 m.

Stationary installations in track are not authorized any more.

In autumn during leaf-fall periods, lubrication is suspended in order to avoid slippery rail surfaces. Rails are then cleaned with high-pressure water to remove the mix of leaves and lubricants.

A control of rail lubrication is realised on representative points of network to calculate a national indicator of rail lubrication state, which is the base of discussions between track maintenance and rolling stock departments.

Comments regarding TOR friction modifiers

TOR friction modification is not applied and not considered to be used in the near future.

3.3.4 ProRail

Present lubrication activities

The policy of lubrication systems is not defined. Only on some rolling stock wheel flange lubrication has been mounted. There is no common use of wheel flange lubrication and there are no respective rules established. The rolling stock operators are free to use such a system or not. The type of lubricant to be used is not specified.

At present a certain number (estimated 80%) of freight locomotives and about 5% of all passenger trains are equipped with lubrication systems.

Stationary lubrication installations (rail lubricators) are employed only at some switches around and within station areas, which are subjected to heavy loads and stresses or wear respectively as well as in curves with heavy wear. A total amount of 395 stationary lubricators are installed in ProRail network.

Comments regarding TOR friction modifiers

Because of Dutch noise pollution requirements there is a project running in order to organise a plan to reduce noise by a minimum of 3 dbA per station area. This noise project is active in parallel to the other ProRail daily infra projects with a separate budget provided by the government. In practice that will result in the installation of many stationary TOR units and flange lubricators of the Rail-Partner-Holland (RPH) Company, especially around switches in most stations of the big Dutch cities. Already now about 1300 systems are installed and installation will go on for the next years: A total of 2600 systems are expected to be in service by 2010. This amount consists of always 50% TOR- and 50% lubrication stationary equipment.

In 2009 the ProRail innovation department will do research and provide pilot installations to test on-board flange- and TOR- lubrication (Headlub). The research goal is to save traction energy, reduce the amount of stationary lubricators and general track maintenance work.

3.3.5 Banverket

Present lubrication activities

Banverket does not have a defined regulation, but rather a recommendation to use lubrication in curves with radii up to 800 meters in case of lateral wear and in switches, e.g. in marshalling yards. All greases fulfil environmental regulations according to class B as defined in SS 15 54 70.

Today there are no regulations about lubricating the wheels; it's up to the owner of rolling stock. There were discussions with different rolling stock owners about letting them do all the lubrication. But no decision has been taken so far.

Reports from practical experience indicate a reduction of wear, in a specific case up to 8 times.

It's very important that the lubrication is on the gauge face only and not on top of the rail. In autumn the lubrication is turned off at specific places were there are problems with "slippery tracks", when leaves from the trees fall down and stick onto the rails.

Snow and rain are very good lubricants for the rail and wheel. Wear is much lower in the autumn/winter period than spring/summer. Actually wear is worst in spring when the air is very dry. In the north lubrication is turned off due to snow and low temperature in winter time, as it is hard to get the equipment to work well during that period.

There is no experience with regard to energy saving. It is common sense that by lubrication one can reduce the derailment risk in tight curves and switches.

Comments regarding TOR friction modifiers

The rolling stock owner Statens Järnväger (SJ) has some trains, which are lubricating on the top of the rail and they report a better running comfort and traction behaviour.

3.3.6 Voestalpine Schienen GmbH

Present lubrication activities

Voestalpine at Donawitz uses in their own track net gauge face lubrication in two narrow curves in order to reduce the lateral wear of the rails. On these track segments the liquid iron is transported with torpedo wagons from the blast furnaces to the steel plant.

Track data: Curve radius: 100 m and 75 m
Load: 5 Million tons per year
Speed: max. 20 km/h
Wagon type: 16 axle torpedo wagon (22.5 t axle load)

No measured wear data is available, but the reduction of lateral rail wear is clearly visible.

Comments regarding TOR friction modifiers

First tests on their full scale test rig were done with dry contact conditions using rail grades R260 and R350HT. Then the tests were repeated with FM application covering the whole rail head (not only top of rail). The FM application was set to one application every 250 wheel passes. This value was chosen from a previous test series that focused on the optimal application rate under test rig conditions. The results showed that with FM-application wear was drastically reduced for both rail grades compared to dry contact conditions.

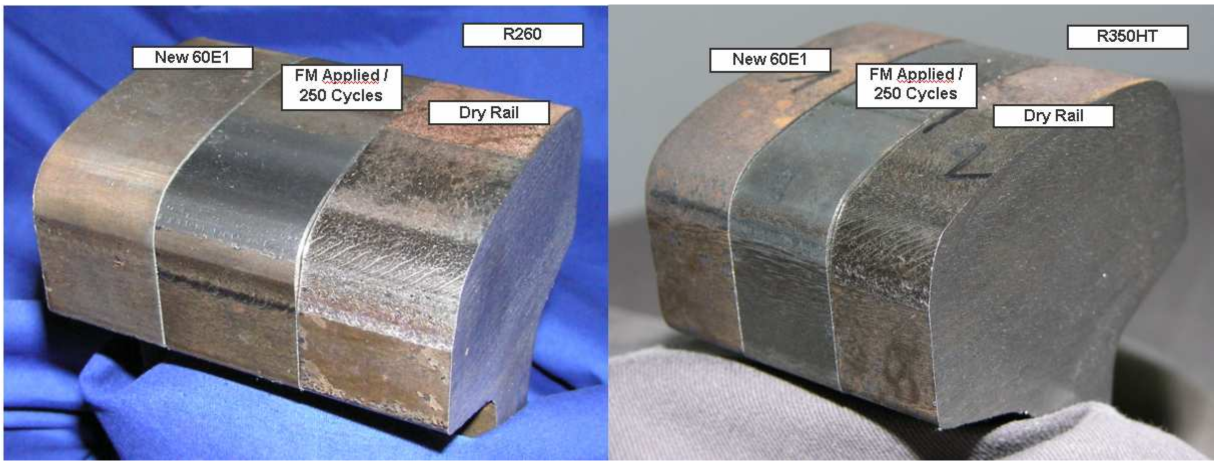


Fig 1: Comparison of rail grades (R260, R350HT) with and without FM application

Concerning Head Checks the results were similar. With dry contact conditions Head Checks formed on both rail types, with the usual rail grade dependence of RCF defects (the R350HT grade showed reduced crack depth and reduced crack distance in combination with less wear). During the FM tests on both rail grades no HC formed at all. A longer term test was also undertaken with each rail grade (4 times more wheel passes) that also produced no HC on both rail grades. For further details see [1].

There is also an Austrian Railways (ÖBB) project that investigates the effect of a friction modifier on corrugation. As this project is still running, no results are available at the moment.

Several field tests exist within Europe, and also worldwide, that clearly show the positive influence of FM application concerning RCF mitigation, corrugation growth reduction, noise reductions and fuel consumption rates; for further details see [2] - [9].

Literature on FM (Provided by Voestalpine Schienen GmbH)

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[9] Makoto Ishida, Takumi Ban, Kohei Iida, Hiroaki Ishida and Fusayoshi Aoki. Effect of Moderating friction of wheel/rail interface on vehicle/track dynamic behaviour, Wear, Volume 265, issue 9-10, 30 October 2008, pp. 1497-1503.

4. Conclusions

Gauge face and wheel flange lubrication is a powerful tool to reduce lateral wear on high rails in curves. Its application depends on local policy, and infrastructure and traffic conditions. There is clearly potential for further research to be undertaken to improve the performance of gauge face lubrication strategies and their use as a tool to aid optimisation of maintenance.

The use of TOR in heavy haul operations and results obtained from laboratory tests show benefits concerning fuel savings, wear, RCF and corrugation formation. In Europe the use of TOR friction modification in conventional lines is in its early test phase and its benefits have not been definitively demonstrated. As European conditions differ strongly from North American heavy haul operations it is therefore recommended that a series of full scale in track tests are undertaken to further verify the claims made as to the benefits of TOR friction modification. As establishing and organising such a project and data collection over a representative period would require at least five years, which is significantly beyond the timescale of the INNOTRACK project, a separate research project should be progressed by IM's and the concerned industry.